Final report

Barriers to adoption and extraction of value from agtech in the Australian livestock industry

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Table of Abbreviations

Agtech	Agtech is used as a generic term for digital technologies that are being developed and commercialised for adoption in agriculture. Agtech is the foundation of the digitalisation of agriculture.
AI	Artificial intelligence
APVMA	Australian Pesticides and Veterinary Medicines Authority
BCA	Benefit-cost analysis
CASA	Civil Aviation Safety Authority
CCA	Cattle Council of Australia
eDEC	Electronic copy of NVD
eNVD	Electronic (fully digital) NVD
ESI	Export slaughter interval
EU	European Union
GMO	Genetically modified organism
HGP	Hormonal growth promotant
IoT	Internet of things
IRB	Industry Representative Bodies
ISC	Integrity Systems Company
LPA	Livestock Production Assurance
MER	Monitoring, evaluation, and reporting
MSA	Meat Standards Australia
NLIS	National Livestock Identification System
NFAS	National Feedlot Accreditation Scheme
NVD	National vendor declaration
OHS	Occupational health and safety
RAM	Restricted animal material
RDC	Research & development corporation
RFID	Radio frequency identification
ROI	Return on Investment
UAV	Unmanned aerial vehicle
WHP	Withholding period

Abstract

The Integrity Systems Company (ISC) 'Strategic Plan: Integrity System 2025 and beyond' identified key investments that are fundamental to maintaining market access and food safety assurance for the Australian red meat value chain.

Four interrelated projects (foundational projects) were commissioned to assist ISC evaluate next generation opportunities for the integrity system. This project focussed on the identification of barriers to the adoption of agtech (digital technologies) with emphasis on real time traceability in the red meat livestock industry.

Barriers identified from a review of Australian and international literature were characterised into seven key themes – value proposition, data issues, infrastructure, policy and regulation, skills, social and technology – and these were confirmed through stakeholder consultation. The thematic review and analysis provided the rationale for the development of a logic framework of adoption barriers and potential solutions including attitudinal considerations and constraints.

Based on information collated within the logic framework and supported by the industry consultations, a non-sequential stage-gate plan of adoption strategies was developed to assist the implementation of agtech for real-time traceability. The stage-gate adoption plan was then customised for the eNVD as a case study of agtech adoption.

The main findings and recommendations from the project were workshopped with key ISC management.

Executive Summary

Background

The Australian red meat integrity system is critical to underpinning market access and food safety assurance for products from the Australian red meat value chain. This system provides traceability from paddock to plate with an essential role in collecting and collating data from all participants in the chain. The Integrity Systems Company (ISC) 'Strategic Plan: Integrity System 2025 and beyond (ISC2025)' prioritised investments needed to ensure whole of value chain compliance and confidence in the key platforms of the National Livestock Identification System (NLIS), Livestock Production Assurance (LPA) and National Vendor Declarations (NVDs).

A series of interrelated projects known as the ISC foundational projects (five in total) were commissioned to enable ISC to make more informed decisions on potential investments to develop next generation opportunities from the integrity system. This project focussed on the identification of potential barriers to the adoption of agtech applications (digital technologies) with emphasis on real time traceability in the red meat livestock industry.

This project undertook the following activities:

- A review of existing project reports on barriers to adoption across key research & development corporation (RDC) investments in technologies.
- A review of other relevant published academic literature from Australia and across the world.
- Identification of key aspects of past and present barriers that may influence adoption of future technologies.
- Conduct of stakeholder consultations to assist in identifying current barriers to adoption of agtech.
- Assessment of current technologies being used on farm today and what is preventing the uptake of these technologies by some sectors of the red meat industry.
- Provision of recommendations on adoption measures that need to be considered to guide investment in research and development of agtech.
- Use of the electronic national vendor declaration (eNVD) as a case study to develop a framework that will support its more rapid adoption. This case study will be used to support insights into an adoption plan for the future integrity system.

Using a customised thematic analysis, this project compared and contrasted identified barriers to adoption of agtech from a range of agricultural industries both in Australia and internationally. The analysis identified seven key areas that provided the dimensions for the development of a logic framework of adoption barriers and potential solutions. That framework identified the attitudinal considerations and constraints which were then road tested with a series of videoconference interviews with key industry stakeholders.

Based on information collated within the logic framework and the industry consultations, a non-sequential stage-gate adoption plan was developed to assist the implementation of agtech for real-time traceability. The stage-gate adoption plan was then customised for the eNVD as an industry case study of agtech adoption. The final stage of the project was a workshop with ISC management where the findings and recommendations arising from the report were presented.

Key findings

The systematic review of published reports on agtech adoption from both Australian and international agricultural industries provided the rationale for the characterisation of seven thematic areas that affect the adoption of agtech technologies. These themes were:

- Value proposition – agtech needs a compelling value proposition – it needs to address and effectively solve a customer's problem.
- Data issues – covers the critical areas of data collection and storage, ownership (intellectual property rights), privacy and data quality (standard language definitions, completeness, accessibility).
- Infrastructure – beyond the actual agtech itself, digital connectivity is often a challenge in rural areas where it is often unavailable, slow, unreliable, and/or expensive.
- Policy and regulation – include intellectual property protection, safety standards for agtech, addressing not just constraints imposed by government, but also regulations to ensure proper use of the technology.
- Skills – include those needed by producers (and other actors along the supply chain) to understand and operate the technology, and/or local access to technological expertise and associated support services.
- Social – to gain adoption, trust needs to be earned between the agtech provider and the producer. This is particularly relevant where technology avoidance is an issue.
- Technology – ease of adoption, interoperability with other agtech, useability, and the need for further supporting R&D can be barriers to adoption.

The industry consultations with beef and sheep participants from the production, seedstock, feedlot, processing, livestock agency and consultancy sectors, ratified the existence of barriers within the seven themes. Value proposition, trialling of technologies within production environments, ease of use and interoperability with other farming practices and technologies were identified as key barriers. In a number of cases, interviewees indicated that time to evaluate and implement technology was often more limiting than the capital, although notably agtech did compete with all other farm investments for access to capital.

Simplicity and robustness of the technology were further key issues, with several interviewees indicating that agtech often resulted in more complex and complicated farm practices which significantly impaired value and adoption potential. In addition to the seven themes, industry stakeholders identified demonstration of agtech, company stability and technology maturity, awareness of functionality, lack of imperatives and evaluation time as barriers that they believe influence agtech adoption for real-time traceability.

A key finding during the development of the adoption logic framework was that barriers to the adoption of agtech were considered in a non-sequential and often quite varied order. That is, stakeholders were motivated by a range of factors and evaluated different elements of the agtech driven by their individual current and future circumstances. Barriers were identified and evaluated within each of the seven themes at different times within the evaluation cycle. In addition, some barriers were concurrently evaluated to satisfy multiple constraints such as value proposition, infrastructure, data and technology (ease of use).

Based on these findings, a stage-gate adoption plan was developed which provided a three-phase, nonsequential approach to reducing barrier impact and investing in areas (identification of practices and activities) that will lead to greater uptake of agtech. Importantly, activities must have flexibility

for the stage-gate adoption plan to be successful. The three proposed phases of the stage-gate adoption framework are:

1. Product evaluation: development of case studies and commercial trials that generate awareness and allow for transparent, independent financial assessment of the value proposition of agtech. Models to assist with evaluation of value proposition both in financial and non-financial terms may also need to be developed.
2. Confidence in the product's future: confidence in the technology maturity and assurance that there is sufficient company robustness for on-going product support.
3. Availability of enablers: access to network of technical expertise to provide support in evaluation and implementation of the technologies.

As the literature review was being conducted, key elements related specifically to the adoption potential of the eNVD were established and reported. An analysis of the barriers to adoption of the eNVD was completed and road tested with industry stakeholders. The eNVD case study accentuates the finding that barriers to adoption of agtech are remarkably diverse and often complex. Significant barriers in eNVD adoption exist in the areas of policy and infrastructure, data, skills, value proposition and social imperatives. More importantly the combinations of barriers are distinctive to different livestock stakeholders which necessitates a stage-gate adoption plan approach.

Using the framework, improving the ease of use (off-line capability and an e-book format), demonstrating the value proposition of the eNVD through cases studies (audit, time saving, interoperability, transfer of data, end-user engagement), ensuring clear standards for data acquisition and protection, and finally a network of service providers to help implementation, were identified as critical activities to eNVD adoption.

Recommendations

This report makes a series of recommendations for ISC's consideration in future planning and investment decisions. The recommendations are listed below, in the order in which they appear in the report. There is no rating or priority given to the recommendations. However, if implemented the recommendations are expected to deliver significant incremental improvement in the adoption of agtech for traceability of livestock data in the red meat industry.

Recommendation 1. To make a technology appealing to the widest audience, it is important to promote the capability of the technology, how it functions and how it can be incorporated into the farming operations of users.
Recommendation 2. A clear value proposition needs to be articulated. It should include the benefits of the technology, how it operates and how it is better than current alternatives.
Recommendation 3. A clear and easily understood agreement on how data will be collected, stored, and used should be integral to the process of deploying the agtech. Where possible, this agreement should comply with industry developed and agreed codes of practice.
Recommendation 4. Data standards should be developed, published, and adopted to enable broad interoperability between applications and devices.
Recommendation 5. Whenever possible, applications should offer an off-line mode to circumvent the absence (or unreliability) of internet connectivity.
Recommendation 6. Agtech needs to ensure that any additional or perceived regulatory burden is proportionate to the value of the technology.

Recommendation 7. A range of support services are required to facilitate widespread adoption of Agtech. Consideration should be given to training (and accrediting) a network of support providers, noting that approaches that work well in urban areas with reliable broadband may not be suitable in rural and remote areas.
Recommendation 8. Where appropriate, use respected individuals (influencers) and trusted organisations to support and promote the case for adoption of the agtech.
Recommendation 9. In design decisions, agtech should tend toward simplicity rather than complexity. This applies not just to the interface, but to how the agtech is embedded into farm operations.
Recommendation 10. ISC should consider increased investment in case studies and commercial trials where public versions of financial metrics are generated within key production systems and across different geographic locations.
Recommendation 11. ISC should consider a segmentation analysis to determine whether there are defined clusters of producers or feed lotters that enter a given stage-gate at the same point and follow either logical or illogical sequences of activities in the evaluation phase.
Recommendation 12. ISC and MLA should consider an 'eBook' concept that effectively positions all eNVDs sent and received within a format that has the equivalent operational functionality of the current paper book.
Recommendation 13. ISC and MLA should consider the development of a next-generation integrated livestock data platform that includes a 2nd-generation digital NVD module ('DNVD').

1 Background and purpose of report

The Australian red meat integrity system is critical in that it essentially underpins market access for products from the Australian red meat value chain. The system provides traceability from paddock to plate that fortifies food safety and product assurance. The system is fundamentally based on ensuring continuing improvement, maximum compliance, and overall confidence in the key platforms of the National Livestock Identification System (NLIS), Livestock Production Assurance (LPA) program and National Vendor Declarations (NVDs).

Within the ISC2025[1], there are three pillars that focus on:

1. Ensuring our integrity system continues to deliver;
2. Pursuing and adopting new integrity approaches and technologies; and
3. Levering integrity data to add value through the chain.

This report focusses on a systematic identification of the potential barriers to the adoption of digital technologies and tools that enable real time traceability. Traceability is required from birth through to slaughter and beyond, to provide product integrity, support biosecurity, and satisfy market access requirements.

This project has used a thematic analysis of both published and unpublished literature to identify barriers to adoption in a range of agricultural industries both in Australia and internationally. The identified barriers have been grouped into seven overarching themes.

Those themes were used to guide the creation of a logic framework of attitudinal considerations and constraints to adoption of the identified potential technologies. Those concepts, the overarching themes, and the logic framework, then formed the basis of consultation with key industry stakeholders covering producers, feed lotters, service providers, software providers, agents, and processors. Insights identified from the consultation process were tabulated and summarised to assist in the development of an adoption strategy that includes a logic framework.

This report contributes important rationale to help ISC understand the business case for further investment and development. The following key objectives have been explored and answers obtained are detailed within this report.

- A review of existing project reports on barriers to adoption across key research & development corporation (RDC) investments in technologies and other relevant published academic literature from Australia and across the world.
- Identification of key points on past and present barriers that may influence adoption of future technologies.
- Conduct of stakeholder consultations to assist in identifying current barriers to adoption of digital technologies.
- Assessment of current technologies being used on farm today and/or what is preventing the uptake of these technologies in the red meat industry.
- Provision of recommendations on adoption measures that need to be considered to guide investment in research and development of digital technologies.

[1] Integrity Systems Strategic Plan – Integrity System 2025 and Beyond, November 2018.

- Use of the electronic national vendor declaration (eNVD) as a case study to develop a framework that will support more rapid adoption of the eNVD technology. Use this case study to support insights into an adoption plan for the future integrity system.

2 Recognised barriers to adoption of agtech and solutions across agricultural industries

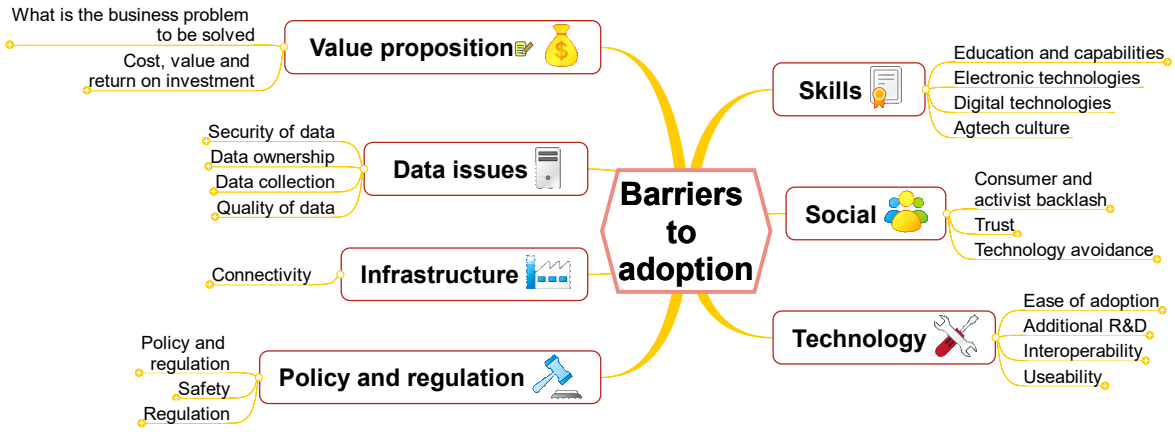
Widespread availability and adoption of digital technologies is a relatively new phenomenon in the agricultural sector, especially on farm. More recently such technologies have often been referred to simply as a subset of the broader agtech (agricultural technology) ecosystem and include solutions to a wide range of challenges or opportunities along the agricultural value chain.

For example, technologies that support the provenance and authenticity of agricultural products can help reduce or identify fraud (counterfeiting, substitution, re-use of packaging) as well as 'add value to products by ensuring food safety, ingredients, origin, production, and other supply chain practices' (GHD, 2016).

Introducing agtech to what is a mature industry with a long history (i.e., the Australian extensive livestock industries (beef, sheepmeat and goats)) is challenging and potentially disruptive. The following sections characterise and describe these barriers to agtech adoption under seven key themes. These themes are listed below and are summarised in Figure 1:

- Value proposition – agtech needs a compelling value proposition – it needs to address and effectively solve a customer's problem, in this case the producer.
- Data issues – covers the critical areas of data collection and storage, ownership (intellectual property rights), privacy and data quality (standard language definitions, completeness, accessibility).
- Infrastructure – beyond the actual agtech itself, digital connectivity is often a challenge in rural areas where it is often unavailable, slow, unreliable, and/or expensive.
- Policy and regulation – include intellectual property protection, safety standards for agtech, addressing not just constraints imposed by government, but also regulations to ensure proper use of the technology.
- Skills – include those needed by producers to understand and operate the technology, and/or local access to technological expertise and associated support services.
- Social – to gain adoption, trust needs to be earned between the agtech provider and producer. This is particularly relevant where technology avoidance is an issue.
- Technology – ease of adoption, interoperability with other agtech, useability, and the need for further supporting R&D can be barriers to adoption.

Figure 1. Barriers to adoption were categorised under seven key themes.



While the order of priority of these themes is likely to differ between agtech technologies, it is expected that 'value proposition' will remain at or near the top of the list. For that reason, 'value proposition' is discussed first with the other themes following in alphabetical rather than priority order.

2.1 Value proposition

What is a value proposition?

Value propositions describe how a product solves a problem for a customer, or in other words, how it achieves the 'job' that customers need to get done. Whether that is knowing when to fertilise, making it easier to keep track of animal location and health, or saving money on inputs, a great value proposition targets an important problem and solves it in a reasonable way.

Weak value propositions do not solve problems customers care about, or they miss the mark on the context or other challenges customers face.

(Sarah Nolet and Cass Mao, 2018)

2.1.1 Description of the barrier

Producers are primarily interested in how a technology addresses their problems. How does it contribute to profitability? How does it reduce input costs or increase output value? How does it reduce labour or make a task easier or more efficient? How does it contribute to reducing production or business risk? That is, what is the value proposition of the technology?

> *'It is critical to first consider the needs and wants of the farmer. Start with the business problem you are solving. Technology should come second.'* (Ros Harvey (The Yield) quoted in KPMG, 2016)

Not having a clearly defined value proposition that solves a user's problem is a major, if not complete, barrier to adoption. Likewise, the inability to clearly *articulate* the value of the technology to potential users is a serious barrier to adoption (KPMG, 2016). Agtech should start by defining the value proposition and then develop the technology to meet the need.

> *'AgTech companies need to be aware of farmer requirements and context to ensure their offering delivers a strong value proposition and ROI. Promises of eventual premiums from downstream consumers are not likely to be sufficient as incentives for adoption'* (Sarah Nolet and Cass Mao (2018).

Challenges for agtech providers include lack of experience in the agricultural production domain and lack of industry networks. Producers are often asked to engage with, or buy, products that have limited functionality or are simply incomplete. Iterative product development as practised by agtech start-ups takes time and time is money for many livestock stakeholders. As a result, agtech adoption is often restricted by previous poor experiences with technology that has not been fully commercialised.

The high cost of hardware and smart technology for some agtech (e.g., robotics) is likely to limit uptake particularly in smaller enterprises where access to capital is limited. Further, with machine learning or artificial intelligence (AI) applications, the return on investment may be lagged while the system assembles sufficient training data for accurate decision making. System failure is a perceived risk that may impact production, profit, compliance and potentially reputation.

Simply being aware of a technology is not enough – producers need to progress to an evaluation phase. Apart from the lack of a strong value proposition, the technology might be outside a viable price range or there may be a lack of information relevant to local conditions (AgThentic, 2019).

Apart from economic value propositions, there are intangible value propositions that may be equally important. Perrett et.al. (2017) identified a number of these during industry workshops. For 'decision agriculture'[2] (and potentially for agtech) they included:

- Providing a benefit to lifestyle, social outcomes and feel-good factor.
- Making farming easier so the user can sleep well – technology should value time and be fun.
- Providing a community benefit in promoting agricultural provenance.

Perrett et.al. (2017) also noted that measures to increase adoption of decision agriculture should:

- Involve a value proposition deliverable through consistency of service and support, and the reliability of technology – It needs to work, or value will be quickly eroded.
- Identify many farmer advocates before a value proposition communicated by sales will be trusted and supported.
- Involve a value proposition that recognises that decision agriculture does not come in a box, however, has multiple players e.g. service provider, agronomist, consultant, grower – which requires that human resources are considered in parallel with technology.
- Deliver value in excess of the perceived loss of control of data.

Furthermore, as noted by Thomas Allison in 2018 many tasks associated with agtech often do not have a direct tangible benefit and require more complex understanding and evaluations to calculate or articulate the returns from investment. He stated that *"…..I believe many on farm systems fail because the benefit is cognitively complex to calculate during tasks such as sensor deployment and data input".*

[2] Decision Agriculture™ is a systems management approach, with local agronomic support & expertise being integral to the overall package. The unique benefit of Decision Agriculture™ is that it removes any potential disconnect between the perceptions of the precision farming data analyst & the localised expertise & management solutions developed by the agronomist. www.cgs.com.au

2.1.2 Overcoming the barriers to adoption

Providing a convincing value proposition is arguably the most important step in driving adoption. Most businesses including primary producers are pragmatic and so will want to understand how they stand to gain by adopting the technology.

The fundamental first step in formulating the value proposition is to identify the issue or exploit an opportunity, the technology is intended to solve, or the opportunity it captures. The benefits of adopting the agtech should then be framed around solving that problem.

The benefits will often be financial, through cost savings or increased income expressed as a return on investment, but might also include improved data accuracy and transmission, reduced labour, improved safety, faster throughput, increased productivity, or lower wastage. These benefits need to be clearly articulated in a format that suits the target audience.

Generally, the target audience will not all warm to the new technology as a homogeneous group. To improve the chance of success, a target segment of the market should be identified, and the value proposition framed to suit this audience. It may be necessary to seek industry assistance to identify and contact that segment.

Provision of localised information will increase understanding of the technology, how it functions and most importantly how it solves the user's problem. For 'localised information', consider more than reports, fact sheets and user guides. Local demonstrations, pilot installations, and field walks allow producers and feed lotters to see the technology being used in conditions similar to their own, as well as observe how the data are collected and what practice changes are needed.

2.2 Data issues

2.2.1 Description of the barrier

Core to the adoption of smart farming innovations is the digitalisation of agriculture – the collection and application of data that promises a host of advantages including improved decision making, increased productivity and profitability as well as contributing to better natural capital outcomes and reduced environmental impact.

DeBoe et.al. (2018) point out that the food and agriculture system is a '*complex physical-economic system with multiple diverse actors, and interactions with natural resources. Organising and coordinating data is all the more useful in this context but may be more difficult than for other sectors.*' Factors contributing to this complexity include the high number of farmers, consumers and transactions.

The shift of data collection from notebooks and journals into an electronic form on computers and more recently into 'cloud' storage has left many producers feeling uncomfortable. This discomfort emerges in several distinct forms.

First, there is the concern that the data will somehow be lost or corrupted, despite the relative ease of making backup copies and the regular and sustained advice to do so. The second discomfort relates to data privacy and the concern that the data will fall into the wrong hands leading to a producer's or feed lotter's competitive advantage being undermined or, worse, that data is used to 'regulate' the livestock stakeholder in some form. Finally, data ownership and ownership rights are issues for producers and feed lotters as they seek to create value from the data they collect.

Despite these concerns, some producers are embracing new technologies and in turn those technologies are transforming the way they farm. Digitalisation is changing '*the way agricultural*

technology and input suppliers interact with farmers, processors, manufacturers, retailers and the broader agri-food sector' (Wiseman et.al. 2019).

Through interviews with grain industry stakeholders, mostly in the Wimmera-Mallee region of Victoria, Jakku et.al. (2019) identified several perceived benefits and risks of 'smart farming' and 'big data' applications (Table 1). Both the on-farm and industry/supply chain benefits listed echo the promises made by broader agtech technologies.

Table 1. Perceived benefits and risks of smart farming and big data applications (from Jakku et.al. 2019)

Benefits		Risks	
On-farm	• Improved efficiency (e.g. through more targeted application of on-farm inputs and automation) • Increased productivity and profitability • Real-time information to help make better decisions • Linking data sets to create greater insight.	**Technical**	• Novel and immature technology • Concerns about data accuracy, reliability, and transferability • Challenges of data storage and handling • Challenge of interoperability • Agricultural data fragmented • New skills and capabilities needed • Limitations of digital infrastructure.
Industry and supply chain	• Optimisation along the supply chain • Improved industry decision-making due to more accurate tracking and prediction of (collective) yield • Improved predictive and analytical capabilities for storage, transport and marketing logistics • Traceability and opportunities for premium products and niche markets.	**Social and institutional**	• Concerns about data privacy and security • Uncertainty over principles, rights and compliance regarding data sharing, ownership, and use • Power asymmetry within industry • Concerns and lack of trust regarding third party (corporate) use of and profit from on-farm data [aggregation] • International competition • Value proposition for sharing on-farm data is not clear for many farmers.

2.2.1.1 Security of data

The technical risks listed largely reflect the early stage of development of smart farming and big data applications in agriculture. Improvements against the listed technical concerns (better and more efficient data collection, storage and handling, improved skills, investment in infrastructure, and more accurate decision support) will likely drive adoption. At the most basic level, there is the need to have automated processes to ensure all data is secured through backup processes commensurate

with the value of the data. Increased adoption will support or encourage further investment in reducing the technical risks.

2.2.1.2 Data ownership

Newton et.al. (2020) report that *'realisation of the full benefits* [of smart farming technologies] *is constrained by (1) farmers' interest in and use of big data to improve farm decision making, (2) issues of data sovereignty and trust between providers and users of data and technology, and (3) institutional arrangements associated with the governance of data platforms.'*

The second and third constraints are mirrored in the social and institutional risks identified by Jakku et.al. (2019) (Table 1). Wiseman et.al. (2019) argue that 't*he lack of transparency and clarity around issues such as data ownership, portability, privacy, trust, and liability in the commercial relationships governing smart farming are contributing to farmers' reluctance to engage in the widespread sharing of their farm data that smart farming facilitates. At the heart of the concerns is the lack of trust between the farmers as data contributors, and those third parties who collect, aggregate and share their data.*'

Drewry et.al. (2019) assessed digital technology adoption and access barriers among crop, dairy, and livestock producers in Wisconsin, USA. They found the most significant barriers to adoption of digital technology included data privacy and security concerns as well as software and system compatibility and understanding how to use and derive value from the acquired data.

There are several global high-profile case studies that demonstrate the importance of establishing clear principles and guidelines with respect to data ownership and access (e.g., Carbonell, 2016). Loss of control of data could undermine a producer's competitive advantage and may push producers to store their data locally rather than through a third party or in a cloud computing environment.

'Regulations surrounding intellectual property rights is [sic] an issue as potential disputes between farmers and service providers may arise regarding the ownership of information. Ownership rights vary depending on how data are being collected and who is performing collection. For example, ownership and use of data generated using ground-based equipment owned by the farmer will be controlled by the farmer, except in the case of machinery operating data, which the equipment manufacturer may reserve ownership rights over' (GHD and AgThentic, 2018).

Disputes over data ownership could become a barrier to agtech adoption if one party is seen to be gaining commercial advantage over another party that believes they have some level of data ownership. *'For example, data on herd health might be used in campaigns to undermine farmers. Banks and insurance companies could use predictive yield data to determine whether to provide a loan or insurance.'* (ACIL Allen, 2018)

Wiseman et.al. (2019) surveyed 1,000 Australian producers from 17 different industries. Relevant findings from this study are shown in Table 2.

Table 2. Key findings from Wiseman et.al. (2019) relevant to producers and the adoption of agtech.

Findings	Implications
Farmers currently lack trust in the way in which their farm data is being collected and managed.	Therefore, if digital agriculture and data are to transform agri-food networks, trust around agricultural data access and use needs to be fostered.
In data licences between farmers (data contributors) and agricultural service providers (data users), there is a lack of transparency about the terms of use and hence how much control is being given to the service provider.	The lack of understanding of how much control is being signed away forms the basis for the lack of trust that farmers have towards some of the digital services and products on offer. Those farmers that better understand the licence conditions were more likely to agree to share data.
Farmers should be aware that ownership rights in raw data only arise if copyright law can protect the data, and copyright ownership can be signed away (lost) through contracts.	It is critical for farmers to look at and understand the contracts they sign with data aggregators. In addition to the use that a licensee might make of the data, consideration should be made of the possibility of further distribution over which the data collector may have no control.
Farmers are concerned at the lack of benefit sharing between data aggregators and data contributors, which reduces farmers' willingness to share data.	Despite this concern, farmers do benefit from the real-time awareness the data provides.

The following points are drawn from the Wiseman et.al. conclusions:

- Farmers' concerns over data licences have a direct impact on their willingness to share agricultural data, suggesting an impact on the adoption of smart farming and digital technology in farming.
- To facilitate data sharing, the terms and conditions of data licences must be made understandable and transparent. It must be clear who has access to the data, who benefits from the data sharing and how privacy will be managed.
- Raising the understanding of stakeholders of the issues around data collection, sharing and use is fundamental to ensuring better data management practices and thus contributing to 'smart farming' realising its potential.

Similarly, the primary recommendation presented by Jakku et.al. (2019) *'is the need to invest in building the capability of growers and farm businesses to be both informed data consumers as well as co-creators and curators of data, by involving growers and their trusted information and advisory networks in the cooperative development and trialling of these systems.'*

2.2.1.3 Data collection

The collection of raw data required by digital agtech is a critical first step. The challenge is how to gather it accurately, efficiently and at an appropriate scale for the intended use. Currently producers see data collection as an extra task or burden rather than an integrated component of production. In many cases mobile applications have been developed to provide real time data collection, but many producers still see that time as wasted when compared to more manual tasks. Autonomous data

collection through remote sensing and automatic capture does offer some benefits, however producers often lack the skills and fail to spend the time verifying that data. In contrast data collection is much less of a burden for feed lotters that routinely use data for decision making.

A further need is to encourage national and industry accepted data standards. A lack of standards slows adoption as producers assess which technologies can be made to work together (ACIL Allen, 2018). Currently agricultural data is fragmented and scattered across many locations and in a range of formats, often proprietary. Complying with agreed standards allows applications access to the data without requiring customisation for each data source. Standards also make it feasible to combine data from different sources. These data standards could include the agreed units of measurement (e.g., kilograms, hectares, AUD), and defined variables that allow different datasets to be linked (e.g., standardised livestock type descriptors (species, breed, sex, etc), livestock ID, property ID, date/time coding).

Data from a limited set of sources such as a single property is unlikely to contribute to an application with a high level of predictive skill. The challenge is then to persuade data collectors and custodians to share and combine / aggregate their data. This provokes the question of data ownership, who pays for the data collection process and who owns the services created. It also leads to an additional question of who owns and has control of the aggregated data and what elements of the aggregated data can be published or used for commercial purposes. In the case of the Australian livestock industries, the NLIS database is essentially a large aggregator of data.

Artificial intelligence applications that are being developed to assist in decision making are reliant on large datasets with their usefulness bounded by the extent of the training data applied. Those training datasets are often collected with more rigour and detail than normal farm data and as such there are limitations in the application of information (Smith, 2018).

2.2.1.4 Quality of data

Central to the usefulness of data is its completeness and accuracy. If critical parts of the dataset are not recorded, incomplete, or not in an accessible format, then processing and ultimately decision making is compromised.

Incomplete datasets might occur for several reasons including from physical losses (e.g. lost ear tags), from sensors failing temporarily (e.g. power failure, flat batteries) or from loss of internet connectivity. Reliability might be compromised by incorrect settings, dirt contamination or GPS errors (ACIL Allen, 2018).

The storage of data in different formats and in different locations limits the value that can be extracted. Big data and artificial intelligence (AI) applications thrive on large datasets covering the greatest breadth of possible scenarios. This is one of the compelling reasons for individual datasets to be brought together (aggregated) and stored in a 'cloud' service.

2.2.2 Overcoming the barriers to adoption

In recognition of the concerns about data ownership and use, there has been recent progress in creating codes of practice.

The introduction to the NZ Code of Practice states that:

> *Farmers will benefit from a highly innovative technology sector that delivers applications that are simple to use and access, which source the information they need without impedance and deliver value. The farm data code of practice provides a basis for primary*

producers to have confidence about those organisations that hold, manage, or move data pertaining to their farming operations across as many industry databases as required.

The (Australian) National Farmers' Federation 'Farm Data Code' (2020) was developed to address the primary concerns of farmers around the collection, use, and sharing of farm data and the benefits that flow from its use. (See Box 1. National Farmers' Federation Farm Data Code)

Box 1. National Farmers' Federation Farm Data Code

In February 2020, The National Farmers Federation released edition 1 of the Farm Data Code. The objective of the Code is *'to promote digital adoption in the farm sector, by ensuring farmers have confidence in how their data is collected, used and shared.'*

The Farm Data Code lists seven principles that providers must commit to and uphold in order to comply. Those principles are described under the following headings:

a. Transparent, clear, and honest collection, use and sharing of farm data
b. Fair and equitable use of farm data
c. Ability to control and access farm data
d. Documentation and record keeping
e. Portability of farm data
f. Keeping farm data secure
g. Compliance with national and international laws.

Stated benefits to farmers include:

- increased awareness and understanding of the ways in which providers are collecting, using and sharing their farm data
- a framework to compare providers and inform negotiations about data policies
- improvements to industry-wide data practices over time.

For service providers, benefits include:

- clear and agreed guidance on data policies
- a helpful framework to inform discussions with farmers about their data.

The purpose of this Code is to facilitate innovation in agriculture by ensuring farmers have confidence in how their data is collected, used, and shared. The Code does this by establishing leading principles for the collection and use of farm data. Specifically, the Code aims to:

a. raise awareness around the collection, use and sharing of farm data
b. improve transparency, clarity and honesty in the way farm data is collected, used and shared
c. encourage the fair and equitable collection, use and sharing of farm data in a way that benefits farmers and Australian agriculture
d. build trust and confidence in the way farm data is collected, used, and shared so that, where appropriate, farm data can be utilised in ways that bring benefits to Australian agriculture
e. allow flexible implementation so that providers can establish appropriate practices around farm data collection, use, and sharing.

(based on Farm Data Code / Edition 1. February 2020)

The objectives of the recently developed EU Code of Conduct on Data Sharing in Agriculture are to set transparent principles, clarify responsibilities and create trust among partners. Interestingly, the Code of Conduct *'attributes to the data originator full ownership and use of the data, as well as a leading role in controlling access to and use of the data from their business. The farmer Is also entitled to benefit from sharing his/her data and must give his/her consent when data are collected, used or shared in future. In particular, the code delinks the agreement governing the use of agricultural machinery from that governing the management and sharing of data generated by the machinery.'* (De Boe et.al., 2018)

Based on the reviewed literature relating to data issues, the following implications for adoption of digital technologies and agtech by Australian red meat industries can be made:

- There needs to be a clear understanding of who owns the data collected. Engage with regulators to provide a degree of security over privacy and misuse.
- Producers need to have confidence and assurance that data collected and transferred through digital technologies will not be used or aggregated in forms that impact on their ability to drive improved productivity and or profitability from the enterprise. Clear, concise and transparent rules of data acquisition and further uses need to be clearly defined and promoted. Lack of trust is a key barrier. It is likely that producers with lower confidence in the system will be reluctant to contribute any further data above that required for compliance or regulations.
- Provide an authoritative assessment of the value of the data to the collector and to aggregated datasets. Understand the cost of collection and offset this against the value created.
- Service providers and industry service companies such as ISC /MLA have a direct responsibility to ensure that all rules, obligations and further uses of data supplied into national data platforms are clearly articulated back to producers and to intermediatory service providers. Simply requiring the user to click an 'I agree' icon to signify consent to the terms and conditions of a license may be expedient, but it does not build trust.
- Data sharing and willingness to share data will be strongly dependent on the trust and confidence that producers achieve through the above points.
- Interpretability and interoperability of data in feed forward and feed backwards positions throughout the value chain are essential to extracting decision making outcomes. The greater focus that is placed on both these elements, the higher the investment in data and the faster the rate of reduction in perceived barriers.
- Encourage the development of data standards that enable multiple sources of data to be logically combined for those applications.

Several of these implications could be addressed by the adoption of the Farm Data Code or a variant of it.

2.3 Infrastructure

2.3.1 Description of the barrier

2.3.1.1 Connectivity

There are multiple key business case drivers for improvement in telecommunications (connectivity) (Leedham and Siebert, 2019). These include:

- *People* - The business has a duty of care to its staff and providing sufficient amenities to attract talented staff involves the provision of personal telecommunications facilities. Key amenities include access to training, education, health, and medical services in addition to personal Internet consumption.
- *Environment* - Care for the land is paramount to providing the food and water to maintain the desired quantity of livestock year on year.
- *Production* - Control and understanding of the key parameters and inputs to healthy cattle and maintaining the highest standards of animal welfare can provide efficiencies in delivery through early identification of concerns from birth to sale.
- *Profit* - The collection and analysis of production and environment data allows for smarter decision making and increased profits through optimisation of sale prices or reduction in expenses.

Connectivity is the principal supporting infrastructure need for agtech. Perrett et.al. (2017) report that most decision agriculture products are reliant on full or partial (e.g., offline mobile apps) internet connectivity. A lack of telecommunications connectivity can therefore directly negate a product's value proposition. While the value proposition might be recognised (i.e., the technology is known to deliver a return on investment), the product cannot be used due to poor connectivity.

Communications infrastructure in many rural areas is poor in both coverage and speed (ACIL Allen, 2018). Data services are relatively expensive. As a result, there has been slow adoption of internet functions (GHD and AgThentic, 2018).

Even with access to an acceptable internet service, there remain networking challenges within a property, and this is most acute on large remote properties. A barrier to sensor deployment can be the need to transfer data over long distances while using little power. Without this connectivity, decisions cannot be made immediately and there may be delays in adding the data to distributed ledgers (e.g., blockchain applications) and centralised data repositories.

The best value and return on investment will be achieved not by the choice of the telecommunications technologies installed, but by installing a communications system appropriate to the various applications, devices and ecosystems that are to be installed. The communications infrastructure is simply an enabler of improvements to core business activities (Leedham and Siebert, 2019).

2.3.2 Overcoming the barriers to adoption

Essentially, there are two possible solutions to connectivity deficiencies. The first is to find a connection option (albeit expensive in many remote locations) or to have an off-line mode available that allows transfer of data and information when connections become available. There are several satellite services being developed and deployed to provide services in areas not serviced by standard broadband services. With time, their coverage is likely to increase and their cost decrease.

In situations with intermittent connectivity, consider developing systems that capture and store data locally, before uploading as a burst or package of data when the connection is restored.

2.3.3 Case study

Box 2. Smart ear tags

The installation of property-wide connectivity enables new capabilities. An example is the use of smart tags on livestock.

Smart ear tags are an emerging agriculture specific trend, where sensor ear tags or collars are placed on individual livestock as a means of tracking the animal's health and location. These devices aim to provide real-time information on an animal's behaviour, temperature, and whereabouts, which is generally viewed through a web portal or mobile app. This information is useful for locating animals and tracking mob movements to reduce human effort to locate animals.

Individual animal health data is important as it is a method to identify potential health issues. This will reduce the number of sick livestock, prevent the spread of disease and in turn prevent economic losses. Producers can also make management decisions based on this data, for example, to identify injured animals and intervene at the earliest opportunity.

The method by which data is uploaded from the devices to the cloud will greatly impact the battery life of the device. Each type of device will have varying battery lives. The desired frequency of livestock status updates will also impact the battery life of devices.

Data can be transmitted to a portal by deploying a fixed network of wireless receiver stations, base nodes, or gateways. It may be possible to rationalise the network infrastructure to common areas or choke points, for example, covering all of the water troughs and setting alerts should cattle not be seen at any water troughs over a 24- or 36-hour period.

Cost is an important consideration for this application especially for properties with large numbers of cattle. In addition to cost, other barriers include infrastructure required to read the tags and process the data, and the current state of development of these applications.

Smart ear tags / Implants	
Strengths	Theft reduction Increased operation efficiency Increased location awareness of livestock Increased animal biosecurity
Weaknesses	Can be costly to purchase tags for all cattle Requires the development of infrastructure to read data in real-time Many providers are still in trial or developmental phases
Typical applications	Livestock health tracking Livestock location tracking Livestock behaviour tracking Heat stress tracking

(after Leedham and Siebert, 2019)

2.4 Policy and regulation

Agricultural policies may affect adoption in various ways including by changing relative costs and by incentivising adoption of technologies to demonstrate compliance with policy requirements (De Boe et.al., 2018).

Policymakers need to ensure adequate training is available for farmers and advisors to raise awareness of the impacts agtech could have on farms and beyond. Changing attitudes toward data-driven agriculture may be a key step. Agtech is a tool to aid decision making, but some farmers may not be willing to give up all decision-making power to the technology, or those with knowledge of the technology.

In addition, there is a need to facilitate collaboration and interactions within the agricultural innovation system and with information and communication technology experts in order to improve responsiveness to sectoral needs (De Boe et.al., 2018).

2.4.1 Description of the barrier

2.4.1.1 Policy and regulation

Clear policies and regulations are required to protect the intellectual property behind the development of agtech. These protections need to cover international as well as domestic domains. Without these protections, limited investment and innovation in agtech will likely inhibit adoption.

As indicated in the section on Data ownership, regulations and/or agreements are also required to govern the ownership of the data collected through agtech and how it can be used. Specifically, there is a requirement to address issues of privacy and confidentiality. In the absence of such regulatory oversight, there will be less sharing of data thereby limiting the value that can be created.

However, there is a public good rationale for pooling agricultural data to generate basic information for use by public and private stakeholders and to provide better-informed and competitive services valuable for society (De Boe et.al., 2018). There is the question of which types of information and derived conclusions can be left with the private sector and which need to be managed (governed) by public authorities. For example, should the detection of a disease outbreak be entrusted to the private sector?

2.4.1.2 Safety

Developments in robotics and autonomous vehicles for example introduce risks including liability for accidents that may not be covered either by current safety standards or insurance policies. These issues need to be addressed to protect both people and property. Without clarity in this area, adoption will likely be limited and possibly risky. Safe Work Australia standards need to evolve to cover agtech (ACIL Allen Consulting, 2018).

With respect to drones, the standard operating conditions required by CASA are premised on the need for public and operator safety. These conditions regulate the height and distance of drone flight and define the meteorological conditions for flight (ACIL Allen, 2018). These rules are currently under review and it is likely that agricultural businesses using drones will have to be licensed within the next 12 months starting in October 2020[3].

[3] https://consultation.casa.gov.au/stakeholder-engagement-group/proposed-remotely-piloted-aircraft-rpa-regulatory/

In addition, safety, trespass and nuisance, and privacy are necessary considerations in the operation of drones where interaction with neighbours or the public is likely (ACL Allen, 2018).

The use of 3-D printing is an example of agtech advancing ahead of the regulatory environment required to ensure its safe use. In addition to protecting intellectual property, there need to be standards in place to ensure 3-D printed replacement parts are fit for purpose.

2.4.2 Overcoming the barriers to adoption

Agtech developers should work with industry to develop clear and easily understood codes of practice for the collection, management and permitted uses of data, with particular attention to data ownership, and the maintenance of privacy and confidentiality. The goal should be to build trust and thus encourage adoption, rather than enforce a legal framework.

Both agtech and agricultural industries should work cooperatively with government to ensure a suitable regulatory framework is developed to protect both the developers and users of agtech.

2.5 Skills

Many producers lack the skills required to take up agtech. Those missing skills include an understanding of the technology itself and the skill or ability to operate and maintain the technology.

In addition, there is often a lack of technological expertise and associated support services in rural or remote areas. This expertise is needed to develop the technology, implement the technology and to manage it for the producer.

Bridging the culture gap between conventional producers and agtech providers (entrepreneurs) is vital to producers in gaining an understanding of the agtech, pushing the product development cycle forward and thus gaining adoption.

2.5.1 Description of the barrier

> *"Put simply, innovation requires a focus not just on the 'hardware' (that is, the new idea or technology) but also on the 'software' (the skills and knowledge required to use and derive benefits from the technology) and the 'orgware' (the formal and informal relationships and arrangements between stakeholders that are required to support the successful and sustained deployment of technology)"* (ACIL Allen, 2018)

2.5.1.1 Electronic technologies

Producers do not generally have the skills or confidence to install, troubleshoot and operate electronic devices e.g., internet of things (IoT) sensors, robotics (ACIL Allen, 2018). Mostly they require devices that need little more than to be physically installed in place and have power connected. Specialist installation including digital connectivity, calibration and troubleshooting often requires technological expertise, something which is often lacking in regional areas.

Without practical training, management of agtech is likely to be reactive, increasing the risk of outages or downtime (e.g., waiting for a technician, spare parts, specialist tools, etc.).

2.5.1.2 Digital technologies

The incorporation of digital technologies into on-farm operations requires a different set of skills to those traditionally associated with agricultural production. These digital literacy skills include the ability to operate digital systems including computers and microprocessors, the ability to manage and process the data that is collected, and then make decisions based on the information generated.

Many producers lack some or all of these skills. If convinced of the value of the agtech (see Value Proposition), the choice is to acquire or learn the skills required or to purchase the skills as a service. This decision will likely be driven by the perceived complexity of the system, the time available to the producer to undertake the learning activity, or the availability and cost of local trusted service providers.

In some cases, government regulations might require the operators of the agtech to be licensed. An example is the use of unmanned aerial vehicles (UAVs) or drones (see under Policy and regulation).

> *Adoption of emerging technologies by farmers is constrained by their ability to readily use the technology, or easily adapt their systems to accommodate the technology. When the adoption process is complex, lengthy, or expensive, farmers are not likely to participate (KPMG 2016).*

2.5.1.3 Agtech culture

Agtech is a new industry often developed by entrepreneurs and start-ups with different skills, networks, and areas of expertise. Unlike traditional research, development and commercialisation, their product's functionality starts small and grows iteratively driven by user feedback (Sarah Nolet and Cass Mao, 2018).

This innovation process is unfamiliar to producers who are generally accustomed to evaluating products only after they are fully developed by publicly funded R&D providers and road-tested by other innovative producers. This is frustrating to entrepreneurs trying to innovate in an industry unfamiliar with the emerging technologies and where they, the entrepreneurs, are separated both geographically and culturally from the producers from whom they need feedback.

2.5.1.4 Agtech maturity

An important consideration in the agtech adoption decision is the maturity and stability of the agtech itself. The rapid pace of development of agtech and the entrepreneurial nature of the agtech developer sector leads to higher levels of company turnover that are not typical within mainstream agricultural industries. Failure is part of the entrepreneurial process, whereas initial failure is often a considerable barrier to future adoption for producers.

Thus, the nature of agtech raises several questions:

- Will the developers be around to provide ongoing support, maintenance, and repairs?
- Is the product offering complete (or sufficient) now, or does it rely on promises of future development?
- Among products competing to provide a similar service, which will survive and continue to innovate?
- Is the agtech solution being offered mature or will future development orphan this product?
- Does this agtech comply with industry standards and thus support interoperability with other applications?

The paradox here is that larger companies tend to be more stable and more committed to seeing the agtech to maturity, but it is the smaller entrepreneurial companies, often driven by the passion of a few individuals, that forge ahead in the agtech space.

2.5.2 Overcoming the barriers to adoption

Training and educational programs around the use of agtech are likely to be vital to producers understanding the value of the agtech and thus increasing adoption (GHD and AgThentic, 2018).

Agtech companies '*need to focus on user experience and ensure they can provide commercially viable and high-quality service to their customers'* (GHD and AgThentic, 2018).

Entrepreneurs and start-ups might improve the uptake of their agtech by carefully launching into situations with a greater number of tech savvy users, for example, targeting Gen Z users who have only known a digital world. Training materials should also be developed in formats familiar to this audience making use of digital distribution and incorporating social media support.

Eastwood et.al. (2019) found that some advisors, faced with the introduction of data-driven smart farming, *'were positioning themselves in a data analysis role, and as expert users of the software. They were combining their knowledge of farming contexts with the data collected via smart technologies in a hybrid knowledge.'* This indicates adoption of a role of supporting farmers to achieve more from the tools '*rather than specifically being a promoter or barrier to technology uptake.'*

Eastwood et.al. (2019) suggest that advisory services may need to evolve '*to incorporate the transformation to data-driven smart farming, and analysis of the data, both with and on behalf of farmers.'* The absence of such services may well be a deal breaker for some technologies, especially those requiring the farmer to acquire new skills.

2.6 Social

2.6.1 Description of the barrier

2.6.1.1 Trust

Trust is an important component of any relationship and for producers and feed lotters to embrace agtech, they need confidence in the entrepreneurs and suppliers. This trust applies at a couple of levels.

First, producers will want to be sure the agtech they are adopting is secure, that their privacy and confidentiality will be maintained, and that they will get a fair share of the value created from use of that data (KPMG, 2016; Sarah Nolet and Cass Mao, 2018). This creates a paradox – users have a desire to keep their data confidential, yet maximum value is created when the data is combined (aggregated) with data from other sources and or shared along the value chain.

The second level of trust is with the technology itself. Most activities undertaken by producers and feed lotters involve them or their employees physically completing the tasks. Developing the confidence to allow agtech to independently and/or autonomously complete those tasks will likely need a personal relationship with the developers or with a trusted third party with experience using the agtech e.g. another producer, an advisor or consultant, or for the social media generation, an influencer.

Related to safety and regulations, new practices that employ agtech and replace existing trusted processes need to demonstrate an equivalent or better standard of performance. For example, 3-D printed parts need to have equivalent performance (e.g., strength, precision, tolerances, etc.) to the factory manufactured product.

2.6.1.2 Consumer and activist backlash

Some technologies have difficulty gaining traction because of fears raised by consumers and activists in the absence of a history of safe usage and or rigorous proof of fitness for purpose. Examples of challenged technology include genetically modified organisms (GMOs), gene editing, nanoparticles, and synthetic food.

2.6.1.3 Technology avoidance

Adoption of new technology can be disruptive, and so resisted by some producers. Content with their current management practices, they may not want or be ready for the disturbance associated with new agtech (Sloane, 2008).

The risk-averse nature of farming and producers is a barrier to adoption – for example, the fear that an error in technology could lead to the loss of a harvest or of income (KMPG, 2016).

Agtech is often promoted while still early in the development cycle. Experience of technology that has failed to live up to expectations is a deterrent to adoption particularly among older producers.

Blockchain is an example of a technology still in an early stage of development, mostly in the pilot stage (Sarah Nolet and Cass Mao, 2018; Williamson, 2019). Producers are wary of such technologies especially when the promise is for benefits to parties further down the supply chain.

In addition, the complexity of the technology and its operation can hinder adoption especially where this makes it hard for users to assess the benefit of the technology. The technology needs to be supported by manufacturers and support services to ensure it is being fully used (Sarah Nolet and Cass Mao, 2018; KPMG, 2016). Failures among the early adopters will likely have a significant negative effect on the adoption curve.

At a community level, the role of technology in reducing the need for labour may lead to a negative view of the technology (e.g., robotics) and thus hinder adoption.

Smith (2018) identified that there are also likely to be negative impacts from artificial intelligence. He indicated that more insightful decision making is likely to be a disruption to the roles and skills needed from producers. Therefore, such technologies may not be adopted as there is a fear that the capability of the producer is being diminished or replaced.

2.6.2 Overcoming the barriers to adoption

The IoT industry needs industry-wide data standards, protocols, and overarching regulation to ensure consistency and allow for interoperability between systems. The use of open standards enhances the interoperability opportunities.

Consumers are more likely to be receptive to the benefits of agtech if delivered by companies without a negative reputation. In challenging situations, launching with a respected partner could enhance the prospects of the agtech.

Complex technology requires significant support, particularly during the early stages of deployment. Manufacturers must invest in support to ensure any setbacks are remediated quickly before reputational damage occurs.

2.7 Technology

2.7.1 Description of the barrier

2.7.1.1 Ease of adoption

New technology needs simplicity for it to be integrated into existing farming and on-farm data / information / decision support systems. The benefits of the technology must outweigh the implementation cost and the disruption to often well-established management practices.

2.7.1.2 Additional R&D

For some new technology, an incomplete understanding of the technology may require additional R&D to increase adoption. As an example, while the practicalities of gene editing might have been

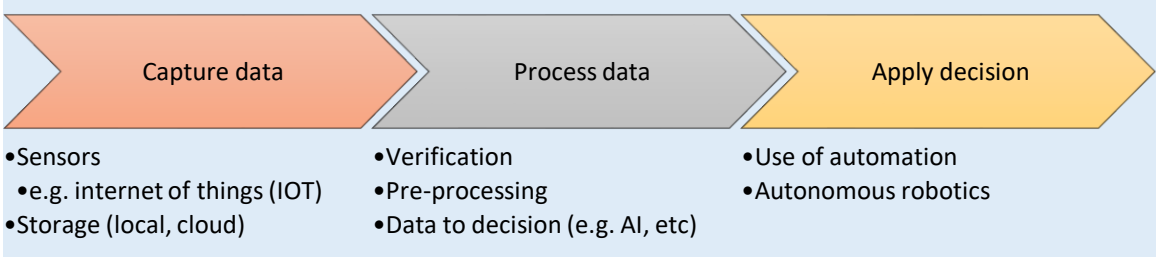
addressed, there is still the need to understand which genes influence which traits, whether those traits are economically important to the production system and whether the technology itself is likely to be consistent with consumer and community attitudes and expectations.

2.7.1.3 Interoperability

Entrepreneurs often develop a solution to a single problem and present it in isolation from other agtech. Producers need to share the data collected or processed with other solutions so that decisions can be formulated and actioned automatically.

A typical sequence might be as presented in Figure 2.

Figure 2. Schematic of the sequence from data capture through to application of a decision.



For this sequence to be seamless, each of the steps needs to be networked together to share the data. Alternatively, all steps can be integrated into a single application. An example of the steps being networked together is a drafting race where sensors in the race (RFID tag reader, weight scales, image analysis for wool length, dag score) pass their data to an algorithm that chooses which gates to open for that animal (based on desired characters) and the gates are opened automatically into defined sub-mobs.

The combination of image capture, analysis, and autonomous application of herbicide to recognised weeds is an example of all steps being integrated into a single application.

De Boe et.al. (2018) ask if there is a role for public authorities to try to consolidate initiatives or broker consensus or interoperability between different groups, to minimise repetitive entries and duplication of data, reduce risk of “lock-in”, and enable more efficient use of the information collected.

2.7.1.4 Useability

Critical to the uptake of agtech is the need for it to perform its task without the operator having to be an electronic engineer or computer scientist. However, inherently due to their nature producers will still want to know what it is doing and be able to adjust it. For producers to use a technology, they need to understand what the agtech is doing and have trust (confidence) in it. Often the inability to problem solve technology is a key barrier for producers.

In addition to understanding the technology, producers also need a commercial benefit from the technology that outweighs the cost of implementation including the inconvenience of any practice change.

2.7.2 Overcoming the Barriers to Adoption

A clear definition of the benefits of the agtech is needed – for example, increased profit (e.g., optimised selection of sale animals), reduced labour (e.g., increased use of automation), more efficient management (e.g., better-informed decision making), or improved comfort (e.g. remote operation of gates, watering points).

Adoption of open-system platforms rather than closed proprietary systems reduces the additional development activity required to combine the required components (e.g., sensors). Public authorities might consider a role brokering consolidation or cooperation between agtech groups to increase efficiency of the innovation process and of the use of the information collected.

2.8 Case studies

Two applications of agtech in agriculture are presented on the following pages.

The first is an app that supports producers, farm hands and truck drivers to deliver grain from farm to CBH (Cooperative Bulk Handling) sites. It is of interest due to a number of features, including that it:

- Coordinates the data between the producer, the carter and the receiver,
- Assists the user by pre-populating fields rather than requiring they be re-entered each time, and
- Is an acceptable form of documentation for transport authorities.

The second case study is for an app and tagging solution for tracking wool bales from farm to mill. While still at the pilot stage, this system offers an interesting approach to the cost of buying electronic tags and the scanning equipment. This involves the attachment of matched RFID tags and QR codes on each bale. On farm and in small wool stores where the cost of scanning technology is likely unjustifiable, a smart phone can scan the QR code. In larger wool stores and along the supply chain, there are significant savings to be had using scanners. The app allows the classers specification to be filled completely and legibly before transmitting to the broker or buyer.

Ideas and challenges for eNVD are noted in each case study.

Box 3. CBH CDF App

What is it? Cooperative Bulk Handling – Carter's Delivery Form in a mobile app.

Who is it for? Growers, farm hands and truck drivers delivering grain from farm to CBH sites.

How does it work?

The app is available for both iOS (Apple) and Android phones and tablets. Upon grower's initial log in, favourites will be pre-populated with information from crop estimates and / or previous deliveries including deliverers, properties, paddocks, commodities, and varieties.

Truck drivers and farm hands can add truck details (once they are registered with CBH) and the grower's deliverer number. The latter then allows their favourites to be populated with sites, properties, paddocks, commodities, and varieties.

Features

- *For Growers and Farmhands*
  - Pre-submit load details to the site before arrival
  - Paddock, commodity, and varieties are pre-populated in the app if crop estimates have been submitted or updated via Load Net
  - The app provides real-time notifications of arrival at site, sampling results and departure times
  - Set up notifications for load-by-load sample results, status of site services and opening and closing times
  - Generate real time reports on paddock weighted averages
- *For Truck Drivers*
  - Populate and submit a CDF (Carter's Delivery Form) using favourites in seconds
  - Set up sites as favourites for quick access
  - Add default truck configurations
  - Add details of deliverer customers including properties, paddocks, commodities, and varieties
  - Track the progress of a load around site
  - View delivery history and generate reports on demand
- A separate app has been deployed to support site-to-site road movements by transport contractors moving grain for CBH. Innovative features include in-app site induction and driver self-weigh for gross and tare weights.

Ideas for eNVD cast study.

- Pre-populate fields (or favourites) in the app with the user's data (e.g. ID, own PICs, destination PICs, species, breeds, livestock descriptions, details of previous transporters).
- Seek approval from authorities to accept the 'app' version of NVD as a valid document (like a digital driver's licence).
- App could be pre-populated with all NLIS/RFID tag details. The 'loaded' subset could be selected from these, with adjustments made crush side or at the loading ramp.

Challenges

- Transmitting the NVD data (and attachments) between vendor and transporter and ultimately the buyer. Where internet connectivity is not available, solutions might involve low range wireless (e.g. Bluetooth) or image capture (e.g. QR code) via smartphone camera.

Box 4. Electronic tags on wool bales and supporting app.

What is it? RFID tags and QR codes attached to wool bales during manufacture and supported by a mobile app

Who is it for? Operators along the wool supply chain

How does it work?

- Australian Wool Exchange is involved in introducing electronic tags on wool bales. It is currently at the proof-of-concept stage.
- Each bale has both a visual QR code and an electronic RFID tag attached during manufacture. The QR code and the RFID tag are matched.
- The purpose of the visual tag is that it can be read by a smartphone. *'There wouldn't be a shed around that doesn't have someone with a smartphone.'*
- In shed, they are testing an app to record the data that normally goes on the classer's specification for the bale. A web site might be easier to get adoption (less of *'not another app to download'*) and the technology is more mature, and easier to maintain.
- At the point in the supply chain that has fewest bales to scan, on farm, the capital investment required is next to zero. Further down the supply chain, in wool brokers' warehouses, the investment in scanners etc. is spread over many more bales. They also make extensive use of warehouse and logistics management machinery and software.
- Wool brokers generally like the system - the data comes to them clean, quickly, complete and electronically.

Some learnings from their developments

- The hardest part is getting producers involved. Once they (or classers) have learnt and used the system, they do not go back.
- Capturing the data electronically has been good along the supply chain - more complete capture, no missing data, better consistency, easier to read, rapid transmission and storage. Ability to reconcile bales against transport and invoicing docs.
- Applications need to be adjusted to ingest the data, but the fields are standard and as they were in the manual capture systems.
- Privacy of the data is a concern. Need to explain why it is being captured and who has access.
- The tools need to be intuitive in order to ease adoption.
- They need to be able to work offline (i.e. when no internet connection is available) because of the location of some farms/sheds.

Ideas for eNVD case study

- Highlight the benefits of capturing the data electronically
  - Data is legible
  - Data can be ingested directly into applications without transcription errors
  - Warnings can highlight missing or incomplete fields
  - Data can be transferred along the supply chain electronically.
- Copies of supporting documents can be attached.
- By using the same data fields as per the paper-based system, the integration with existing software systems should be easier and the training required by users is minimised.
- Standard fields can be pre-populated for quicker completion. Control lists can enforce standardised input.
- App could contain biosecurity and animal welfare guidelines to reinforce vendor and driver responsibilities (e.g. fit-to-load guidelines).

Challenges

- App needs to be operable in the absence of internet connectivity. This is not just capture of data, but also transferring data between stakeholders. Consider wireless or QR code options.
- Acceptance of electronic documentation by road authorities and police.

2.9 Drivers of adoption

Kuehne et.al. (2017) developed a model (ADOPT) for making quantitative predictions for the adoption of agricultural practices or innovations. In reviewing barriers to adoption, it is instructive to review the inputs included by the authors in ADOPT. A brief introduction to their conceptual framework is followed by a discussion of their inputs and how these might apply to adoption of eNVD.

They started by identifying two overarching factors influencing the adoption process: the relative advantage of the practice, and the effectiveness of the process of learning about the practice.

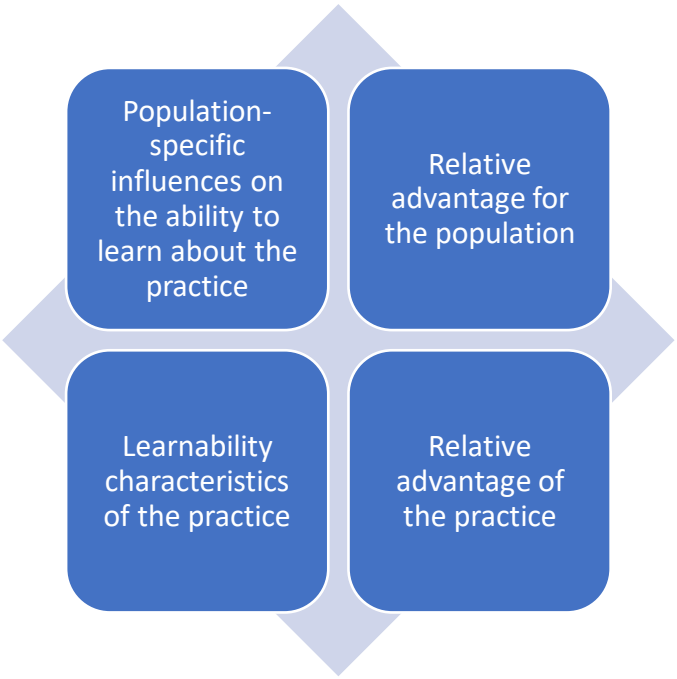
- *Relative advantage* is the main driver of how many in a population decide to adopt – it may be influenced by riskiness and cost.
- The *learning process* influences the time lag before decisions to adopt are made – it may depend on the observability of the practice and growers' access to extension services.

Kuehne et.al. (2017) maintain that several variables influence these overarching factors. The variables of their conceptual framework can be divided into two categories:

- Those that relate to characteristics of the target population.
- Those that relate to characteristics of the practice.

Combining these factors and categories gives the four quadrants of the conceptual model shown in Figure 3.

Figure 3. Basic conceptual framework used to model peak adoption level and time to peak adoption (after Kuehne et.al.)



A table of 22 inputs spread across the four quadrants was chosen for the model. Each variable was given a rating between 1 and 5. Those variables and the questions asked are presented in Table 3 with a note on how the variable might influence the adoption of eNVD.

Table 3. The variables chosen by Kuehne et.al. for inclusion in their ADOPT model and relevance of each variable to the adoption of eNVD

Quadrant	ADOPT variable	Question asked in ADOPT	Relevance of variable to eNVD adoption
Relative advantage for the population	1. Profit orientation	What proportion of the target population has maximising profit as a strong motivation?	Improvements in efficiency of operations provided by eNVD would likely be attractive to those motivated to maximise profit.
	2. Environmental orientation	What proportion of the target population has protecting the natural environment as a strong motivation?	A high rating might be associated with a tendency to support sharing quality and sustainability credentials.
	3. Risk orientation	What proportion of the target population has risk minimization as a strong motivation?	Those with risk minimisation as a motivation would likely need complete confidence in eNVD before transferring from the 'safety' of the system they know.
	4. Enterprise scale	On what proportion of the target farms is there a major enterprise that could benefit from the practice?	Larger enterprises are more likely to consider eNVD because of the efficiencies it can offer and the lower relative cost of the required hardware and software. Larger enterprises are likely to use the eNVD more often thereby reinforcing their learnings.
	5. Management horizon	What proportion of the target population has a long-term (greater than 10 years) management horizon for their farm?	Those operators with a long-term management horizon are more likely to invest time and money into learning and adopting eNVD
	6. Short-term constraints	What proportion of the target population is under conditions of severe short-term financial constraints?	Those operators under short-term financial constraints are unlikely to consider eNVD while a minimum viable alternative exists. To engage them would require a strong financial case with a short term (almost immediate) payoff.
Learnability characteristics of the practice	7. Trialling ease	How easily can the practice (or significant components of it) be trialled on a limited basis before a decision is made to adopt it on a larger scale?	If expensive equipment is required (RFID readers, new yards/drafting facilities) to trial or adopt eNVD, then adoption will be slower. Providing opportunities/processes to trial eNVD using minimal additional hardware and software would likely lift interest in trialling eNVD
	8. Practice complexity	Does the complexity of the practice allow the effects of its use to be easily evaluated when it is used?	Some operators will likely consider the digital version of an NVD more complex because of their unfamiliarity with digital systems. This is despite the eNVD completing much the same process as the paper-based version.
	9. Observability	To what extent would the practice be observable to farmers who are yet to adopt it when it is used in their district?	In small groups it should be easy to demonstrate the basic operation of eNVD provided the host is going to sell (or buy) livestock. Provision of demonstration functionality would allow for testing and assist trainers/demonstrators (Consultants, advisers, livestock agents, etc.)
Population-specific influences on the ability to learn about the practice	10. Advisory support	What proportion of the target population uses paid advisors capable of providing advice relevant to the practice?	Where a significant proportion of the target population use paid advisers, leveraging them through a train the trainer program might improve adoption.

Quadrant	ADOPT variable	Question asked in ADOPT	Relevance of variable to eNVD adoption
	11. Group involvement	What proportion of the target population participates in farmer-based groups that discuss farming?	Farmers learning from farmers is a powerful model provided the influential farmer has a good experience with eNVD. Early involvement, perhaps with incentives or subsidised training, of respected influencers is likely to be positive toward eNVD adoption.
	12. Relevant existing skills & knowledge	What proportion of the target population will need to develop substantial new skills and knowledge to use the practice?	Uptake of eNVD does require some computer literacy and personal confidence in the operator's ability to complete the task. Those with fair to good computer literacy are likely to adapt quickly, while others are more likely to need training and ongoing local support.
	13. Practice awareness	What proportion of the target population would be aware of the use or trialling of the practice in their district?	Higher awareness of local use is likely to drive interest in exploring the sue of eNVD. Local stories, case studies and field days could be used to raise awareness and invite trialling of eNVD. Demonstrations at saleyards is another opportunity that might connect with some of the more traditional operators.
Relative advantage of the practice	14. Relative upfront cost of the practice	What is the size of the up-front cost of the investment relative to the potential annual benefit from using the practice?	The level of up-front cost that is acceptable will vary depending on the scale of the operation. Providing pathways to adopting eNVD at different scales is likely important. The smaller operator will want a low-cost option (e.g., a smart phone app, or PC software) and will be prepared to enter most data by hand or scan with their phone's camera. Larger operators will want to capture more data electronically but are also able to spread the cost over a larger business and longer time frame.
	15. Reversibility of the practice	To what extent is the adoption of the practice able to be reversed?	While the paper based NVD provides a minimal viable alternative, operators can trial eNVD in relative safety. However, if they must invest in expensive equipment, hardware and software, then they are going to need greater confidence and reassurance before transitioning to eNVD's.
	16. Profit benefit in years that it is used	To what extent is the use of the practice likely to affect the profitability of the farm business in the years that it is used?	Simply put, if eNVD were to provide a demonstrable increase in profitability, then adoption will be quicker and more widespread. Scale of the operation is likely to impact on the relative benefit of adopting eNVD.
	17. Profit benefit in future	To what extent is the use of the practice likely to have additional effects on the future profitability of the farm business?	Larger operations will likely benefit from adopting eNVD more than smaller operations, if there is a profit to be derived from eNVD.
	18. Time for profit benefit to be realized	How long after the practice is first adopted would it take for effects on future profitability to be realized?	While there is a viable alternative to eNVD, uptake will likely be slow unless profit (or some other tangible benefit e.g., more efficient admin) is delivered early. Providing a clear demonstration of the benefit is likely crucial to adoption momentum.
	19. Environmental impact	To what extent would the use of the practice have net environmental benefits or costs?	There is probably little or no environmental advantage or disadvantage from shifting from paper to eNVD.
	20. Time for environmental impacts to be realized	How long after the practice is first adopted would it take for the expected environmental benefits or costs to be realized?	Likely not relevant

Quadrant	ADOPT variable	Question asked in ADOPT	Relevance of variable to eNVD adoption
	21. Risk	To what extent would the use of the practice affect the net exposure of the farm business to risk?	Improvements in compliance with NVD regulations/requirements (fewer errors, less transcription errors, faster exchange of information) may have provide a small reduction in business risk.
	22. Ease and convenience	To what extent would the use of the practice affect the ease and convenience of the management of the farm in the years that it is used?	Where infrastructure (principally connectivity) and capability (operator skill and computer literacy) exist, a case for use of eNVD is likely easier made, and more appealing in larger operations. Adoption is likely more difficult if any of those dimensions (infrastructure, capability, scale) are diminished.

3 Implications for eNVD from the identified barriers to adoption

Throughout the review of the literature and the identification of the seven thematic barriers to adoption, the impact of those barriers in the eNVD case study were considered and are summarised in the following sections. This summary provides some background rationale for the establishment of the rubric analysis criteria and some of the questions used during the consultation phase. The order of the summary is consistent with the seven theme areas.

This summary was also used to identify critical activities in the stage-gate adoption plan provided in section 6.6.

3.1 Value proposition – implications for eNVD

As there is a viable alternative to an eNVD, namely a manual or paper based NVD, the value proposition for eNVD must at least equal and more likely exceed that of a paper based NVD. Options for eNVD to provide a better proposition relative to a paper based NVD include:

- Improved data capture and transfer of NVD information.
- Reduced transcription errors.
- Near zero time between transmission and receipt.
- Integration of eNVD applications into existing livestock or accounting systems.
- Use of eNVD data to streamline livestock audits.

3.2 Data issues – implications for eNVD

Based on the data issues identified in the literature, likely implications for the eNVD are:

- Provide clear signals of who owns the data, how it will be used and what limitations on further use and aggregation are in place.
- Develop resilient off-line systems that ensure that data is not lost during temporary internet interruptions.
- Improve methods of data collection (integration with other on-farm software, improved tag readers etc)

3.3 Infrastructure – implications for eNVD

The collection and recording of NVD information often occur in locations with no internet connectivity or where the connection is unreliable or expensive. As a result, applications for completing and transmitting an eNVD should be capable of being operated in an offline mode with the completed data uploaded when a connection is available.

To meet regulatory requirements, a printed copy might need to be provided to transport operators. A more elegant solution could involve wireless transfer (e.g., Bluetooth) of the eNVD from smartphone to smartphone.

3.4 Policy and regulation - implications for eNVD

With respect to eNVD, the primary policy and regulation concerns are around data ownership, privacy and confidentiality and allowable uses. Developing clear statements supported or endorsed by industry bodies will be essential to developing trust and thus improve adoption and compliance.

3.5 Skills – implications for eNVD

Resources need to be applied to supporting users of eNVDs who have little or no experience or

confidence in using computers. The transition from a physical paper-based system to an eNVD that is completed on and stored in a computer is daunting for many first-time users. Apart from a carefully designed and refined user interface, with context sensitive help, other support services that might be needed include:

- Training courses (both local and online)
- Phone support
- Step-by-step training guides (preferably visual).

In addition, targeted training of local service staff (livestock agents, consultants, saleyard staff) who might be able to provide local assistance should be considered.

3.6 Social – implications for eNVD

Introduction of the eNVD should be facilitated by a service provider with a solid reputation. Uptake will be improved where the eNVD module is linked to or part of the management software being used by the target audience.

3.7 Technology – implications for eNVD

It is important that users both trust and have confidence in the eNVD platform. Apart from the data ownership, privacy and confidentiality, and rules around data usage, there is also the need for users to be comfortable that they can use the eNVD platform without losing data or making irrecoverable errors.

Having the eNVD integrated with other on-farm practices and information systems (farm accounting, livestock management) will ease adoption and present an advantage over the use of a paper-based approach.

Use of NLIS electronic tags and readers that allow animal ID to be recorded electronically will improve accuracy (fewer read errors, fewer transcription errors) and save time. For this to occur, confidence is required in the usability of NLIS electronic tags e.g., easily read, minimal losses.

4 Industry consultation

Following the detailed review of relevant local and international literature, as presented in section 2 of this report, interviews were conducted with stakeholders of the Australian red meat supply chain to:

a. confirm the relevance of the barriers found in the literature;
b. identify any further barriers;
c. better understand the process of adoption of agtech from the users' perspective;
d. understand their usage of and barriers to adoption of the eNVD.

Twenty-seven interviews were conducted with some individuals representing more than one role in the red meat supply chain (Figure 4). Interviewees included those who handled cattle/beef (19) and those who handled sheep/lamb (14). Six of those interviewees dealt with both cattle and sheep. The distribution of the interviewees by state/territory is shown in Figure 5.

Figure 4. Number of interviewees by role in the red meat supply chain. Some interviewees represent more than one role

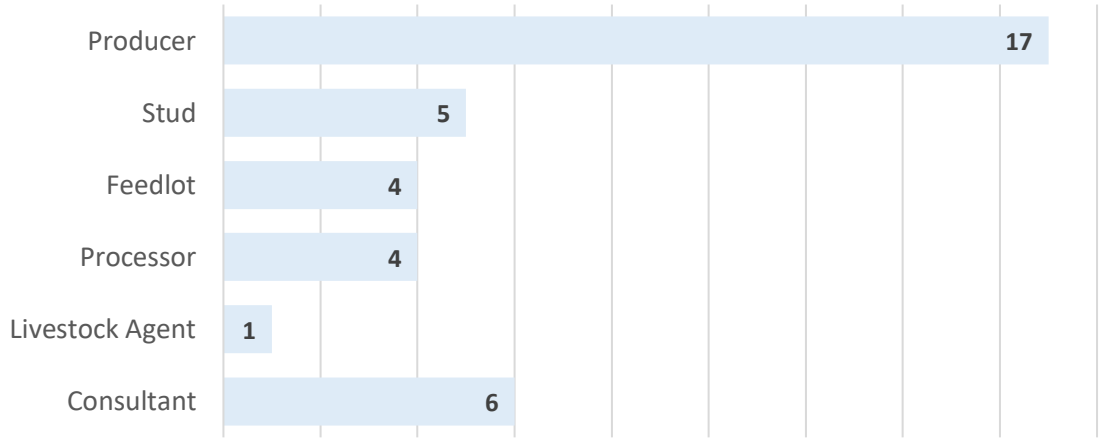
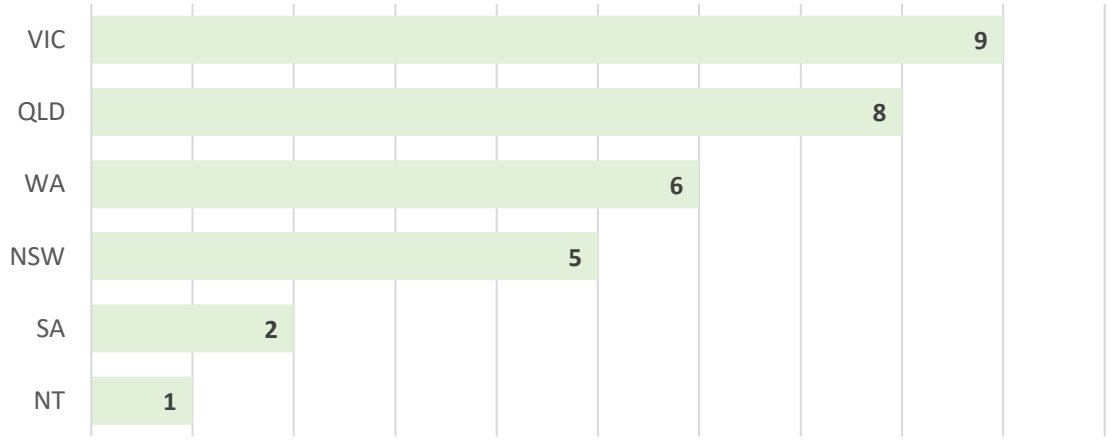


Figure 5. Number of interviewees by state or territory with which they are involved. Interviewees may be involved with more than one region



The interview process, while informal in nature, was guided by the underlying desire to gather input across six key topics:

- What agtech have you considered; how did you evaluate or choose it; what were the barriers to adoption of that agtech?
- Describe the barriers to adoption of agtech and possible solutions.
- Who should provide support for agtech? How and why?
- Who influences your agtech adoption decision and why?
- What other concerns do you have about adopting agtech?
- What motivates adoption of agtech?

The following sections present a summary of the observations recorded against each topic. Note the responses to the questions on the eNVD are included in section 6.

4.1 Key observations and findings from consultations

4.1.1 What agtech have you been considered; how did you evaluate or choose it; what were the barriers to adoption of that agtech?

When asked about the agtech adoption decision process, the responses provided could be grouped into either:

a. those that 'described a desired service, benefit, or capability they wanted to acquire' (Table 4), and
b. those that 'wanted to understand how the technology could be applied and evaluate (or measure) its suitability and benefits' (Table 5).

Some interviewees included responses in both groups. These responses are summarised in the following tables. Clearly, the adoption decision includes both.

Table 4. List of services, benefits, and capabilities expected from adoption of the nominated agtech.

Expected service, benefit, or capability[4]	eNVD apps	Digital scales and auto drafter	Walk over weighing	eID	Sensor tags, Biometric tags	Farm management software	Virtual fencing	Property mapping	Crush side data capture	WIFI connectivity
Supports improved management practices		✓	✓			✓	✓	✓	✓	
Supports improved individual animal management and animal welfare monitoring		✓	✓	✓	✓				✓	✓
Offers improved decision-making capability		✓	✓	✓	✓		✓		✓	
Offers improved accuracy		✓							✓	
Supports compliance with regulation				✓				✓		
It will save time		✓		✓						
Allows linking to other data				✓		✓				
Supports collection, recording, and storage of data				✓		✓				
Assist with farm assurance and audit requirements						✓		✓		
Supplied and supported by processor	✓									
It will reduce costs		✓								
Offers a 'Sense of competence'				✓						
Supports traceability				✓						
Supports tracking genetic performance				✓						
Assists in sharing data with other software, staff, service providers						✓				
Enables other Agtech										✓
Supports real-time data capture and access										✓
Enables communications (e.g. email, social media, support groups)										✓

[4] Only those services, benefits, and capabilities nominated by an interviewee are recorded for the nominated technology.

Table 5. List of evaluation processes and questions, by agtech considered, aimed at understanding how the technology operates and evaluating (or measuring) the benefit

Evaluation process or question[5]	Agtech (generally)	eNVD apps	Digital scales and auto drafter	Walk over weighing	eID	Sensor tags, Biometric tags	Farm management software	Water monitoring and pump control	Virtual fencing	Bunker management	Health diagnostics	WIFI connectivity across farm
Can this technology be seen demonstrated?	✓		✓	✓	✓					✓		
Can I try this technology on my property?		✓	✓	✓			✓					
Talk to other producers with experience of this technology			✓	✓	✓					✓		
Seek online info (specs, opinions, reviews, etc.) on this technology			✓									
Is good info from a trusted authoritative source available?	✓											
What is the value proposition?	✓		✓		✓					✓		
Will this technology lead to a saving in labour?	✓				✓				✓		✓	
Will this technology save time or improve efficiency?	✓				✓							
Will this technology increase income?	✓										✓	
What is the cost of the technology?					✓		✓					
What is the payback period?			✓									
Will this technology improve my decision-making capability?					✓	✓	✓		✓			✓
Does this technology support better information collection and reporting?							✓	✓				✓
Is there support to assist in interpreting the data collected?	✓					✓						
How does this technology compare with other options?					✓							
Does this technology provide improved accuracy? Is this technology better than 'eye-balling'?			✓	✓								

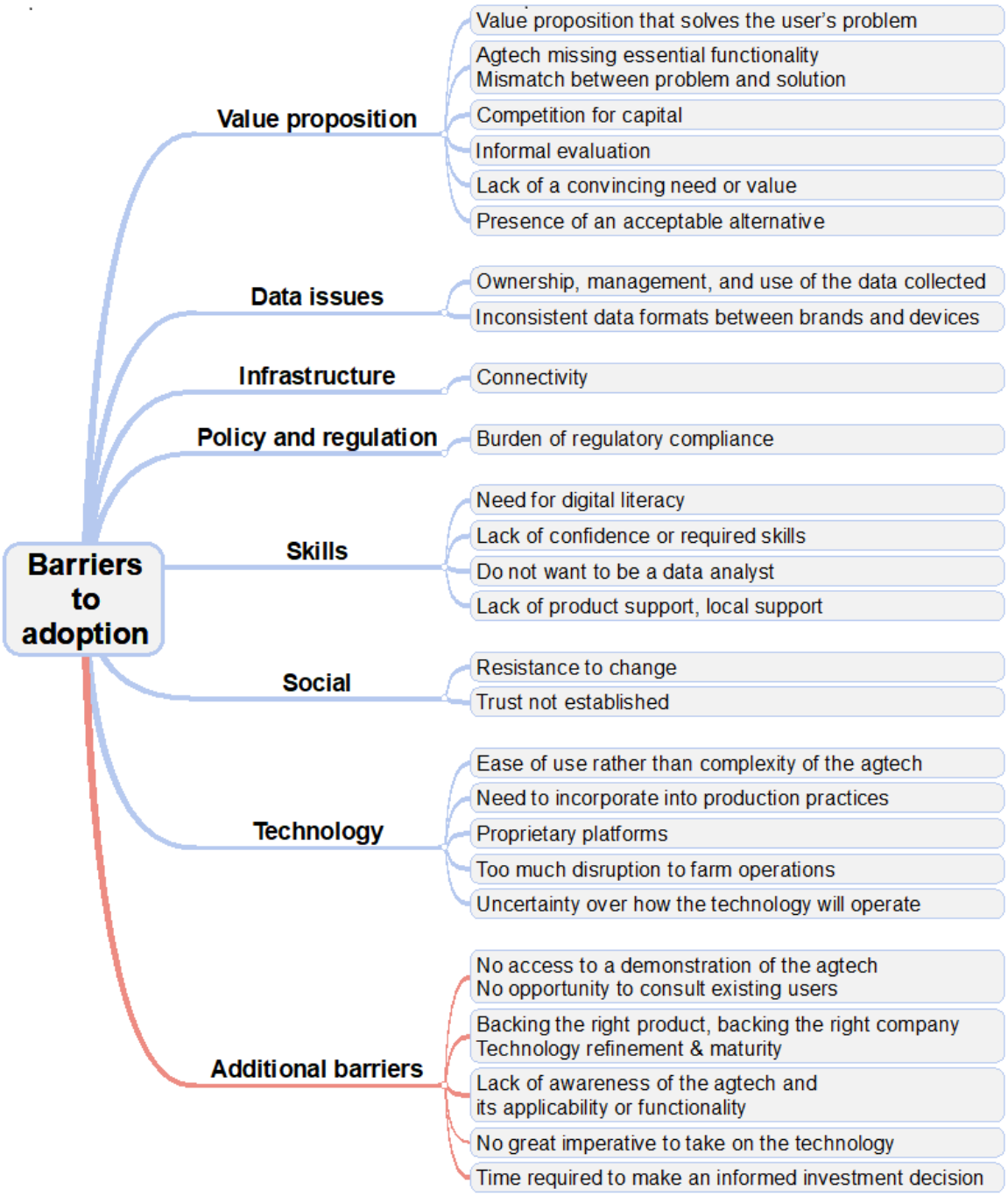
[5] This table reports only those combinations found during the consultations. Other combinations may have been reported if additional stakeholders were consulted.

Evaluation process or question[5]	**Agtech (generally)**	**eNVD apps**	**Digital scales and auto drafter**	**Walk over weighing**	**eID**	**Sensor tags, Biometric tags**	**Farm management software**	**Water monitoring and pump control**	**Virtual fencing**	**Bunker management**	**Health diagnostics**	**WIFI connectivity across farm**
Does this technology support compliance with regulations and or audits?					✓		✓					
Does this technology work first time?	✓							✓				
Is this technology easy to use, without unnecessary complexity?							✓	✓				
Is this technology supplied by other stakeholders (e.g. processor)?		✓										
Can I encourage the developers to trial this technology on my property?			✓									

4.1.2 Describe the barriers to adoption of agtech

From the literature review described in section 2 of this report, barriers to adoption of agtech were categorised under seven key themes (see Figure 1). During the consultations, this set of themes was confirmed with examples of barriers identified for each of those themes (Figure 6).

Figure 6. A summary of the barriers identified during the stakeholder consultation phase grouped by the key barrier themes identified from the review of literature. An additional five barriers that do not easily fit under the original seven themes were identified



A further five barriers were identified from the literature review (also identified within the consultations) that did not easily fit under the original seven key themes. These ungrouped additional barriers are also shown in Figure 6.

The barriers shown as the terminating leaf of each branch in Figure 6 (right-hand end) are described in the following table, along with any solutions that were suggested.

Table 6. Barriers to adoption of Agtech identified by stakeholders along with some suggested solutions. For some barriers opposing views were provided indicating the diversity of opinions and priorities held by the stakeholders interviewed

Barrier	Description	Solutions
Value proposition		

Value proposition that solves the user's problem by:
• **making money**
• **saving money**
• **saving time**
• **reducing labour**
• **making life easier**
	• Value proposition is critically important. How much money will it make, or how much will it save? This may have to be worked out for each use case as they are different and will have different acceptance thresholds.
	  ○ Corporates are likely to undertake more systematic economic analyses and have thresholds for metrics like ROI or payback-period.
	  ○ Smaller operations (e.g., family businesses) will still want to know the value proposition but may be less analytical in the evaluation. They are more likely to talk to others, ask if it makes money, and rely on others to do the testing.
	• Margins are low so very price sensitive.
	• Unless the new information extracted from the agtech can be incorporated into production practices, then there is unlikely to be a viable value proposition.
	• Is it going to make my life easier? More important than the dollar value. Motivation is not driven by profit. More about labour or time saving. Looking at intrinsic properties of the agtech.
	• Does digital technology add anything to my place if I sell it?
	• Many digital technologies do not stack up against 'physical improvements' (laneways and water points etc.)? *'I still have much more to improve, $300 /ha for pasture improvement, but I expect to get $1200 in beef in 12 months.'*
		• Need to publicise the agtech in a way that explains the value proposition, then provide support during evaluation and adoption.
		• Provide transparent financial analyses preferably from an independent, authoritative source. Support with a financial model (spreadsheet, web, app) that can be updated with user's own costs and prices.
		• Document the non-financial benefits, and include the other requirements e.g., skills or services required to use the agtech, necessary adjustments to farm practices, etc.
		  ○ Corporates are much more likely to adopt for inventory control and for measuring performance.

Agtech missing essential functionality. Mismatch between problem and solution	• Some essential function is missing, not working or only promised.
	  ○ Example: Inability to attach required documentation/ certificates to eNVD (e.g., pink tag exemption).
	  ○ Export NVD required for slaughter declaration to Vietnam that had additional requirements that were not linked to eNVD.
	• Agtech companies not understanding the business and the space of agriculture resulting in impractical products.
		• Developers should work with early adopters to make sure scope of product meets users' requirements.
		• There needs to be a commitment to continue development and support of product. Incomplete or abandoned products are a risk to reputation and future adoption.

Competition for capital	• Capital for investment is limited. • Financial position and opportunity cost influence adoption. The view is that generally, you get more monetary return from physical improvements. Need to evaluate infrastructure costs including for agtech. • Concern over recurring costs of agtech (licence fees). These are an operating rather than capital cost.	• Describe a clear value proposition that stacks up against other investments.
Informal evaluation	• In small or family businesses, often evaluation is done on a *'feel for the benefit*'. As a result, other people's opinions or actions may influence the decision. • Trialling the technology and seeing it used elsewhere is often the primary evaluation.	• Clear, targeted promotion is needed from a trusted authoritative source. • Opportunities to trial or see the agtech in use are very important to producers.
Lack of a convincing need or value	• Having a reason to adopt. Something that solves a problem and can be incorporated into the management program. • Something that increases income or decreases cost (labour) • Technology must have a value add, making it easier or making money.	• Need to publicise the Agtech in a way that explains the value proposition, the benefit to be gained, then provide support during evaluation and adoption
Presence of an acceptable alternative	• An acceptable alternative, especially if it is the current practice is a major barrier to adoption of the new technology. • While there is an acceptable alternative, the value proposition must be based on the marginal benefit.	• Document and demonstrate the benefits – financial, safety, accuracy, etc. • Highlight the advantages over alternative.

Data issues		

Ownership, management, and use of the data collected	• There is some concern over the use of the collected data for other purposes. This relates to a loss of confidentiality and trust, and a fear of the data being used against the user.
	• Data ownership is far from clear in some cases and this ruffles feathers.
	  ○ Producers less likely to care, though there is an issue when they have to buy their 'own' data from service providers.
	  ○ Processors are extremely cautious about providing data to third parties for additional analysis or to make money.
	• Handling data is a key issue. A lack of data portability and difficulties transferring data between systems.
	• Adopting of digital technologies requires upgrading systems to handle larger and more complex data sets.
		• Clearly stated agreements regarding the collection, ownership, management, and use of data is required. These agreements need clearly explained privacy and confidentiality provisions.

Inconsistent data formats between brands and devices	• Need to work on the basics. Example is changing wands and having format differences between wands and not having lifetime records due to wand changes. • Getting harmonisation of data formats between devices as an industry standard is an imperative. See format of the NLIS number across different platforms.	• Requires industry standards so data can be transferred between devices so data (e.g., life history) is not lost.
Infrastructure		
Connectivity	• Connectivity is a major barrier for adoption of some Agtech. Primarily access to the internet. It is still an issue for many producers, especially where the Agtech is dependent on access at the point of use. For example: ○ eNVD. Must be done using a mobile signal. It must be available crush side, must have flexibility and be able to be used across all staff consistently.	• Solutions that have an offline mode. • An expensive solution is to expand coverage to relevant parts of property or seek satellite solutions. • Options are becoming cheaper; need to assess if the connectivity is needed or just nice-to-have. • Blockchain is a technology that requires solid connectivity. If the value is high, then can pay high costs of connectivity but must either increase

	○ Site wide access. This is a difficult space for non-technical specialist to navigate. Should not need to be a digital communications expert to evaluate options. '*Did investigate but cost of covering farm with Wi-Fi was too high (~$7k).'* ○ '*Some neighbours have Wi-Fi installed. I'm waiting and watching to see how they go, what the benefits are, and see if the technology evolves or improves. Also see if the manufacturers and distributors survive. It seems to be a crowded space and not all are likely to be around in the future.'* • Cost of increasing demands for connectivity is a real issue. Miles away from national standards of connectivity. • Many are reluctant to invest in connectivity solutions as they see that as competition for time spent on farm.	production or reduce costs. Higher animal value will drive adoption of technologies if prices are maintained. • Providers need to build confidence in their solution and longevity "I prefer to wait and invest with someone who will be there in the future." • National standards for connectivity required.
Policy and regulation		
Burden of regulatory compliance	• Less is better. • "Standards" are important. Having consistency through a common language and through data standards is vital. • Compliance can be onerous. Part of the reason for trying farm software was to assist with audit compliance. • Yes, [regulation] has a big impact. See NLIS, LPA etc. • Should be very important, but often producers see regulation as an impost and are reluctant to do any more than the minimum requirements.	• It is essential that Agtech where appropriate tries to minimise the costs associated with regulation or ensure that compliance with such regulations is straightforward and transparent.
Skills		
Need for digital literacy	• Digital literacy is a barrier, especially for those who have not grown up with computers. • Some producers need assistance to use their computers (Excel, handling data files, Zoom) and connect to the agtech. This can	• Basic training is needed because they do not know where to start. • Training – not just online modules as accessing these can be a problem due to limited connectivity.

	be a barrier especially in the face of social pressure and embarrassment. • Digital technologies are different to traditional technologies. Mostly there are different skills to be learned (or bought in) and they result in changes to current management practices. • *'Older generation might be more receptive. Younger people make active choice not to engage with technology.'* • The lower the age the more adoption will occur. Will not get a higher technology adoption phase until there is a generational turnover. • Some agtech is not used often enough and so they forget how to use it, and soon stop using it.	• One-on-one support when starting with something new, or when experiencing great frustration. • The technology has to be simple to use and for infrequently used applications, provide guidance on how to proceed. Complexity will stifle adoption in all but the most 'digitally' fluent.
Lack of confidence or required skills	• Need training, particularly for software systems and getting data between systems. [This is co-related to the digital literacy barrier.]	• Provide the basic training required to gain confidence and benefit from the agtech.
Do not want to be a data analyst	• Do not want to analyse data. Must a have clear reason to collect the data - that is it must inform some decision. • Have got access to soil moisture probe but does not use the data.	• The adoption process must go well beyond the purchase or installation of the shiny new hardware. It needs to incorporate all the steps from turning on the technology through capturing data and transforming it into a decision that has practical application. • Consideration should be given to utilising a service provider. Establishing a network of qualified providers may be a critical step toward adoption. • Will rely on the private consultant to make informed decisions and guide investments.
Lack of product support, local support	• Things do go wrong, they fail, and communications fail. Knowing how and by whom these events will be solved may be critical to adoption of some Agtech. • Service response times and delivery of updates and new functionality is another consideration. • Tyranny of distance – getting support for complex technologies is often a problem. New technologies are reliant on the	

	developers for support. Need to do the commercialisation (communications, support, etc.) better.	
Social		

Resistance to change	• Reluctance to change is a key issue.
	• *'Within the supply chain 20% will adopt straight up, the remaining 80% is the challenge.'*
	• eID the barrier: When eID was made mandatory in Victoria, there were all sorts of complaints and reasons why it would not work. The livestock agents were most vocal.
	• Cost of change inhibits adoption.
	  ○ e.g. NLIS – requires structural changes to existing systems – what is the value proposition? Changing a working system means identifying the marginal benefit.
	  ○ Will not move to other alternate NLIS forms unless they are compatible with the current system
		• eID the solution: By carefully working with a few livestock agents and ironing out the issues, after 12 months they became the most vocal supporters. They found how good it was – can scan a mob easily, can process transfers without the manual tag reading. Reconciliations are a breeze.

Trust not established	• People want to have trust in the current system first. • Producers tend to trust opinions of other producers.	
Technology		
Ease of use rather than complexity of the agtech	• '*Most people do not want increased complexity. Keep it simple, though simple varies between individuals.'* • Provide ease of use, but with flexibility to cope with actual scenarios. • Ease of use is number one barrier. Agtech needs to be simple and applicable across all the company employees. Needs different levels within the technologies. • Agtech (e.g. eNVD, farm software) just must be easy to use. '*Complexity kills every time. While the manual approach works and is easier, it is hard to commit to the expense, the learning, the disruption and the risk of changing to a digital system.*'	• It is better to be able to have both 'basic' and 'complex' versions so the user can start simple and build up as they gain confidence and familiarity.

Need to incorporate into production practices	• Digital technologies are different to traditional technologies. Mostly there are quite different skills to be learned (or bought in) and they result in changes to current management practices. • There is a need to understand where and how the technology fits in the business.	• Trialling is a big part of adoption. Need to evaluate under extensive commercial conditions.
Proprietary platforms	• Proprietary platforms prevent modification and integration with other applications. Compatibility across platforms or applications is therefore critical. • Multiple technologies do not always work together. The problem arises trying to integrate different standards and different proprietary platforms.	• Encourage development and support of open platforms, or open standards for data interchange.
Too much disruption to farm operations	• Similar to resistance to change, adoption will be impeded if there is too much disruption to farm operations. The disruption can trigger a flow on to other operations and disturb resource allocation. • It just must be easy to incorporate in to farm practice.	
Uncertainty over how the technology will operate	• *'One cannot fully comprehend how the Agtech will function from brochures, internet, conversation.'*	• There is a need to see the agtech in operation on another farm or at a demonstration site. Try before buying. Encourage developers to test on farm. • Undertake more trialling. • Test on own property is critical.
Additional barriers		
No access to a demonstration of the Agtech. **No opportunity to consult existing users**	• Peer review and testing. Whether it has been tested in a commercial environment. • *'Trialling and other producers demonstrating a technology is fundamental.'* • Must have producers willing to share information and experiences. There is a fear that if things do not work then failure is seen as issue. • Would talk with other producers and like to see technologies in use before purchasing. One of the extension groups had a	• Need demonstrations, either fixed or temporary. Preferably independent of those distributing or developing the agtech. • Suggested there should be demonstration sites in each state (e.g., at state research facilities) that show different brands of auto drafters – these should be shown in a live demonstration at field days – run 150 sheep through each one so they can be seen operating.

	company representative demonstrate it and explain the capabilities of their products. • Would need confidence that [the technology] will work. Best seen through demonstration and talking with users. Did this at a NT demonstration farm. Uses personal network to learn about it.	• Need to publicise the agtech in a way that explains the value proposition, then provide support during evaluation and adoption. • Producers generally learn best from others – seeing the agtech demonstrated, talking to existing users, trialling the agtech on their own place.
Backing the right product. **Backing the right company.** **Technology refinement & maturity**	• Big issue is the stability of the provider, too many examples of Agtech companies moving to other systems and early innovators being left without support. • *'Often there are competing products essentially doing the same thing. The problem is knowing which one will be around so your invested does get grounded. Do you buy VHS or Beta-max? Will this brand of drone survive?'* • Technology has been disappointing; many software companies have fallen by the wayside. • Too many players emerging – difficulty picking the winner. • No, I do not want to be a leader… will invest after technology is mature.	• Continue development of product. Incomplete products are a risk. • Do not be the innovator, be the early adopter. • Developers may have to set up demonstrations to get it started. Use industry networks to seek out the early adopters/risk takers.
Lack of awareness of the agtech and its applicability or functionality	• Awareness of agtech or its options can be a barrier to adoption. *'I did not know that {software} has an eNVD module.'* • Did not know there was an eNVD mobile app (more than one) • There is a real lack of enablers out promoting the technologies. Not enough people trialling technologies that are willing to share information both positive and negative. • Real challenge with on farm connection. People lack connection with people that advise them on change. • Refer to the cropping industry and the role that agronomy consultants provide in Agtech adoption. People in the livestock industry often do not have a strong understanding and there is a lack of extension. Need to find a new type of enabler to help facilitate evaluation and adoption. Seeing accountants and financial advisors starting to enter consultancy market. Industry	• Cannot adopt what you do not know about. • Need to work on novel and new extension platforms. • Real push from MLA to improve awareness and adoption. • Work on trialling systems first.

	will need to engage to that sector of the industry in generating knowledge of Agtech and particularly the Practical agricultural knowledge that exists within NAB, Rabo etc. Who engages with these people in agtech innovation if a key adoption target for consideration?	
No great imperative to take on the technology	• *'[Many] producers are complacent and do not need to exact maximum value. Producers do not need every last dollar.'* • Producers do not need to go outside their comfort zone. *'[Saving] time and energy are motivation to change. Achieving a goal is expensive. Changing scale is easier than changing technology. [Where it is] more intensive in the south, they might change technology.'*	• Technology must be very applied. People will put effort in if it is a simple practical process. • People have become immune to all the new technologies being pushed toward them.
Time required to make an informed investment decision	• 90% of producers do not have time or capacity to invest. • *'Mum and Dad operators don't have time to invest in technologies.' There is* no active decision-making process, nor a skill set to make decisions. They do not do feasibility studies and then firm up assumptions. • Education and time are a real issue. Do not have time to invest in the new technology nor in the logic of the new technology.	

4.1.3 Who should provide support for agtech? How and why?

As identified in the literature review, successful adoption of agtech generally requires support to upskill the users of the technology and to service and repair the technology.

Interviewees provided a range of responses when asked who should be providing that support. While local support is preferred because of the proximity to the installed technology and the likelihood of reduced response times, the reality is that such support networks are unlikely to be available for a large proportion of new technologies.

Table 7 lists the support providers suggested and the justification for those suggestions. It is evident from this list that a range of support providers are required to cover different phases of adoption and use.

Table 7. Who should provide support for agtech adoption?

	Justification
Developer	• Initially, it should be the developers or service providers trained by the developers that should provide support. This is an opportunity for developers to learn from full-time commercial operators and extend their learnings beyond pilot or demonstration usage. Often the developer is not aware of the practical problems the producer faces nor the challenges of integration with other technologies. • A transition to local support should follow as uptake of the technology expands.
Distributor	• Local support is often critical. Local distributors will have better knowledge of how the Agtech is being used in their area and so able to support their existing and potential customers. It may be an opportunity for them to develop additional skills and deliver a new service. • With agtech, there is likely a need to bridge the wide gap that more often exists between the digital literacy of the developer and that of the end user.
Consultants or independent service providers	• Many potential agtech adopters will desire advice that is authoritative and independent i.e. not from someone who stands to gain from a sale. • Often there are new skills required – either these need to be developed by the producer, processor (e.g. operating the agtech, collecting, distributing, and analysing the data), or they can be purchased/contracted.
Other producers	• Producers tend to trust and value the opinions of other producers. Once adoption commences, recruiting existing users as advocates is a powerful way of spreading the message and in some cases providing support. • Social networks influence producer decisions. Word of mouth is key to innovation and early adoption.
Industry bodies	• There has been a real push from MLA to improve adoption of the outcomes of R&D. Through their extensive networks, industry bodies can play a vital role in raising awareness of a technology (a precursor to adoption) and in providing independent review and analysis. They are also able to produce and deliver commercial case studies, an approach that resonates with producers, especially if there are similarities between the case study scenario and their own production system.

State Departments of Agriculture	• State department properties (research stations, demonstration farms, etc.) could be used to trial, compare, and assess technologies. • This would allow many producers to interact with the technology at scale, and to compare each option operating under the same conditions. An example might be the use of eID, digital weigh scales and auto drafters. • Developers could use the facility to demonstrate their technology and show how it integrates with other devices.

4.1.4 Who influences your agtech adoption decision and why?

In addition to asking who should provide support for agtech adoption, interviewees were asked who else might influence their decision to adopt agtech. Apart from the provision of support, training and service functions, there are other groups that influence the adoption and use of agtech.

As highlighted in one interview, *'if another sector needs some data recorded, then it will be done (to the minimum requirement). If a digital solution is better (cheaper or quicker or more accurate), then it will likely be adopted rather than relying on 'pencil and paper'*.'

Within the younger generation, '*… definitely peer influence is strong.*'

Other influential groups are listed in Table 8.

Table 8. Who influences your adoption decision?

Influencer	Reason
Processors (and other supply chain partners)	• Where an agtech is necessary to conform to a processor's or brand owner's requirements (and perhaps receive an incentive such as priority delivery, or a price premium). • Processors want sustainability modules to get market access. All the basic things that underpin beef rely on market pull through from processors. • However, the opposite may apply. For example, '*… if eNVD is not used by works, why would a producer use it.'*
Saleyard requirements	• Livestock buyers and sellers might consider some technology if needed for dealing with saleyards. For example, software to exchange data on livestock being sold, or on the lots purchased.
Corporate client	• Very demanding of data. Often corporate producers are much more likely to adopt digital technology to either collect data or to share data with key financial elements within those businesses. More often CFO and COO aspirations drive agtech adoption.
Other producers	• The practical experiences of other producers are a key component in assessing a new technology. Their experience and opinions are important. • Seeing a technology operating in a commercial environment and being able to ask producers what works and what does not is valuable if not essential for most agtech adoption. • Just knowing or learning that other producers are getting value is persuasive.

Influencer	Reason
	• Trialling with other producers. Letting other producers make decisions. Often producers look to other producers within a defined sphere of influence and will let other group members invest in technology. Those producers (and to a limited extent feed lots) will not invest, unless technology is trialled and proven within the group. • '*Seeing the technology in operation builds trust. It opens the mind to what can be achieved. Seeing technology on this property has stimulated other people to adopt. Education is a huge part of the technology adoption phase and understanding.*'
Consumers	• Consumers definitely do influence attitudes towards innovation and consideration of agtech adoption. A key example that was cited is the increasing focus on remote sensing for environmental elements such as carbon, ground cover and natural capital. Producers are perceiving that consumer trends are likely to impact on access to future markets and capital and are making intermediatory investments to obtain base line data for the future.
Our accountant	• Often the business or family accountant also has a big say. '*If it doesn't reduce debt or increase capital value, then it is a low priority.'* • In a couple of scenarios, access to capital was measured by the bank and that influenced direct investment in elements that improved net worth rather than agtech.

4.1.5 What other concerns do you have about adopting agtech?

In addition to asking about barriers to adoption of agtech that the interviewee had considered, they were asked about any other concerns they had about adopting digital technologies. This was undertaken to determine if there were more general issues, not related to a specific technology, that inhibited consideration of digital technologies.

The responses from this discussion are grouped in the following table (Table 9) by the same themes used to group barriers (see Figure 1 and Figure 6).

While many of the concerns are related to already mentioned barriers, some additional barriers were identified:

- *Market fluctuations dwarf agtech benefits.* Often the benefit of the agtech is quite small relative to the market fluctuations that apply to users' products.
- *Develop or purchase data storage capability.* Establishing data storage infrastructure is often a completely new practice to be undertaken when adopting agtech. Most producers intuitively relied on the technology provider to store and backup data.
- *Pride and reputation of workers.* Social issues around the pride and reputation of workers is a concern where the adoption of agtech 'dumbs down' the role of workers. This may result in a poorer understanding of why a task is done, leading to adverse outcomes e.g. food safety risks, reduced compliance.
- *Agtech is not always better.* Sometimes the capital cost of the agtech cannot be justified, particularly where the scale of the farming operation is relatively small.

Table 9. Other concerns about adopting digital technologies raised during the consultations.

Concern	Description
Value proposition	
Save time and reduce workload	• For agtech to be adopted, there must be a process that requires less time than the practice takes now and provide additional information and less workload. Agtech innovation cannot require more work.
Need an effective screening and assessment process	• Another key barrier is that we do not do a benefit-cost analysis and then a trialling phase. Do not have an effective screening and assessment process. • Must find digital technologies that address the demands of current issues.
Marginal benefit	• Pricing system is a key barrier as can get market fluctuations of $100's per animal and technologies are talking about a $1-5 benefit.
Data issues	
Data misuse	• Concern over the use of the producer's data for purposes other than those agreed to by the producer.
Infrastructure	
Agtech enablers	• Connectivity is needed to enable access to digital technology. In addition, there is a need for a data repository, something new to most in agriculture.
Skills	
Agtech adoption is harder	• There are a multitude of agtech companies offering solutions without validation or verification. Consequently, adoption of digital technologies is going to be a lot harder than adoption of hard technologies. • Digital technologies are often outside the comfort zone of the target users.
Social	
Impact on workforce – respect and pride	• Concern raised over increased use of, and reliance on, technology including automation. There is a risk that this might lead to the dumbing down of the workforce as technology takes over many of the activities and even some of the decision making. The concern is that this abstraction of the workforce from the production process may result in poorer understanding of why they are doing things and so leading to undesirable outcomes e.g., food safety issues, poor compliance to NVD requirements. • Further, the 'dumbing down' of the operators can lead to less respect both for themselves and from others.
Attitude to technology	• Social acceptance – it was suggested that men are less likely to adopt technologies in agriculture. Adoption is more driven by female participants in the family farm who are more open to technology adoption.
Leader in new technology	• Do not want to be a leader in technology adoption. Prefer to wait until the technology is mature and then adopt. Prefer to be an adopter rather than an innovator.

Concern	Description
Technology	
Maturity of the agtech	• It was suggested that digital technologies are generally not mature and as a result, the developers sometimes lose interest before all the bugs are ironed out.
Backing the right product (or company)	• Often there are competing products essentially doing the same thing. The problem is knowing which one will be around, so your investment does not get stranded. Do you buy VHS or Beta-max? Will this brand of drone survive? • Stability of the agtech and companies is a concern, particularly for some technologies. Need confidence in the company providing the technology.
Potential for disruption	• How is it going to impact on how I am doing things now? • I want things to be more efficient and lower in cost, but also simpler and more reliable.
Other barriers	
Agtech may not be the right choice	• Preference is still for manual approach e.g., paper based NVD. It is more tangible, something preferred by many farmers. • Digital solutions are not always better than pragmatic manual solutions. Even if they are cheaper, quicker, etc. it is not necessarily so for all producers. The learning curve for some is just too long and too steep. • The capital cost may not be justifiable against the saving in cost or time.
Decision making	• People are still reluctant to make decisions. They have lots of information, but do not make decisions. More often interviewees indicated that although agtech creates opportunities for better decisions to be made, the reality is that time constraints still resulted in more intuitive rather than informed decisions. • Change of management and teams in innovation occurs faster than the time required for adoption. • Agtech often increases the complexity of decision making, thus increasing the time needed to make decisions in an environment where time is a crucial resource. As a result, the Agtech solution often creates less capacity for informed decision making.
Agtech scepticism	• There are a lot of technologies with little backup information or proof of value. A lot of people have made decisions based on anecdotal evidence! People are now very sceptical about adding extra technologies.

4.1.6 What motivates adoption of agtech?

In contrast to the barriers to adoption that have been discussed in the previous sections, motivations for adoption were also recorded.

Table 10. Motivations for adoption of agtech

Motivations
Value proposition
• Understanding the value proposition.
• Technology must solve a problem, and its use has to fit in with management practice.
• Tools to assess payoff period. Benefit cost analysis for some.
• Create and promote the value proposition. Age is a barrier to value creation. Data entry is seen as time wasting.
See it. Discuss it. Touch it. Trial it.
• Observing and trialling the technology.
• Talking to farmers.
• Gaining confidence that they have the skills to use the agtech, or they can acquire them (learn, buy).
• (Walk over weighing) For adoption, would want to see in operation, talk to someone using it. Likely to use personal network for this. Values the practical knowledge.
• Network of demonstration sites, or user advocates.
• Demonstrations, either fixed or temporary. Preferably independent of those distributing or developing.
• Having a go or seeing it in action.
Independent assessment (or support to assess)
• Role for an honest broker in evaluating technology. Key is to have capacity to manage and evaluate the technologies.
• Independent supporting information on the technology. Prepared from the producer's perspective. Focus on the problem it solves and how well it does that.
• Industry could review and provide an assessment tool – the sort of role the Kondinin Group once played.
• Understanding how the tech will complement their setup.
• Rarely talk profit, talk about benefits and experiences. Consultants that have a reputation for good transfer and evaluation of technical information often are preferred by stakeholders when dealing with agtech. A key point of difference is the ability to understand where value exists beyond the financial considerations.

4.2 Key conclusions and recommendations from the consultations

A diverse though admittedly small group of industry stakeholders was consulted during this phase of the project resulting in many insightful and practical observations regarding the adoption of agtech. This result highlights two aspects of these key observations:

1. Any condensation of these observations into a few key messages necessarily diminishes the rich variety and diversity of input received; and
2. There is no simple, shortlist of practices that promise or lead to widespread adoption.

Therefore, the observations presented here are those thought most relevant to ISC and the agtech that supporting ISC programs may potentially consider for adoption.

Figure 7 depicts a high-level schema of the observations categorised under 6 headings. The left and right sides of Figure 7 are further expanded in Figure 8 and Figure 10 respectively and summarised in the following sections.

Figure 7. Summary of the key observations from the stakeholder consultations. The left side and the right side of this diagram are expanded by another level in Figure 8 and Figure 10 respectively

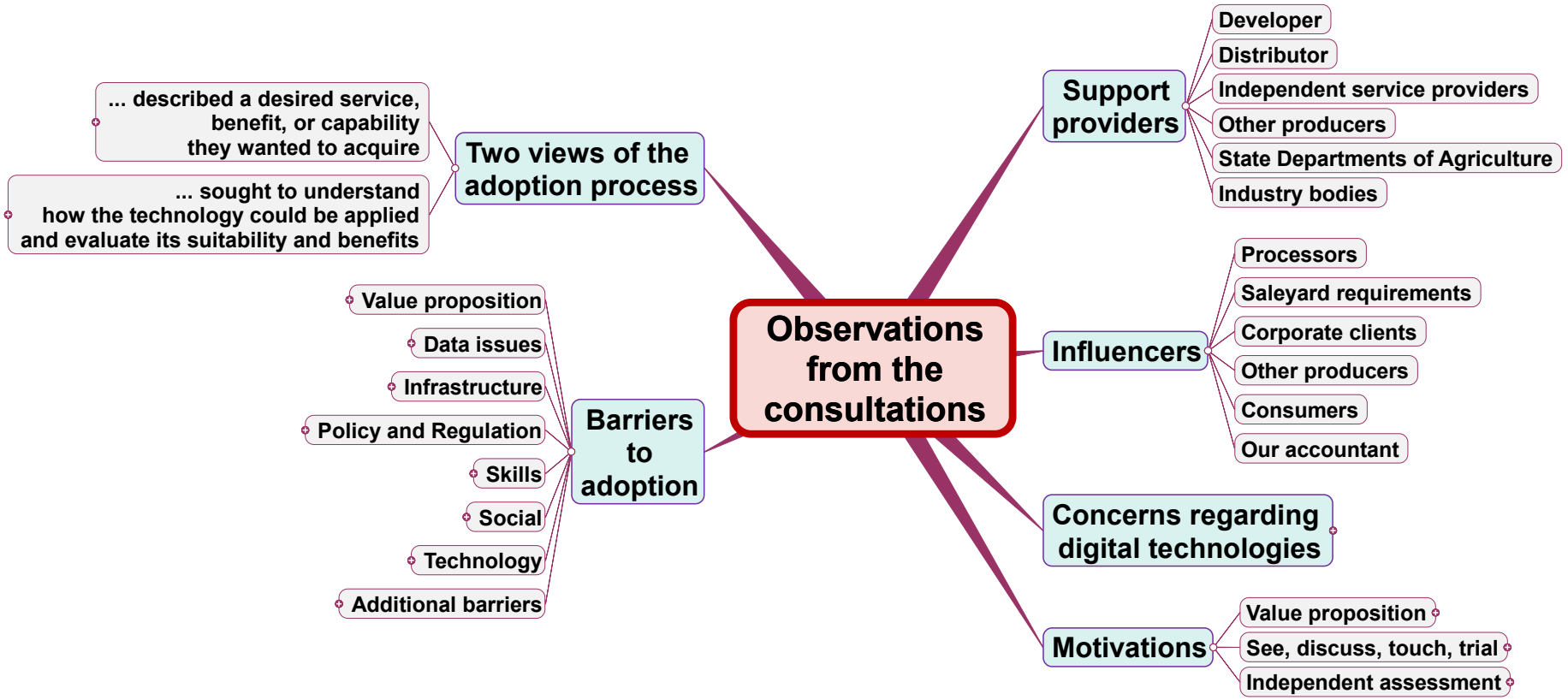
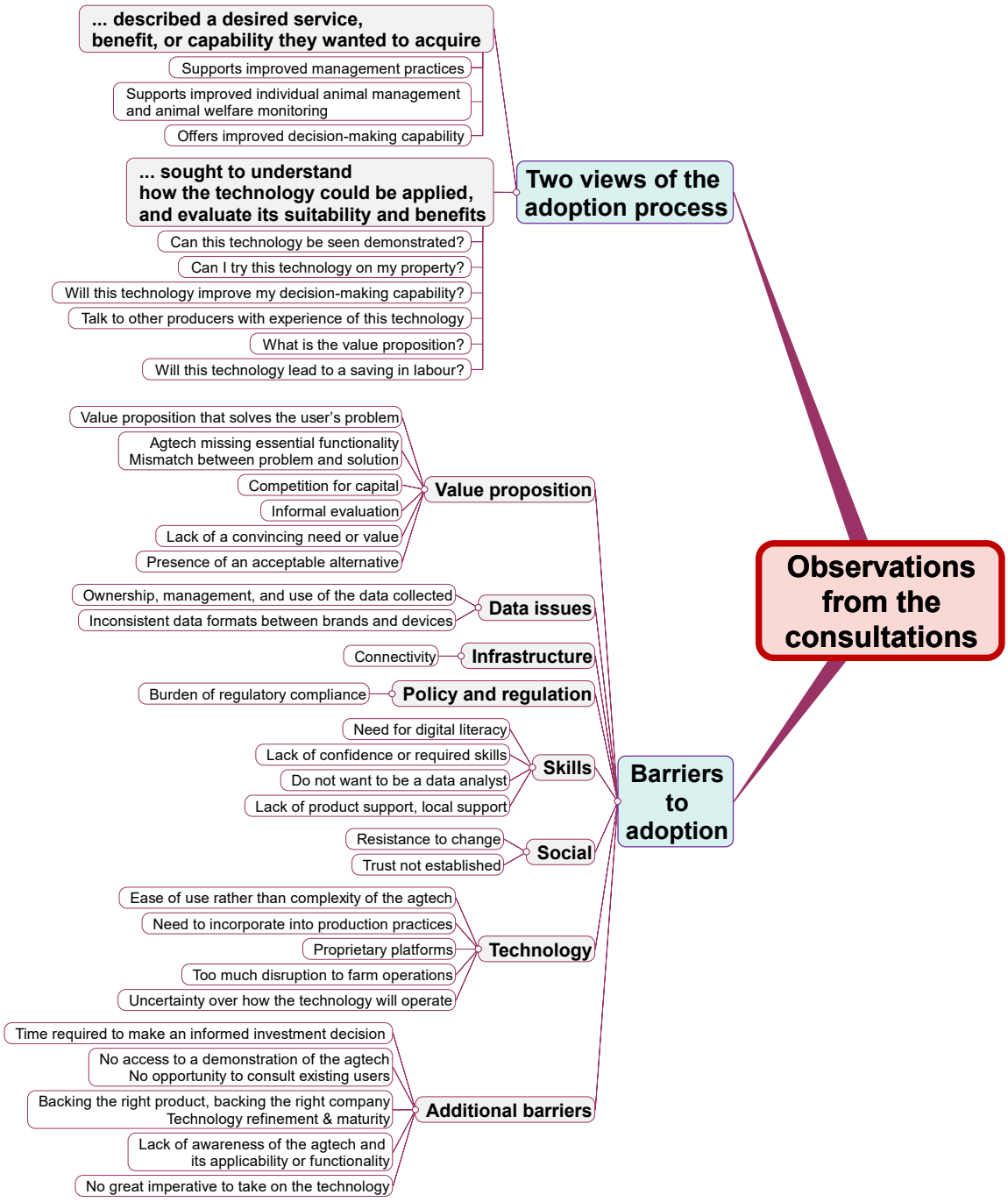


Figure 8. Key observations from the stakeholder consultations – views of the adoption process, and barriers to adoption.



4.2.1 Two views of the adoption process

The top branch in Figure 8 shows the adoption process described by the stakeholders largely entailed one of two approaches:

- They identified the service, benefit, or capability they wanted to acquire by adopting the technology – mostly by supporting improved management or decision-making capability.
- They sought to understand the technology and evaluate its suitability and benefits.

Recommendation 1.	To make a technology appealing to the widest audience, it is important to promote the capability of the technology, how it functions and how it can be incorporated into the farming operations of users.

4.2.2 Barriers to adoption

The word cloud in Figure 9 shows the relative occurrence of the barriers to adoption that were identified and discussed during the consultations. Clearly, the absence of a suitable value proposition and missing or unsatisfactory functionality are the most common barriers to adoption. Unsurprisingly for a geographically rural and remote industry considering the adoption of digital technologies, access to the internet is also a significant barrier.

Figure 9. Word cloud indicating the relative frequency of barriers to adoption identified in the interviews

The barriers to adoption identified in the interviews mostly fitted into the themes identified in the literature review. These themes and the corresponding barriers are shown in the lower half of Figure 8.

4.2.2.1 Value proposition

The technology must solve a user's problem or deliver a desired outcome. It will likely fail in the absence of a convincing need, if there is an acceptable alternative, or if some functionality is missing, faulty or mismatched to the problem.

Even if all these criteria are met, competition for capital might still prevent adoption.

Recommendation 2.	A clear value proposition needs to be articulated. It should include the benefits of the technology, how it operates and how it is better than current alternatives.

4.2.2.2 Data issues

Stakeholders remain concerned about the use or misuse of 'their' data. The main concern is the use of the data for purposes not originally and explicitly agreed to, including against the collector (particularly in commercial scenarios). In addition, there is the perception that the data collector is not getting fair value for the data while others are profiting from it.

A further barrier is the incompatibility of data formats between technologies. Proprietary formats, perhaps aimed at locking a customer to a specific brand or technology, are a barrier to adoption.

Recommendation 3.	A clear and easily understood agreement on how data will be collected, stored, and used should be integral to the process of deploying the agtech. Where possible, this agreement should comply with industry developed and agreed codes of practice.

Recommendation 4.	Data standards should be developed, published, and adopted to enable broad interoperability between applications and devices.

4.2.2.3 Infrastructure

The requirement for a live connection to the internet is a major limitation for many producers in extensive agriculture. There were several examples that indicated that whilst one part of the property may have access to the internet, often access was limited or non-existent at the point where the data was being collected (yards, paddocks, bunkers etc).

Recommendation 5.	Whenever possible, applications should offer an off-line mode to circumvent the absence (or unreliability) of internet connectivity.

4.2.2.4 Policy and regulation

A high regulatory burden has two consequences – it results in poor adoption or poor compliance. There was a clear sentiment that many of the agtech technologies could potentially lead to increased regulation or requirements for data acquisition for regulatory purposes. Agtech itself should not be advocating a value proposition based on increased regulation as this will most likely lead to poor adoption potential.

Recommendation 6.	Agtech needs to ensure that any additional or perceived regulatory burden is proportionate to the value of the technology.

4.2.2.5 Skills

The adoption of agtech usually relies on a degree of digital literacy, or access to those skills either through training or by buying as a service. A lack of confidence in operating computers or smartphones etc. can be a deterrent to adoption, or even the consideration of adoption of digital technologies. Many people in the agricultural industries, especially producers, do not want to become data analysts nor do they want to spend excessive amounts of time collecting, looking at or interpreting data. They prefer to be out of the office.

These skills deficiencies should be addressed through the development of a support network that can provide training from basic digital literacy relevant to the agtech through to a direct service role.

Recommendation 7.	A range of support services are required to facilitate widespread adoption of Agtech. Consideration should be given to training (and accrediting) a network of support providers, noting that approaches that work well in urban areas with reliable broadband may not be suitable in rural and remote areas.

4.2.2.6 Social

A significant inhibitor to the adoption of new practices and technologies is a general resistance to change, particularly among those who are deep into their career or in circumstances where the motivation for change is low (high equity positions). Overcoming this resistance involves both demonstrating the benefits and developing trust in the technology and those presenting it. Aligning the technology with respected companies or using influencers to promote the product may be required to overcome adoption inertia. Addressing any negative perceptions is critical.

Recommendation 8.	Where appropriate, use respected individuals (influencers) and trusted organisations to support and promote the case for adoption of the agtech.

4.2.2.7 Technology

In addition to being able to solve a user's problem, the agtech itself must be usable by the adopter. Ease of use is critical to widespread uptake; complexity is a barrier. It is critical that the technology can be incorporated into standard practices without major disruption to farm operations.

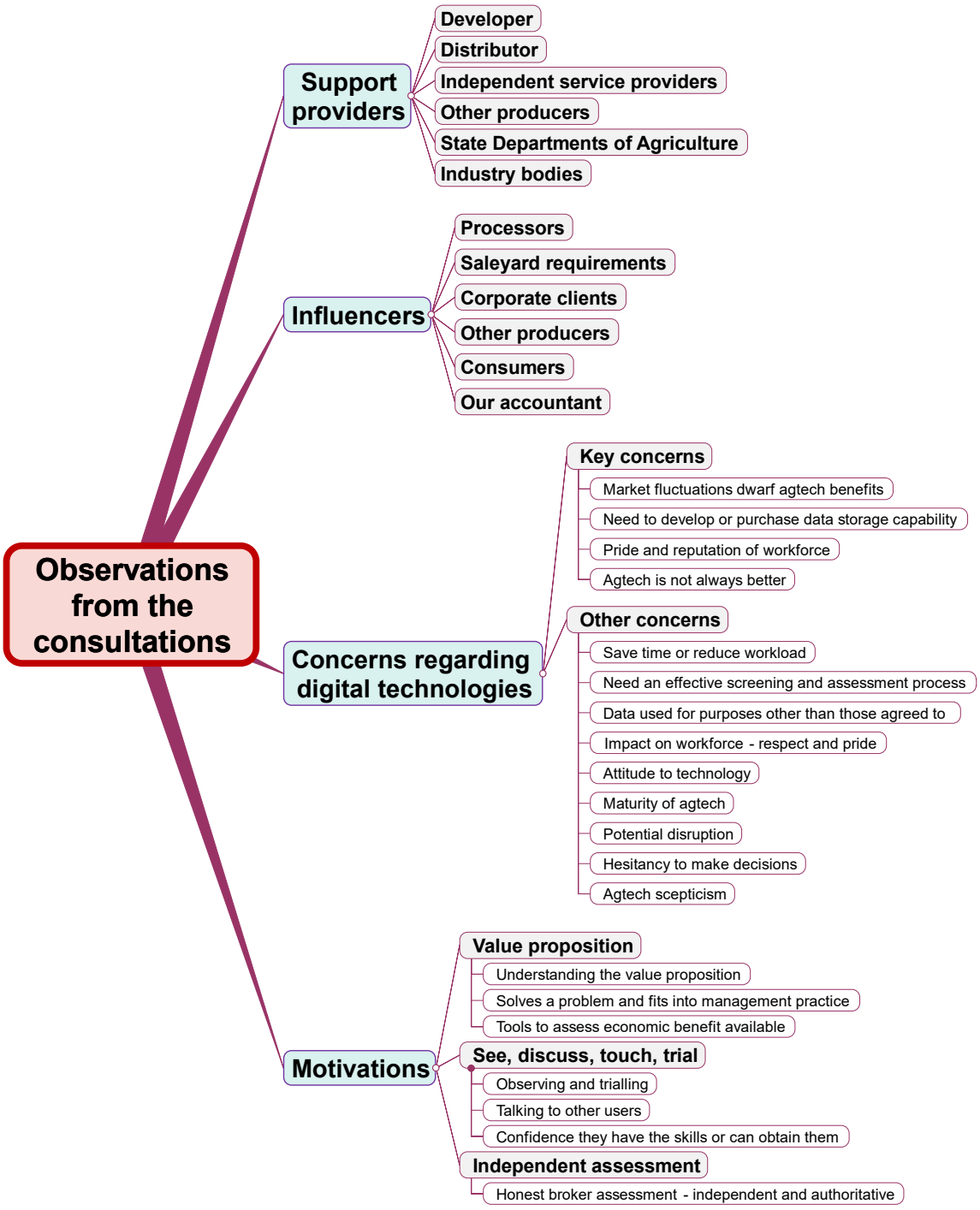
Recommendation 9.	In design decisions, agtech should tend toward simplicity rather than complexity. This applies not just to the interface, but to how the agtech is embedded into farm operations.

4.2.2.8 Other barriers

In addition to the barriers identified under the above themes, several new themes were identified.

- An obvious though overlooked barrier to adoption is a lack of awareness of the agtech. As a key example, while there are several eNVD applications that have been developed and are available (including the mobile NVD), several of the stakeholders interviewed were not aware of them or not aware of the capabilities.
- For many agtech investments, there is a significant time requirement if an informed decision is to be made. Unless there is an imperative to adopt (e.g., a regulatory requirement), the assessment process and decision will often be put off. Flagging the importance of making a decision by a set date may be necessary for some forms of agtech. This might be achieved by a change in regulations (e.g., making an existing practice non-compliant), or by indicating a cost increase or price penalty.
- With multiple companies producing different products aimed at the same problem, there is reluctance to make a decision for fear of backing the wrong one or at worst a non-survivor. Often greater flexibility in choice of technology providers confuses the market and delays adoption as people try to work out which one is most appropriate. In addition, incomplete or immature technologies are a key barrier to adoption by a community accustomed to considering fully developed mature products. Failure of immature products is also a significant impediment to future adoption considerations. The first iterations of the eNVD and water telemetry were cited as key examples of early failures that had essentially stopped consideration of those technologies.

Figure 10. Key observations from the stakeholder consultations – support providers, influencers, concerns regarding digital technologies and motivations



4.2.3 Support providers

The stakeholders that were consulted suggested a range of possible support providers to assist in adoption and use of agtech (top of Figure 10).

With new technologies, the product developer should be encouraged (or in key cases incentivised) to provide support. Often, they learn more about the needs of the user, making it a two-way

process. Trialling or demonstrating their product on farm provides a grassroots opportunity to showcase the technology's potential and establish champions for the product. This can be undertaken with early adopters who are more accommodating (and understanding) of early setbacks or failures.

With more established products, the distributor network was suggested due to its proximity to the users and the opportunity to further develop their business.

Other producers and/or feed lotters are considered a trusted source of information, especially around the practicalities of using the agtech. Producers and feed lotters generally trust and value the views of other producers and feed lotters, respectively. State Departments of Agriculture and industry bodies are also trusted entities that could offer authoritative support especially during the evaluation phase.

4.2.4 Influencers

It was suggested that there are several groups that can have a direct impact on the adoption of agtech (Figure 10). Entities along the supply chain including processors and saleyards may have specific requirements that are best met through the adoption of some technology. In some cases, they may provide the technology. Corporate clients can be very demanding of information to satisfy their management and shareholders. Often if producers or feed lotters have direct engagement with corporate entities, they are more likely to consider adoption of agtech. A key example was the need for information that large feed lotters require from producers that background cattle.

In a more indirect way, other producers can influence an adoption decision because they are successful, or their opinions are respected.

Bankers, financial advisors, and accountants have an influence over adoption decisions through either a restriction on the availability of capital or advice on the profitability or riskiness of an investment.

4.2.5 Concerns regarding agtech

It was recognised that agtech, while new and perhaps innovative, is not always better than traditional ways. Often the gains from agtech are small relative to the market fluctuations faced by producers. Producers also indicated that it was very rare for agtech to lead to increased capital value of the farm asset, in contrast to fertiliser, pastures, genetics and water infrastructure that had a direct impact on the capital value of the farm or farming enterprise. As a result, long term considerations of capital investments often preclude adoption of agtech.

The use of technology to make decisions normally made by the workforce has potential ramifications for the workforce including the potential that roles are 'dumbed down' reducing the standing of those workers.

Less skilled workers may have less pride in their work and less understanding of why a task is done resulting in poorer performance and lower compliance with expected standards. Furthermore, in cases where younger workers seek opportunities as an intermittent lifestyle choice, they are not motivated by office-based or data collecting activities. This was highlighted in northern Australia.

The lack of understanding of the purpose and importance of the data being collected combined with low motivation for data recording will likely result in compromised accuracy and consistency.

4.2.6 Motivations for adoption

4.2.6.1 Value proposition

Having a clearly articulated value proposition that is readily understood is a big step toward adoption. It should explain how it solves the user's problem and how it fits into their operation.

Having the tools to evaluate the agtech against their own conditions enables the process to proceed.

[See Recommendation 2]

4.2.6.2 See, discuss, touch, trial

Being able to observe and trial a new agtech product firsthand is critical to adoption for many producers. Setting up demonstrations, being visible and available at field days, and providing access to a network of people who can provide firsthand experience of the agtech will build support, trust, and adoption of good products. These interactions help build confidence that the product is right, fit for purpose, robust and that they will be able to use it.

4.2.6.3 Independent assessment

In addition to the practical assessment options outlined in the previous section, detailed, easy to read information from an authoritative source is vital to answering many of the doubts that arise when contemplating a new technology. Being independent of anyone who stands to gain from the sale is really important.

4.2.7 Adoption schematic linking adoption processes, support providers across categories of users

Figure 11 shows the progress of adoption from initial uptake by innovators followed by early adopters and then the middle majority.

4.2.7.1 Innovators

The 'innovators', those who are first to adopt, tend to be more tolerant of failure and more likely to experiment. This group is likely to be valuable to developers because of their willingness to trial new products and provide valuable, pragmatic feedback. They are likely to be open to conducting pilot trials with the developer in order to better understand the value proposition of the agtech under trial. They might serve as future product ambassadors. ISC might contribute to this process by connecting agtech developers with appropriate respected innovators.

4.2.7.2 Early adopters

The 'early adopter' group are likely to consider the agtech more broadly before making the decision to adopt. Value proposition, opportunities to observe and discuss the agtech, ease of use and compatibility with existing systems are likely key components of their evaluation. Capitalising on first-mover advantage can be a motivation for this group. As relatively early adopters, they will seek support from the sales and distribution network, the developers (e.g., at industry field days) and from innovators in their local personal networks. Influencers within this group should be considered for case studies and as a source of data to inform or calibrate evaluation models.

4.2.7.3 Middle majority

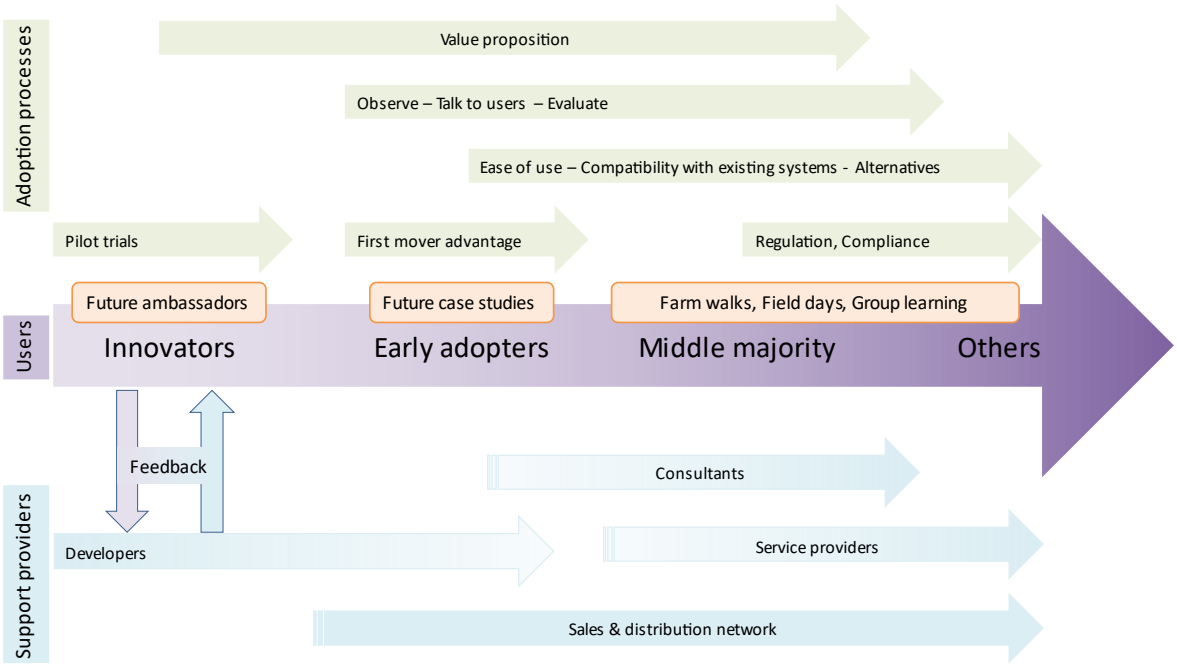
Adoption by this group most probably involves similar considerations to those of the early adopters, but with the need for greater assurance of success. This is likely gained through observing greater adoption of the agtech and through the emergence of support services.

Rather than going-it-alone, this group are more likely to rely on consultants and service providers to assist with adoption and operation of the agtech, to maintain the equipment and in some cases process the data they gather. As a result, uptake will follow the emergence of these services.

Case studies published through relevant communication channels will raise awareness. Farm walks and field days along with group learning activities will assist this group to commit to adoption.

Regulation and compliance might be effective in driving adoption by this group but only if the required support services (sales and distribution networks, service providers, and agtech trained consultants) are established and accessible.

Figure 11. Schematic indicating the relationship between categories of users, evaluation processes and support providers



4.2.7.4 Others

The remaining cohort are likely to need confidence that the agtech has a positive value proposition for them and is easy to use relative to their skills (or the skills they can readily develop or contract). Observing the agtech in use through participating in farm walks and field days, talking to their business and social networks, as well as talking to their consultant or local service providers will contribute to building the necessary confidence.

Regulation and compliance are most likely drivers of adoption especially if there are economic consequences for failure to comply. However, if the required support services are not available, there are likely to be adverse and unexpected consequences from a big-stick approach.

5 Rationale and logic framework to address barriers to adoption of agtech for the livestock industry

A systematic examination of the reviewed published literature and available research reports (see section 2) has identified that in respect to the adoption of agtech in Australian agriculture, and more specifically in extensive agricultural sectors such as livestock, there is no such thing as a single list of activities or solutions that are able to resolve all the adoption barriers that exist. Furthermore, given the broad range of industry challenges and technology solutions, as well as the varied needs and constraints of livestock producers and feed lotters, addressing only one of the barrier themes in isolation will not be effective mechanism to drive adoption. In fact, it could lead to a disincentive to adopt.

The consultations conducted (although limited in number; see section 3) with a wide range of livestock industry participants confirmed these finding and observations from the literature and further cemented the need to consider adoption not as a sequential process, but more of an interacting series of experiences. Therefore, the adoption logic must have an approach that is dynamic in nature to address those interactions in a simultaneous and continuous manner.

It was also determined that some of the key activities require the producer or feed lotter to allocate the necessary resources and develop skills to identify, evaluate, trial and where appropriate, share information about the technology. Establishing the 'need' for allocation of both time and capital resources requires a multifactorial and multifunctional approach.

This, in turn, implies the need to deploy a broad spectrum of resources to drive widespread adoption. Adopters of agtech will contemplate adoption from both a range of starting points and a varied list of objectives. For this reason, this project has developed an interesting and potentially different approach to the adoption of agtech. Rather than consider adoption as a sequential process or sequence of activities, we believe that adoption should be considered in a multifunctional format with various activities that occur either simultaneously or potentially in quite different orders depending on the stakeholder. We have termed this approach a stage-gate adoption plan which is illustrated in the following sub-sections.

5.1 Stage-gate approach to adoption plan for agtech

Given this complexity and the complications of treating barriers as sequential or isolated, this project developed a stage-gate approach to adoption activities that is designed to motivate the producer and feed lotters to move through the conceptual phases of innovation: interest, awareness, trialling, evaluation and finally adoption.

Figure 12. Conceptual stage-gate plan of adoption of agtech for livestock stakeholders

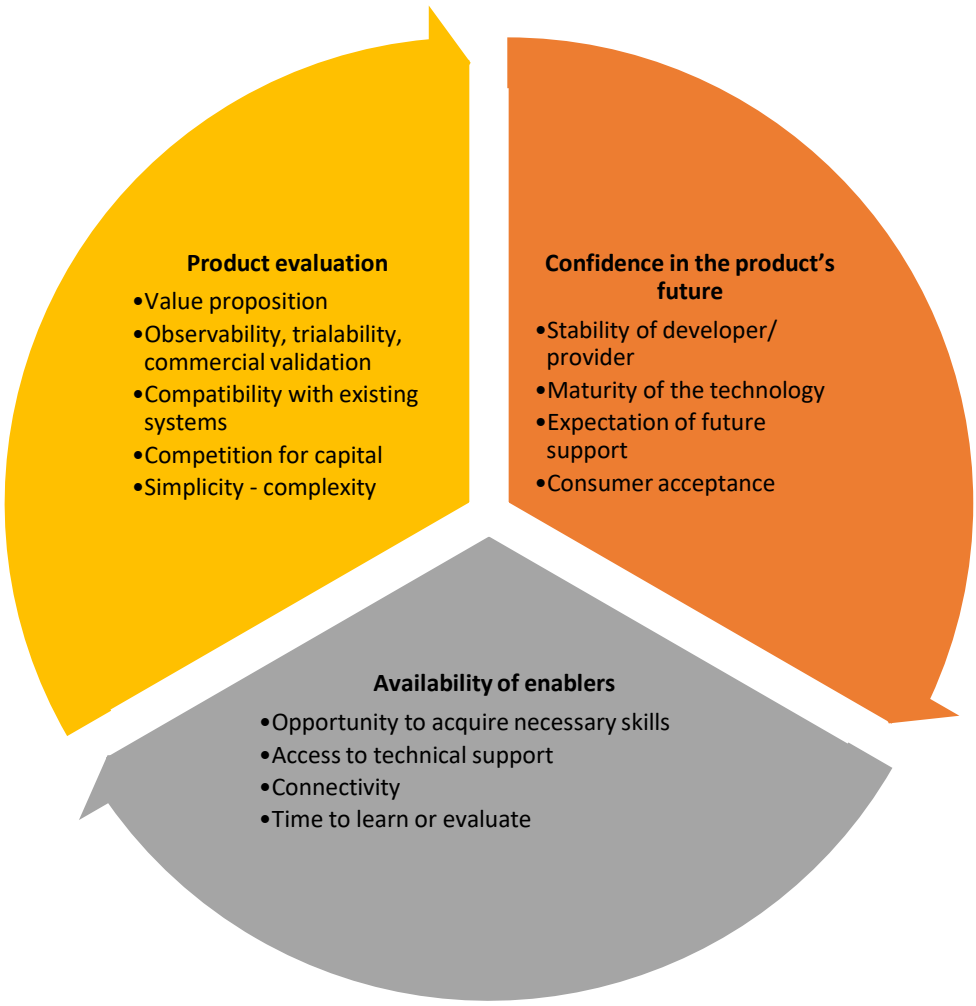
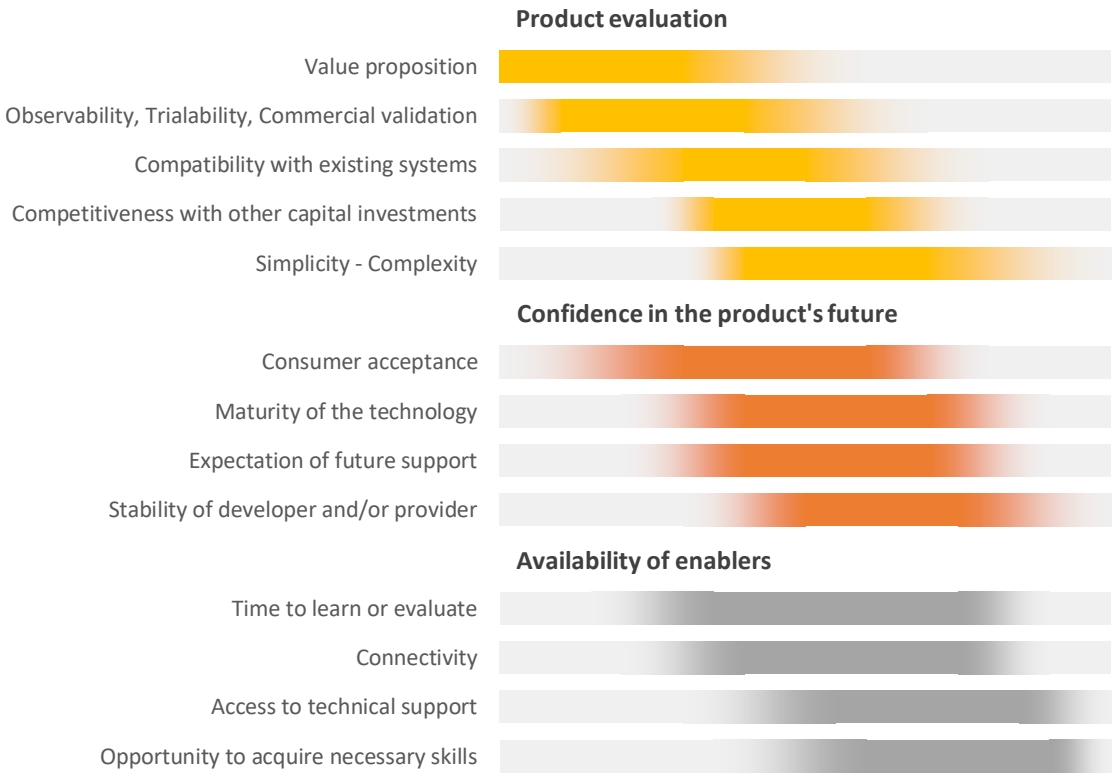


Figure 12 provides the conceptual stage-gate plan for adoption of agtech for the Australian livestock industries. What is distinctive about this stage-gate adoption plan is that it demonstrates that a potential adopter of technology can enter each of the three stage-gate phases at any of the identified thematic barriers. To transition through each of those barriers requires the adopter to embrace or embark on a series of decision activities including prior consideration (interest and identification), contemplation, trialling and active evaluation, decision and decided (investment or practice change). The actual time and therefore resources 'invested' by each adopter (producer) in each of those decision activities varies with the barrier and more importantly with the actual technology that is being considered (see Figure 13). It is also very difficult to predict the speed of transition through those decision activities as this will vary significantly and will be highly dependent

on the technology and the 'motivation' the producer has for the actual technology (time, capital availability, labour, regulation, personal interest, etc).

Figure 13. Decision activities and timelines of options for the stage-gate adoption plan



A critical feature of the stage-gate adoption plan is that adopters can and will often engage with different elements within the three phases simultaneously. That is, they will be undertaking decision activities relating to key barriers within product evaluation, confidence in the product's future and availability of enablers in parallel. As a result, the adoption logic must have the necessary activities (and flexibility within those activities) to satisfy multiple decision points at any point in time.

It is also important to note that not all barriers have to be overcome for the decision activities to be complete and for the producer to move to an adjacent barrier, and that not all barriers within each stage-gate phase must be overcome, before that stage is effectively completed. However, it is our belief that most elements of the stage-gate need to be completed (satisfied) before adoption can occur.

The following sections provided a brief outline of each of the elements of the stage-gate adoption plan.

5.1.1 Product evaluation

Although the stage-gate adoption plan has been presented as a continuum of connecting stages and elements within stages, the product evaluation stage-gate potentially should have the highest priority as several of these barriers if not satisfied will result in the technology not passing the critical 'interest phase'. Factors such as a lack (or perceived lack) of a strong value proposition, the

technology lacking sufficient maturity, the technology being outside of the viable price range or a lack of information relevant to Australian conditions and/or buyers, all inhibit initial interest.

Furthermore, a lack (or perceived lack) of availability in Australia or a lack of resourcing (time and/or capital) available to evaluate and trial are key barriers to initial product evaluation. Adoption is also more likely to occur when the results from the local evaluation and trialling of technologies are clearly communicated in an engaging manner, with quantitative results provided about the benefits, costs, and limitations of the technology.

The value proposition must be clearly identifiable and transparent. Key positives are to either reduce time, improve efficiency, or reduce labour. Reducing risk is a lower priority. Feedback received during the consultation phase clearly indicated that there is a wide divergence between sectors in the formality and rigour used to calculate the value proposition, and that these also vary with different forms of technologies. For example, corporates (including feed lots) require substantial financial metrics like BCA or ROI, with a payback period less than 5 years and often 3, whereas family units often have less sophisticated measures but are still driven by dollar returns, with payback usually required within five years and at times within a noticeably short time frame (if not immediate). If a BCA or ROI is calculated to inform industry stakeholders, that analysis should include all costs associated with full system changes to provide confidence in the actual numbers being presented. A spreadsheet or web-based evaluation model would assist potential adopters of the agtech to undertake evaluation using their own inputs.

Recommendation 10.	ISC should consider increased investment in case studies and commercial trials where public versions of financial metrics are generated within key production systems and across different geographic locations.

Producers, lot feeders and processors often require (expect) proof of application and demonstration within similar production environments and within systems that have similar geographic impediments or nuances. The absence of trialling or commercial validation is a key barrier identified by stakeholders and within the reviewed literature. Furthermore, is it highly desirable that most technologies have a demonstrated ability to integrate with other farm functions, as that they are directly compatible with other on-farm or feed lot technologies. Being able to integrate with existing data platforms is also a strong requirement.

Interestingly, first adopter advantage is usually minimal for agtech or digital technologies. The adoption requires other motivations for producers / feed lots and even processors to trial agtech. Saving time and labour are two of those motivators. Connectivity is usually tested under the trialling phase, so trialling within areas that have similar connectivity challenges is important to those stakeholders that are located within regional and remote areas.

For large numbers of producers, capital is a key restriction. Agtech compete with other capital investments that can be made including infrastructure, genetics, nutrition, feeding management, water management, livestock etc. Often producers resonate with those alternative investments through personal interests or historical experiences resulting in agtech having a lower perceived priority for capital. The fact that often there is no hard-visible reinforcement of the outcome from investment in digital technologies is a real barrier for many producers. As a result, agtech is often required to value add to current resource investments, rather than being considered as independent investments.

The concepts of ‘plug and play’ or ‘turn the switch on’ were often cited as key adoption features (requirements) for stakeholders that are time poor or located in areas where direct access to outside

expertise is limited. Technologies that increase complexity or require significant time resources in implementing and/or operating are most likely to see poor adoption rates. Often entrepreneurs developing the technologies fail to use 'design led thinking' approaches to scope the necessary functionality of such technologies. Producers stated that if they cannot see progress in a day (or less) then often that technology will quickly fail in the trialling phase.

5.1.2 Confidence in the product's future

Stakeholders will be reluctant to invest in technologies unless there is confidence that the agtech company has a solid reputation and the capacity for a long-term future and ability to service future product requirements. All sectors of the industry indicated that they have had experiences with technology providers that have either ceased business or been bought out in an acquisition. As a result, product service became limited or non-existent. This lack of stability in agtech companies was a key reason that producers sought very quick pay-off times. Furthermore, there is greater confidence that further support will be available from those companies that service several different agricultural industries. A key example was water telemetry.

A lack of maturity of the technology is also a key barrier. Often digital technologies have been delivered with promises of further features and these have not been delivered or have taken significant time to achieve commercial viability. GPS tag technology and virtual fencing were two examples given where producers are waiting for the technology to fully mature before making substantial investments.

Acceptability to consumers and/or value chain partners is a further consideration. Digital technologies that enhance animal welfare or reduce OHS risks often are more likely to be adopted. Technologies that remove labour requirements are also more favourably considered for adoption, particularly in regions where labour is difficult to acquire or for tasks where labour is difficult to manage.

5.1.3 Availability of enablers.

For many producers, time and capital constraints restrict evaluation of technologies and reduce opportunities for implementation. In regional and remote areas access to technical expertise is a key barrier not only for the agtech but also to maintain associated infrastructure such as internet connectivity, computer hardware and software or physical units such as weigh scales, NLIS readers etc. Having a third-party service provider that not only assists with the implementation, but also offers added security in terms of product support, was important to those producers who were either time poor or lacked digital literacy.

For this reason, establishing and promoting enablers who have trialled and valued the technology is important. A key adoption activity for ISC should be the development of a service provider / consulting network that can provide local support for agtech adoption. This could involve livestock agents, agricultural consultants, State Department officers, as well as influential processors, feed lot operators and producers.

This concept is highly consistent with the recommendation number 7 and from the SA Agtech Advisory Group[6] that recommended the development of a 'Trusted Independent Intermediaries & Agtech Ambassadors' program with accredited service providers. The key practice advocated is to utilise producers, who have adopted agtech extensively, as ambassadors to champion and exemplify

[6] SA Agtech Advisory group (2020) Accelerating AgTech adoption in South Australia. Strategic draft plan. PIRSA.

the benefits of those technologies. This reflects the key observation that livestock producers are most likely to adopt agtech if another known producer has trialled and adopted the technology.

Producers who use private consultants to assist with farm management decisions indicated that they listen to the advice and opinions provided by consultants on technologies. Therefore, private and public consultants (state livestock officers, LSS etc) should be a key target to progress through the stage-gate adoption plan.

5.1.4 Stage-gate adoption plan example for agtech

As indicated above, adoption of agtech is likely to be both complex and complicated for the livestock industry, with the additional challenge of a significant variety of barriers that often are non-sequential in both the time and effort required to overcome them. The stage-gate process described in Figure 12 highlights the recommended non-sequential approach to an adoption framework. Within that framework, there are still logical elements of the motivations that must be addressed – the key activities, who has responsibility and finally what priority should be given to those activities. Table 11 provides a summary of that logic.

It should be noted that whilst the table presents a sequential appearance of steps, in practice ISC should consider simultaneous investment or structuring of activities within and across the stage-gate phases. Furthermore, it is recommended that additional effort should be placed into understanding what demographics or segmentation analysis could be used to determine where producers and feed lotters enter the stage-gate and what logical or illogical order of activities they may follow to navigate through the evaluation phases of adoption.

Recommendation 11.	ISC should consider a segmentation analysis to determine whether there are defined clusters of producers or feed lotters that enter a given stage-gate at the same point and follow either logical or illogical sequences of activities in the evaluation phase.

Table 11. Stage-gate adoption plan focus options

Stage-gate framework phase	Motivations addressed	Key activities or actions	Responsibilities	Priority
Product evaluation				
	• Technology must be proven in commercial environments, must be simple, cannot be complex or complicated and cannot be overwhelming (scalable). Needs to have 'chunking' capability[7]. Bite size information that can be understood and valued before moving to the next piece of information. • Value proposition for smaller and family orientated farms is not necessarily financial. Time, labour and OHS are key motivators that are often missed in promoting agtech. • Concern that data collected will be used for other purposes. Confidentiality, trust, fear of the data being used against the user.	• Develop a standard methodology for BCA analysis of agtech including definitions of assumptions and suggested values to be used. Promote standard methodology to agtech companies and intermediaries that may calculate value propositions. • Set up commercially relevant and transparent case studies with producers/ feed lotters/ processors that have credibility with most of the marketplace. Undertake with producers and feed lots that are willing to be fully transparent. • Complete BCAs on a range of agtech within a key production system and across different geographic regions. Note that BCA must include the integration of the agtech within the whole farm system.	ISC with partnerships with agtech providers	Critical

[7] Chunking. In cognitive psychology, chunking is a process by which individual pieces of an information set are broken down and then grouped together in a meaningful whole. The chunks into which the information is grouped is meant to improve short-term retention of the material, thus bypassing the limited capacity of working memory. A chunk is a collection of basic familiar units that have been grouped together and stored in a person's memory. These chunks are able to be retrieved more easily due to their coherent familiarity. It is believed that individuals create higher order cognitive representations of the items within the chunk. The items are more easily remembered as a group than as the individual items themselves. These chunks can be highly subjective because they rely on an individual's perceptions and past experiences, that are able to be linked to the information set. The size of the chunks generally ranges anywhere from two to six items, but this number varies with language and culture. https://en.wikipedia.org/wiki/Chunking_(psychology)

Stage-gate framework phase	Motivations addressed	Key activities or actions	Responsibilities	Priority
		• Develop, for both large scale family farms and corporates, BCAs that indicate ROI, NPV and payback period. • Document additional non-monetary benefits of agtech to assist producers with establishing a triple bottom line value proposition. • Develop and promote widely a clearly stated set or principles and agreements regarding the collection, ownership, management, and use of data including standards for privacy and confidentiality. • Develop a national set of guidelines for the aggregation and deidentification of regional, state, and national information that can be used by the decision support services provided by ISC, MLA and industry representative bodies (IRBs). • Provide a schematic oversight of technology clusters and where they potentially integrate in whole farm systems (a 'livestock agtech' roadmap). The outcome is to stimulate increased awareness of interoperability of agtech amongst both agtech providers and livestock stakeholders. • Provide an authoritative assessment of the value of the data collected along the livestock value chain and to aggregated datasets. This should include estimates of the cost of collection and indicative estimates of the value created.		

Stage-gate framework phase	Motivations addressed	Key activities or actions	Responsibilities	Priority
Confidence in product's future				
	• Agtech companies not understanding the business and the space of agriculture. • Agtech generally lacks agricultural practical knowledge. • Agtech being released in pre-commercial beta formats which results in failure.	• Develop (and potentially accredit / incentivise) enhanced user groups for agtech companies to approach to trial technologies. Ensure that access to that group is only made available to companies that demonstrate a medium-term capacity to support the product. • Develop a network of production system specialists that can assist agtech with technology development, testing and design thinking options. Incentivise specialists to engage with early phase trialling. Provide independent supporting information on the technology prepared from the producer's perspective. Focus on the problem it solves and how well it does that. • ISC should consider developing an accredited process (with trademark)[8] to signify that agtech is compatible with existing livestock solutions and can participate in interpolation of data across the livestock value chain. • Consider the development of an accreditation trademark that could be used to identify those agtech technologies that have been effectively evaluated through the above activities. Licence use	ISC and state agencies	Critical

[8] Stakeholders identified the need for an independent organisation to verify the suitability and robustness of agtech for different livestock sections. ISC has the capacity and the network of stakeholders to provide an independent testing platform that could be used to underpin confidence in the agtech solution. MLA provides the same mechanism for eating quality through the MSA program and the MSA trademark.

Stage-gate framework phase	Motivations addressed	Key activities or actions	Responsibilities	Priority
		of the trademark to agtech providers with review based on support, compliance to national data and data use standards and clearly identified adoption targets.		
Availability of enablers				
	• Compatibility across platforms or applications is critical. • Multiple technologies do not always work together. Problem with different standards and with proprietary platforms. • Time and formal processes of evaluation are often lacking with producers and smaller feed lots. The use of service providers that have the capacity to assist with evaluation and then implementation of agtech will increase the probability of adoption success. • Extension and adoption of digital technologies to 'mum and dad' producers is the next quantum leap for adoption. The current model of state department and RDCs funding and evaluating agtech will not work.	• Encourage and support the development of open platforms for data sharing. Promote the digital data architecture for the Australian livestock value chain. • Develop a core group of service providers to assist with the evaluation and adoption of agtech (see Trusted Independent Intermediaries & agtech Ambassadors). • Complete a scoping segmentation analysis of producers and feed lotters to identify critical features that determine where they enter the stage-gate process and whether there is a logical or illogical order of activities that could be followed. This will potentially inform where critical points of investment are needed in enablers and which are key target demographics for those enablers. • Develop training modules for advisory services that provide methodologies and tools to analyse data collected from agtech on behalf of farmers and transform this data into smart decisions. This should be linked to aggregated benchmarks arising from national databases.	ISC and	Best practice

6 Outline of the eNVD case study and the eNVD stage-gate adoption plan

The following case study on the eNVD has been constructed to demonstrate the principles contained within the thematic analysis of identified barriers to adoption of agtech. It provides an opportunity to explore and potentially quantify adoption barriers as well as to provide a clear exemplar of the stage-gate adoption plan and activities that ISC may consider within a formal adoption plan for the eNVD.

6.1 Purpose and function of the eNVD

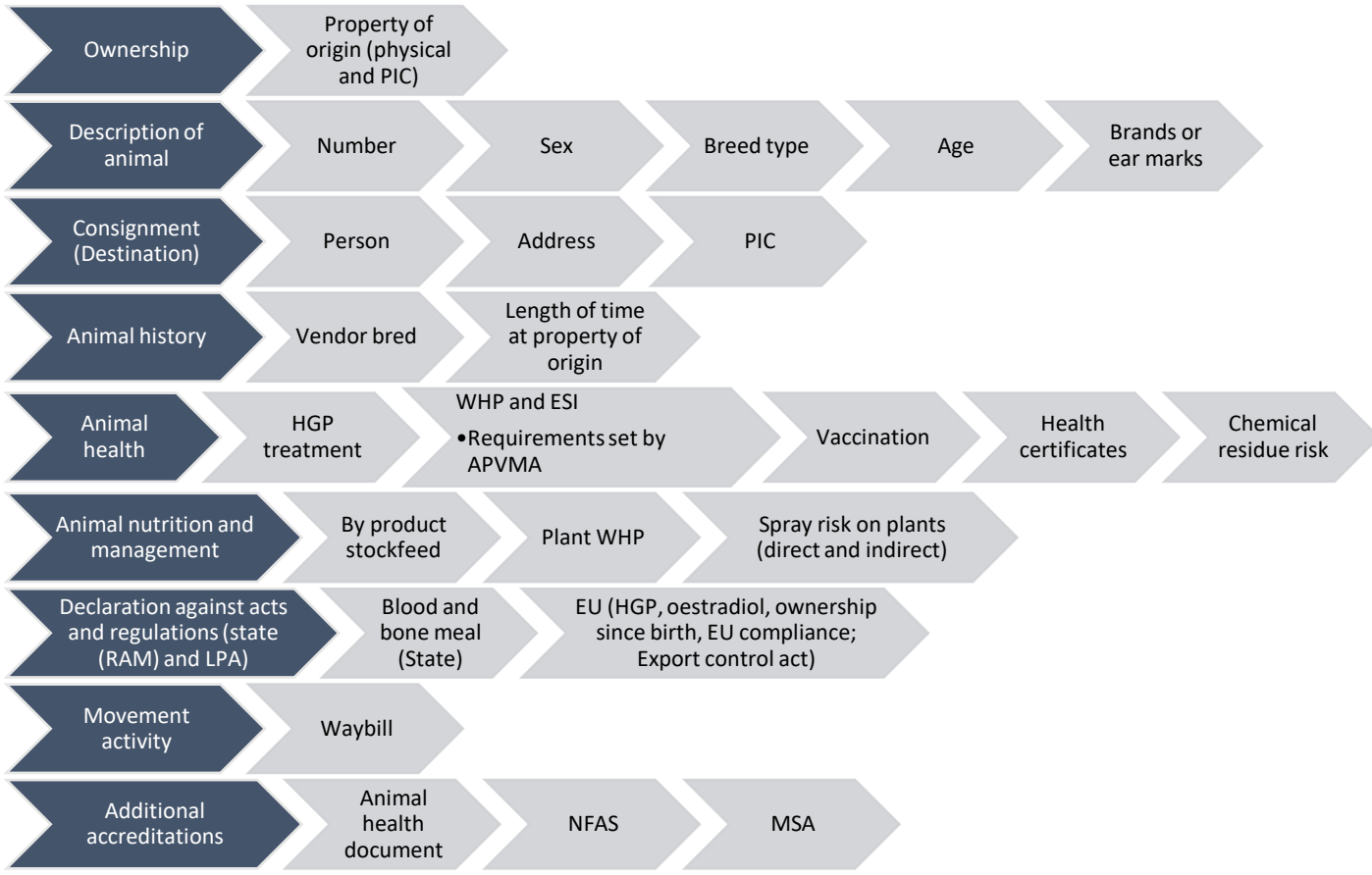
The Livestock Production Assurance (LPA) National Vendor Declaration (NVD) is the legal declaration and guarantee to buyers of livestock that information that is declared by the producer on a range of attributes associated with the management, exposure to chemicals, and health of animals listed on the NVD, meets the minimum standards for assurance of food safety and product traceability.

The eNVD is the electronic iteration of the NVD. It provides a paperless digital version that facilitates the transfer of information between the producer (vendor), intermediaries such as livestock carriers and the final purchasers of livestock. The transfer of digital information is designed to reduce time and transcription errors and increase accuracy and integrity of information.

6.2 Features of the NVD and eNVD

The following diagram lists the key information sets and declarations that are contained within the NVD and the eNVD. Producers under the LPA accreditation process are responsible for ensuring the accuracy and integrity of the information provided. The signed declaration commits the producer to that information.

Figure 14. Schematic of the key functional elements of the NVD and eNVD.



6.2.1 Critical points of difference of the eNVD

The following information summarises the critical advantages that the eNVD must offer and deliver to the stakeholder in comparison to the standard NVD, for it to offer a compelling value proposition for industry stakeholders. The eNVD should:

- Provide fast, easy and more accurate transfer of information in comparison to the NVD.
- Pre-populate fields using previous entries ('favourites').
- Provide mobile-friendly access to information and resources– that is, information is available in real time – at point of dispatch.
- Provide flexibility in livestock demographic change (numbers) and management options.
- Provide the ability to forward plan an upcoming consignment (28 days).
- Ensure the latest versions of the NVD are available to meet market requirements.
- Reduce duplication and time spent completing or copying livestock assurance and health declarations.
- Reduce the cost of storing and retrieving historical consignments for auditing, reporting and administrative purposes.
- Allow stakeholders (both producer and processor receivers of information) to log in and view consignments.

It is essential that each of these critical points of difference is achieved or at least functionally available for stakeholders to extract optimum benefit from the eNVD. Barriers that either reduce or inhibit the critical points of difference will ultimately reduce the value proposition of the eNVD.

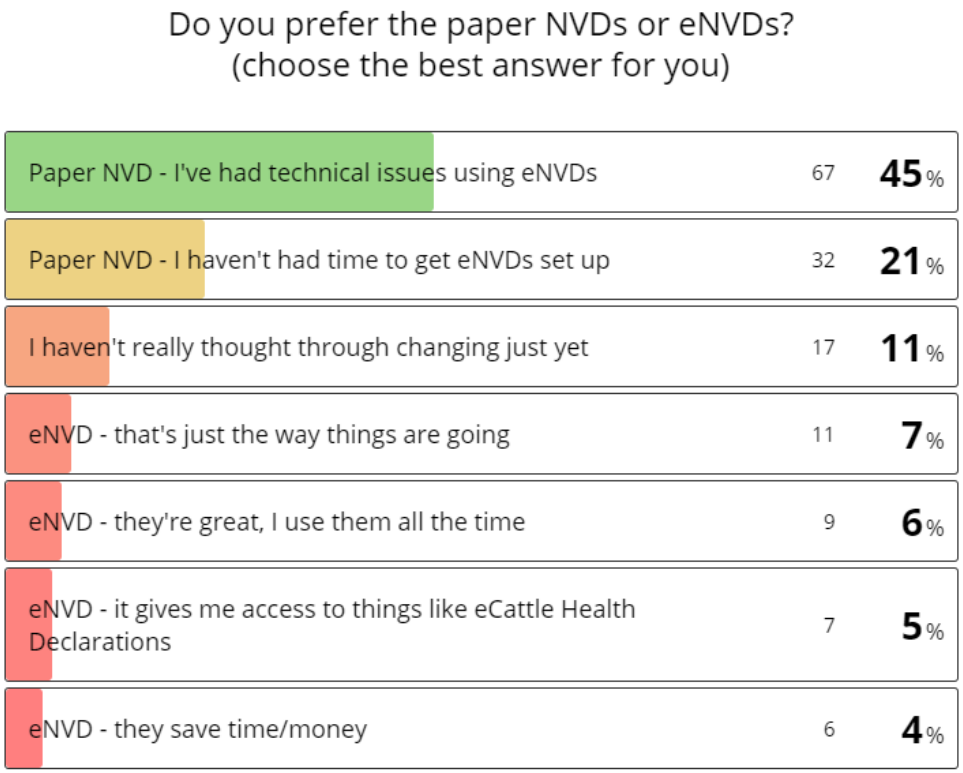
6.3 Barriers to adoption of the eNVD

Motivation to adopt is high if there is a direct pricing incentive or when technology is seen to directly lead to a saving in time or costs. Motivation driven by compliance is usually restricted to ensuring that the immediate threat or consequence of non-compliance is met – that is, only the minimal actions and data requirements required to avoid non-compliance are usually seen as the essential target.

To date, producers have generally had little appreciation of the value of the NVD and the importance of having accurate information declared within the NVD. There is a consistent deficiency in the establishment of what the 'essential' nature of the NVD is and where it fits within the market expectations of both domestic and international consumers. These are barriers to the whole NVD process rather than the eNVD specifically.

A recent Cattle Council of Australia (CCA) survey of members looked at preferences for NVD (paper) versus eNVD. That survey identified several potential barriers to adoption of eNVD with 77% of cattle producers preferring the paper NVD. This is consistent with the ISC statement that 20% of producers are now utilising the eNVD. Those barriers are shown in Figure 15. These barriers will be further explored within each of the key 'barrier to digital technologies' themes.

Figure 15. Survey of preferences for NVD vs eNVD from Cattle Council of Australia (August 2020)



6.3.1 Policy and regulation

Most producers see regulation as an impost on business with little or no recognition of direct links to value or value creation.

LPA is the minimum industry-level standard for reporting and compliance against regulations. Most producers therefore see the paper-based system as satisfactory in meeting that minimal standard. Additional value-adds or supporting documentation including health statements, MSA etc are useful for company requirements but not seen as enhancing critical information for compliance.

A proportion of the producer population fails to understand the link between LPA, quality assurance and market access. They do not see direct market premiums or the costs of non-compliance. Furthermore, they see duplication in data entry for other purposes. Most of the NVD information collected is not causally related to price or on-farm management positions.

Access to veterinary product information including withholding periods (WHP) and export slaughter intervals (ESI) is an issue, but this same constraint would be applicable to all forms of NVD.

The eNVD requires a signing process to complete legal transactions. For some users of mobile technology this provides a barrier in that they are unable to complete the signing process.

Industry has also questioned what the penalty for non-compliance to the NVD is. The current system that provides a notice of non-compliance has limitations in terms of motivations to improve.

6.3.2 Infrastructure

Coverage and access to the internet, both direct and through time (that is consistency of access) are key limitations. Internet access in regional and remote areas is usually expensive (see satellite costs). Most loading or handling facilities are in positions with little or no access, resulting in reliance on other methods to collect data (physical or off-line) and transfer of data to centralised system when available.

eNVD at point of dispatch is challenged by connectivity (linkage to carriers). There is a perceived risk that the system or connectivity will be low at critical times, and this translates into producers ensuring that they have a fail-safe system with minimal risk. This leads to a reliance on paper systems.

The actual cost of the RFID reader(s) is also a key barrier. Whilst it is not essential to have a reader, for many smaller scale producers, the investment of upwards of $1,000 in readers and supporting software is a significant impediment to ownership and use. In addition, the time to install and configure the software required to collect EID information and link that to the NLIS database is significant with estimates from the consultation phase putting that at between 2-6 hours. The production of simplified and cheaper reader technology with the ability to display EID and NLIS visual information may assist.

Incompatibility between RFID stick readers, weigh scales, on farm software and eNVD third party providers is another key barrier. The physical and logistical issues with reading tags and reading large volumes of tags are important. Simple facility design and capability is a key barrier. The eNVD must operate at the crush and be mobile ready.

The link between third party providers and the overall ISC / LPA system is important. Producers resort to using the ISC system to avoid software and hardware incompatibilities.

6.3.3 Data issues

Producers do not have a culture of sharing data or information. Market signal control and the position of being a price taker in modern markets has restricted producers' ability to see win-win situations for data sharing. Several producers cited poor experiences with loss of data control in terms of livestock prices and access to markets.

Producers also noted that failure to understand where their data is transferred to is a barrier. However, lot feeders noted that electronic data provided an easier mechanism for doing an audit of compliance against HGP etc.

Increasing market sophistication is driving more accountability and therefore greater need to collect, manage, and report on data. However, larger value chain participants by nature generally are reluctant to contribute data where they believe a market position or advantage may be lost.

Data collected for compliance that is not then used for decision making appears to be valued less by producers. Effort is commensurate with obtaining minimal standards rather than achieving best quality.

Another issue with the eNVD is the inability to accurately describe cattle numbers and descriptors at the time of dispatch. A key example is the notification of breeding units, be that cows and calves or ewes and lambs. The number of cows and number of calves or the number of ewes and the number of lambs need to be recorded separately, as it is not possible to record them as the number of cow/calf or ewe/lamb pairs.

Loss of and nonreadable tags is another key issue, leading to a loss of lifetime traceability. In some markets there are direct penalties associated with loss of lifetime traceability, whilst other markets simply make such animals ineligible for that market (both feedlots and processors).

Also, one-way transfer of data without feedback is a key issue. In this sense, the underpinning requirement that the data originator (being the producer) should benefit (or have the right to benefit) from the data is not obvious. In the case of the NVD, and therefore the eNVD, this right of benefit is not associated with direct market access and hence producers fail to recognise benefit for effort.

Other barriers identified include a lack of a formal answer to the questions '*does the eNVD assist with the auditing process?*' and '*will producers be able to access information effectively and efficiently using the eNVD platform?*' These are valid barriers and there would be significant value in quantifying and verifying these capabilities. However, such metrics are not available. The generation of a case study that demonstrates and quantifies these benefits would be a desirable activity.

For purchasers using the eNVD system (mainly backgrounding producers), the inability to transfer information from the eNVD to their own farm records is a key barrier. The concept of a 'ebook' for eNVD will be discussed further in the eNVD adoption logic framework.

It was noted that carriers (transporters) often change and therefore their details need to be updated after consignment (which may suggest the need for a printing option). Producers perceived that there was less flexibility in change and management of the eNVD.

6.3.4 Skills

Producers generally are active, hands-on learners, with a large proportion of knowledge transfer occurring either intergenerationally or through contact with other producers (farmer to farmer transfer). A lot of knowledge learning is through direct trial and observation which effectively builds an intuitive position for producers. A significant number of producers participate in livestock production for reasons other than direct business profit, which means that increased monetary value may not always translate into a direct motivation. Low technical (digital) skill and fear of becoming too technically orientated compared to using 'gut feel', acquired intuition and industry wisdom are key barriers. A similar barrier exists with genetic selection, eye vs objective measurement.

Frequency of use is also a key issue. Producers who routinely use the eNVD are more likely to be confident in its use. On the other hand, producers that only use it 3-4 times per year often forget simple processes and instructions and this becomes frustrating at point of use. The paper system requires less retained knowledge and learning. Smaller producers and lifestyle producers would see limited value in eNVD.

6.3.5 Technology

Integration of various forms of technology at farm level, being assured that that technology will work when required with no issue and having its immediacy at point of dispatch are key issues. Producers have indicated that eNVD is hard to complete in the office in advance as they are not always sure of animals to be transported or if animals listed on the NVD are not to be trucked for some reason (misadventure, illness, lack of fitness to load etc). The paper based NVD provides the flexibility of completing animal numbers, types etc at the point of dispatch.

6.3.6 Value proposition

The primary consideration is the tension between a 'direct price or monetary incentive' and a 'minimal position to ensure that compliance is met'.

Often, climate and market volatility reduce producer willingness to invest in agtech. Scale and access to capital are also major inhibiting factors to the uptake or adoption of digital technologies including the eNVD.

To vendors, there appears to be no direct value in the immediate access or transfer of information via the eNVD. It does not alter direct decision making. Data that can be used for immediate or future decision making has a greater value proposition. Most of the data collected on the eNVD is historical in nature and therefore has limited value for future decision making.

While paper based NVDs meet the minimum standard, they remain a barrier to adoption of eNVD. The 'what is in it for me' proposition to migrate to an eNVD where 100% confidence that the system works at the time it is needed is a key barrier.

An additional complication is that several stakeholders confuse the eDEC with an eNVD. As a result, producers see the eNVD as just an electronic version of the book and do not actually see the benefits of an active data management system that the eNVD potentially provides. Removal of the eDEC will assist this, however the eDEC may be an effective intermediate technology that stimulates interest in the eNVD. This is a double-edged sword that requires careful consideration.

Furthermore, there is no market incentive for producers or feed lots to provide eNVD for many processors which the exception of Coles. In that case, Coles has made an active and progressive approach by facilitating the introduction and preference for the eNVD. Whilst incentives usually consist of either price or market access, enhanced feedback systems based on carcase or animal health such as in LDL offer significant opportunities in terms of establishing a clear value proposition.

An additional barrier is that the eNVD itself is not specifically a commercial product. Several software providers identified that the eNVD needed to be integrated with other on-farm activities and management interventions. An effective digital livestock management system (through commercial providers) that links to the eNVD would be a key enabler of adoption. For many producers, the eNVD is seen as just one element of a migration to digital livestock data management. So, it is not simply the value proposition of the eNVD that needs to be satisfied, but also the value proposition of investment in on-farm digital livestock data management systems. This transition has costs in both time (learning) and capital with software and hardware.

6.3.7 Social

As the NVD and eNVD are critical components of the overall LPA integrity system that is managed by the ISC on behalf of industry, access and confidence in industry structures, databases, and ownership rules impact some stakeholders' willingness to embrace and adopt these technologies. Trust in industry-led systems is a critical barrier. Such trust is gained through positive experiences and confidence in the system to safeguard against potential food safety and market access issues. Trust is lost when the system either fails the individual through challenges with data reporting or transfer etc. The eNVD must obtain a confidence level higher than the current paper based NVD for transfer of data. In this case 100% transfer rates are usually demanded which is a high barrier to overcome.

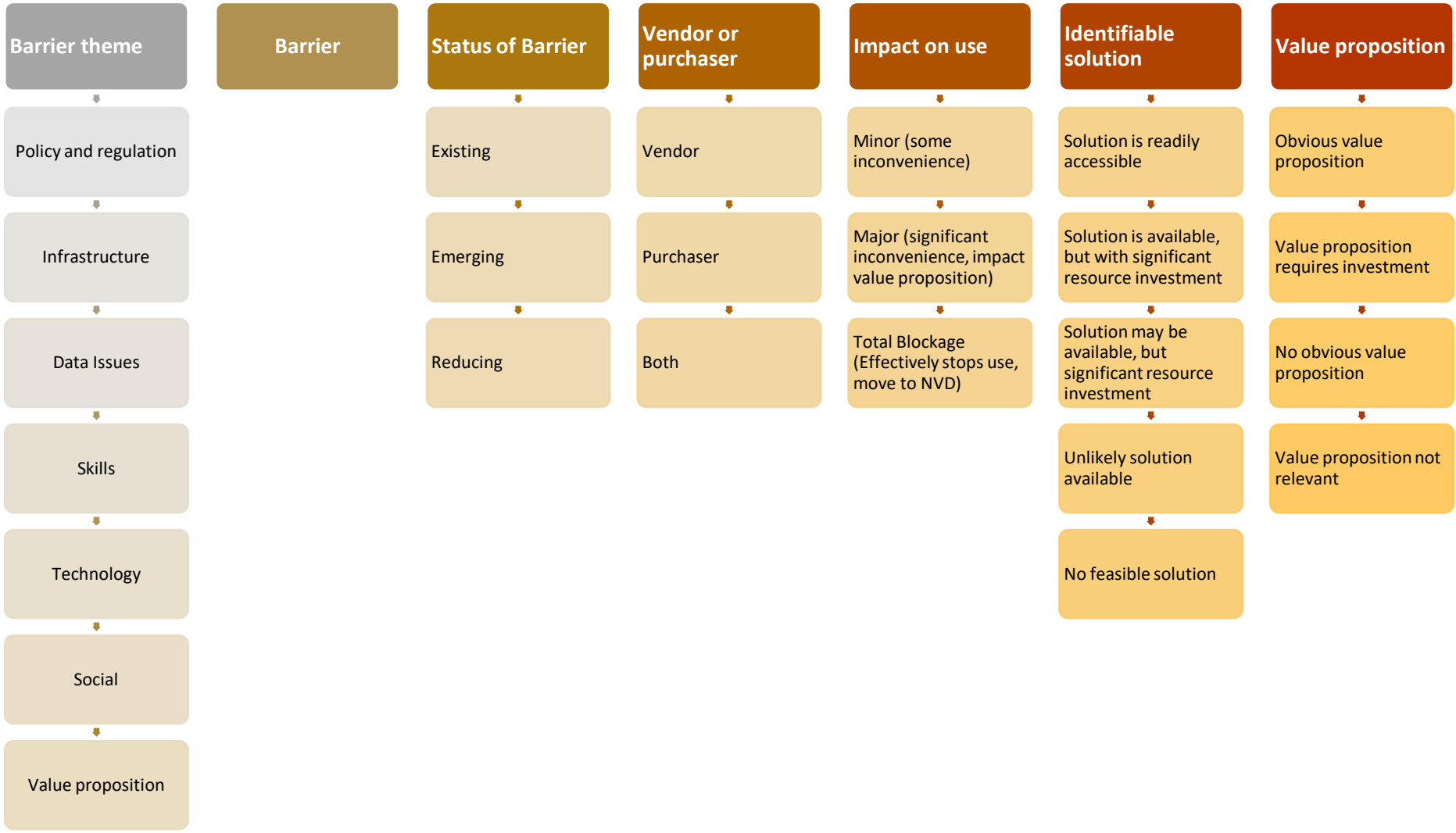
Producer attitudes to innovation and technology, access to capital, scale, frequency of use, debt ratio etc are all factors that influence adoption of technologies. As a significant proportion of producers use the rural agency network in the sales transaction, those intermediaries' attitudes to technology can have a very profound impact. Motivation is the still the key factor, but what drives motivation differs between producers. Producers that are more engaged with the 'value' of a differentiated or 'superior' product are more likely to be engaged with digital technology. Traders working on margins see minimum compliance as containing costs.

6.4 Assessment process

A rubric assessment framework was created for the eNVD (see Figure 16). This tool will be used to rank and prioritise barriers to adoption of the eNVD that will be obtained from consultations with industry stakeholders. That data will be used to identify key solutions to the critical barriers and then to inform the adoption plan in the final report. Each barrier identified through the consultations will be classified into one of the barrier themes (column one, Figure 16) and then rated according to the assessment standards listed in the other columns.

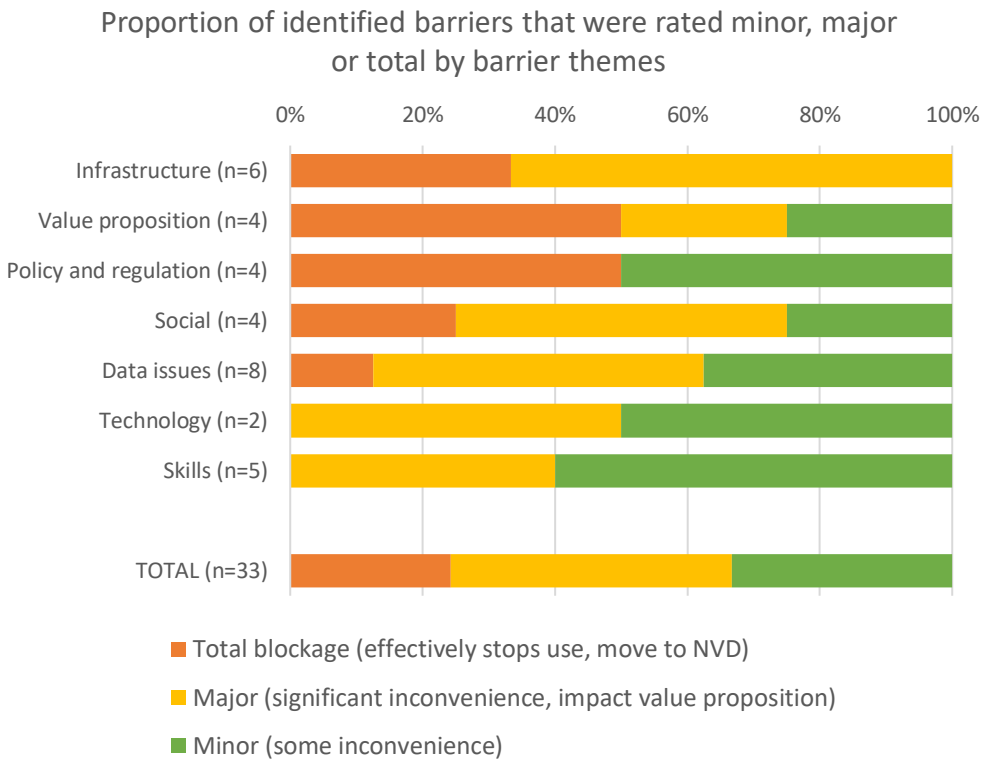
See section 8 (Appendix 1. Rubric assessment of barriers to adoption of eNVD) for more details including the ratings proposed, and a list of 33 barriers proposed as a starting point for consultation.

Figure 16. Rubric elements and assessment standards for each criterion for the eNVD.



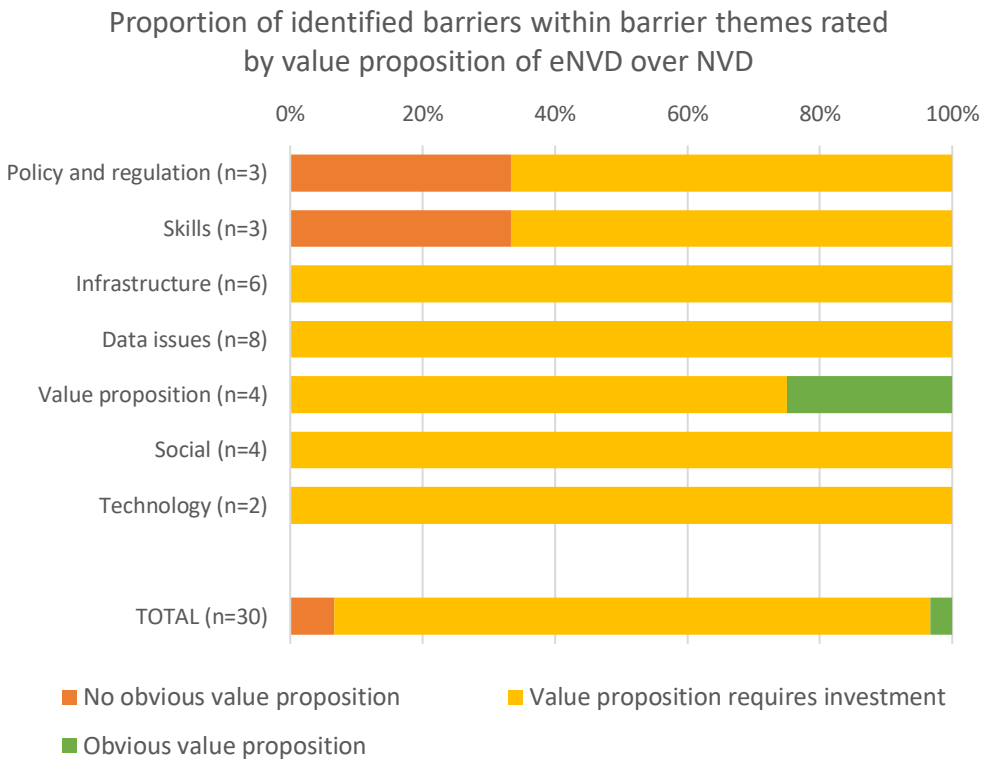
To demonstrate the application of the rubric assessment framework, 33 eNVD barriers identified by the project team were evaluated. Those barriers are shown in Table 14 (Appendix 1). A summary of the barriers (grouped by theme) by impact is shown in Figure 16. There were a higher number of barriers identified in data issues and infrastructure, with many of those barriers having a major impact or an effective total block on adoption of the eNVD. Importantly over 60% of the identified barriers were either 'major' or 'total blockage' in impact. Confirming or adjusting these findings will form the basis of the project's consultation phase.

Figure 17. Summary of barrier by theme and by impact as rated internally



As noted previously within this report, a lack of an identifiable value proposition is one of the key barrier themes. In this case study, the rubric was used to quantify the position of the eNVD relative to the paper based NVD in terms of the value proposition (see Figure 18). In most barriers identified there was either no obvious value or the value that could be extracted required investment. As a result, overall, there is a clear message that adoption of the eNVD is very much inhibited by a lack of a compelling value proposition when compared to the NVD. This supports the inclusion of a clear focus on solutions that address the value proposition of the eNVD and the conclusion that value proposition should be the highest priority in the adoption plan for the eNVD.

Figure 18. Value proposition of movement from NVD to eNVD for identified barriers within barrier themes



A full summary of the current rubric analysis of barriers to eNVD is contained in appendix 1.

6.5 Consultation with industry stakeholders on the eNVD

Section 3 provides details on the consultation process conducted to ascertain industry stakeholders' attitudes to the adoption of digital technology. A detailed semi-formal questionnaire was developed based on the criteria set within Table 13 and the rubric assessment shown in Figure 16. This questionnaire not only sought confirmation and ratings on barriers and solutions but was also used to identify any additional barriers (and solutions) not identified by the project team. Within that semi-formal questionnaire there were 4 questions concerning the use of, the barriers to and suggested improvements to the eNVD.

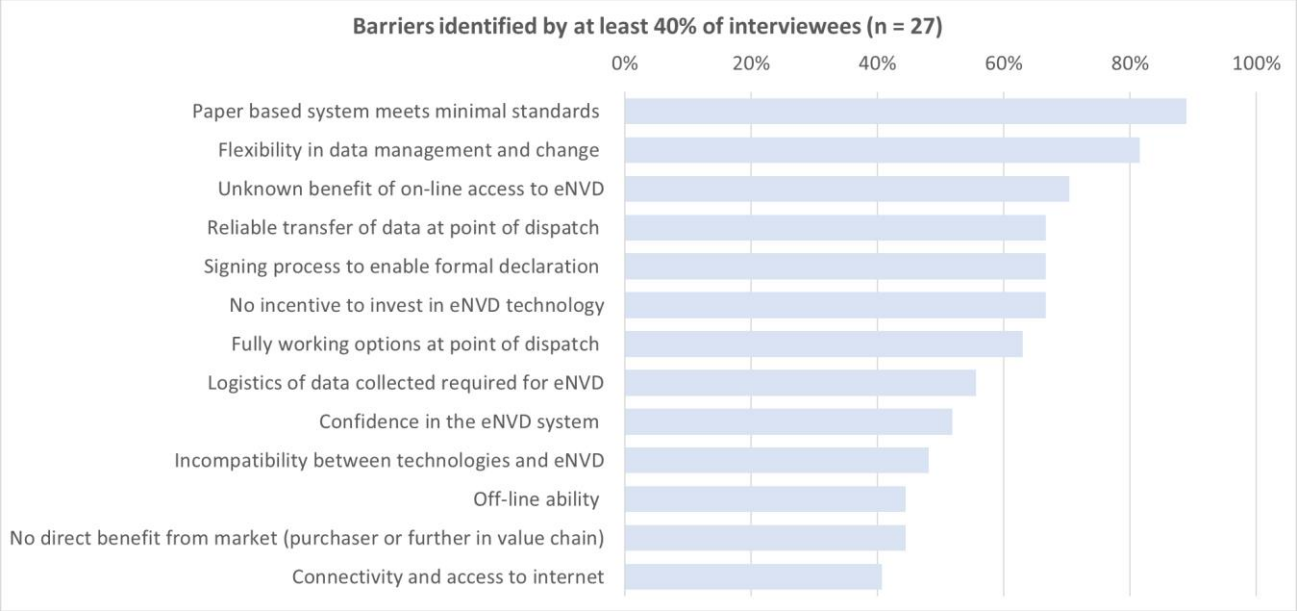
Of the 27 industry stakeholders interviewed, 24 had direct knowledge or experience with the NVD and the eNVD. Of those 24 interviewees, 9 have used and continue to use the eNVD (39%), which is higher than expected given industry survey information. This probably reflects the high level of industry engagement in the selected interviewees (sample bias).

Common reasons for eNVD use included paperless system, time saving, accuracy of information and easy transfer of information. None of the eNVD users had formally or informally completed an assessment of the value proposition of the eNVD. Most of the users were industry stakeholders who had high digital technology literacy and could be considered as early adopters. In a few cases adoption was driven by the purchaser requirements (see Coles eNVD version). An important observation was that several users of the eNVD indicated that they continue to use the eNVD under sufferance and without confidence. They cited issues with data accuracy, flexibility in data entry and change management, and issues with additional declarations and transport regulations as key

barriers that will need to overcome to get mainstream adoption of the eNVD. These responses have been included in the barriers to adoption analysis.

The responses to the 'barriers to use of the eNVD' question were categorised within the themes listed within the rubric. That categorisation was either as 'yes or no' answer to the barrier. The highest-ranking barriers to adoption (at least 40% of respondents citing the barrier) of the eNVD are shown in Figure 19.

Figure 19. Highest ranking barriers to adoption of the eNVD from the industry consultations.



It is obvious from this analysis that although the barriers have been treated as separate items, there are strong interrelationships between all the higher-ranking barriers. For example, the flexibility in data management and change is highly associated with reliable transfer of data and having fully working options at the point of dispatch. Hence these key features that the industry stakeholder is seeking already exist within the paper based NVD and need to be replicated in the eNVD.

The current paper based NVD has significant perceived advantages over the eNVD for 12 out of the 14 highest-ranking barriers. It is not surprising that the highest ranked barrier to adoption for the eNVD (90%) is that the current paper based NVD satisfies the minimal compliance standards for LPA. To reiterate, for producers, feed lotters and processors, the current paper based NVD is fulfilling the most basic requirement of the integrity system.

Many industry stakeholders noted that, as the current paper-based system is set to remain for some time, they will have to run dual systems to manage both the paper NVD and eNVD. For these stakeholders, transitioning to the eNVD is a low priority whilst the paper NVD remains an active component of national traceability system.

The observations from the consultations show that, in general, providing solutions to policy and regulation, data issues and value proposition barriers are the most critical to eNVD adoption, while infrastructure and technology barriers are intermediate and skills and social are ranked much lower in comparison.

One interesting observation is that confidence in the eNVD system was identified as an intermediate barrier (52%), with both users and non-users citing several examples of where the eNVD had failed

in data transmission, flexibility, acceptance by intermediaries such as transport operators or in simple 'loading ramp' dispatch/ receival accuracy (that is, numbers of animals on the eNVD that were loaded or received). Several non-users relayed comments about experiences of 'others' which suggests that the traditional key adoption pathway of producer-to-producer information sharing is actually inhibiting the eNVD.

A further quite surprising observation was that internet access was only an intermediate ranked barrier (40%) despite the geographic distribution of the interviewees being highly skewed to regional and remote areas within Australia. A few interviewees indicated that it was the LPA and NLIS systems that resulted in difficulties rather than direct internet access. They also stated that internet access could be solved through capital investment, but inefficiencies in the system that cause time loss is a much greater disincentive for the eNVD.

6.6 Proposed adoption logic framework for the eNVD

Throughout this report, within the relevant sections, key implications or insights that are important to the acceptance or adoption of the eNVD have been highlighted. A key outcome from the literature review and from examples in other industries is that producers (and feed lots) generally will consider several different elements simultaneously and perhaps intuitively around the areas of value proposition, decision making, confidence, and risk of failure (as illustrated in Table 3). Moreover, the adoption of the eNVD by the different sectors of the livestock value chain is most likely driven by quite different combinations of the above-mentioned elements.

The rubric assessment (see Figure 16) shows that there are several critical barriers that need to be resolved or at least tempered in terms of barrier impact. Interestingly, in many cases, almost all these elements must be satisfied before the technology is adopted which potentially reflects the inherently conservative nature of producers. This differs from corporates and feed lots where value proposition has a clear overriding impact on adoption.

The following suggested stage-gate adoption plan has been formed for the eNVD. This process has also been developed based on the rubric analysis and the incorporation of information received during the consultation phase. It is also consistent with the overall adoption logic proposed for agtech generally and has been compared (road-tested) with industry consultation feedback on what would potentially encourage the stakeholder to adopt the eNVD.

A critical objective or key decision point within the initial stage-gate of product evaluation is the simple question of whether the outcome is to completely replace the current paper-based solution with the eNVD (which is not foreseeable within the short-medium term) or whether the eNVD should be promoted as an alternative that will appeal to certain stakeholders. Given that it is not within the remit of this project to answer that question, the stage-gate adoption plan has been constructed to achieve the second outcome.

6.6.1 eNVD stage-gate adoption plan

Table 12. Stage-gate adoption plan for eNVD case study.

Stage-gate phase	Key activities or actions	Responsibility (priority)
Phase 1. Product awareness and evaluation		
• **Ensure the robustness and operational effectiveness of the eNVD**	• To facilitate widespread adoption, eNVD solutions should have the ability to operate with or without internet connectivity. Ensure and promote eNVD off-line capability and ability to produce printed versions of all documentation. • The eNVD must provide flexibility to alter/correct data before finalising at loading ramp dispatch. The final eNVD must be sent or scheduled for sending at this point. • The signing process should include the incorporation of a digital signature that verifies proof of dispatch. • The eNVD must be totally interfaced with all other industry declarations including MSA, cattle health certificates, NFAS etc. • The eNVD must have a visual image of the document that can be sent to intermediaries to satisfy transport authority requirements (waybill etc). • Standardised data interchange formats must be defined to allow data movement between all implementations of the eNVD. • Ensure that the eNVD has customisable autofill and auto-checking capability that can switched on and off by the user. • Establish a clear timeline for potential phase-out of paper-based NVD (say 5 years).	ISC and /or software provider (critical)
• **Value proposition**	• Quantify the economic value of eNVD in terms of time saving and improvement in addressing audit requirements. Complete a time study and	ISC (critical)

	semi-formal BCA that can be promoted publicly and can be verified. Complete for at least 5 different sub-sectors of industry. • Complete full infrastructure requirements for the eNVD including hardware requirements (PC, laptop etc). • Consider greater incentives for trusted third-party software providers to integrate eNVD capacity within standard on-farm software offerings. • Work with AMPC to establish an incentivised uptake of the eNVD through processors providing additional information on animal health, yield and eating quality.[9] • Complete analysis of NVD vs eNVD in auditing process and promote outcome (both time and accuracy of audit). • Identify the position of the eNVD in the livestock agtech roadmap. Highlight interoperability with other agtech.	
• **Promote data regulation positions of the eNVD**	• Clearly articulate and promote all data standards and data protection protocols relating to eNVD to ensure compliance. • Ensure that only those eNVD implementations that comply with the defined data standards are certified. • Promote industry aggregation and compliance reporting as essential to industry confidence and market credibility.	ISC and certified software providers (critical)
Phase 2. Confidence in product's future		
• **Reignite confidence and trust in the ISC eNVD** • **Complete thorough road test with commercial partners**	• With either ISC eNVD or commercial partner, trial eNVD with a group of early adopters to iron out the bugs and practical problems (process difficulties). • ISC should develop, or contract development of, supporting material that addresses the 'product awareness and evaluation' dot points that potential users will be considering. There will also be a need to conform to regulations or seek to have these amended – for example, variations in the documentation required by transport operators, or digital certification of copies of declarations. • Promote 'value chain based' eNVD solutions to demonstrate robustness of eNVD and ISC systems.	ISC (critical)

[9] Digital transformation roadmap. Benefits, readiness, responsibility, and digital maturity assessment.

• **Replicate critical features of the NVD**	• Ensure that data flexibility is paramount. • The eNVD system should consider a 'eBook' concept that effectively positions all eNVDs sent and received within a format that has the equivalent operational functionality of the current paper book. This includes the capacity to scan and link received paper NVDs into the 'eBook' for the stakeholder. This 'eBook' should be meet all requirements of a third-party auditor. • Consider the design of the eNVD to replicate the current NVD as an on-line tool that can be edited directly. • Construct, with the assistance of transporters, a dedicated app for livestock transporters to provide a copy of the signed eNVD quickly and efficiently as a waybill within certain states.	ISC (best practice) should develop prototype 'eBook'
Phase 3. Availability of enablers		
• **Demonstrate 'value' beyond compliance**	• Establish linkage to 360° feedback systems for data within eNVD. Develop aggregated insights that are only available to data supplied within eNVD format to create point of difference beyond compliance – for example, 'breed' or 'geographic' aggregation summaries of livestock sold by month and by type or direct relationships between on-farm animal health records and antemortem health data.	ISC and MLA (best practice)
• **Establish network of accredited enablers and promote simplicity of eNVD usage**	• Establish 10 working case studies with updated fully functional eNVD (with 'ebook'). Ensure that case studies are located within Northern Beef, Feedlot, Southern Beef and Sheep. Each case study should have designated service provider. • Build on-line eNVD tutorials lead by producers, agents and processors rather than ISC staff. • Build a pyramid of service providers (potentially within the private and agency sector) that can provide independent support. • Consider the use of Zoom or other video conferencing facilities to enable more face-to-face training opportunities with producers.	ISC and stakeholder partners (best practice)

Recommendation 12.	ISC and MLA should consider an 'eBook' concept that effectively positions all eNVDs sent and received within a format that has the equivalent operational functionality of the current paper book.

Throughout the consultation phase of this project, a common theme that emerged was that the eNVD has unfortunately already obtained a negative reputation across the whole livestock value chain. This reputation is restricting industry uptake, particularly with producers, with several interviewees indicating that they were unwilling to move to eNVD as it has many issues, despite their not having direct experience with the eNVD. In addition, the inclusion of 'NVD' in the eNVD product description provides an additional barrier to adoption through a few stakeholders simply having less than satisfactory experiences with the NVD, LPA or the NLIS system.

Furthermore, there are several clear advantages that the electronic transfer of data offers partners in the value chain, over and above the direct information contained within the eNVD. At present, despite having the eNVD, there are limited ways in which data can be extracted for further use. The current 'print' only capacity of historical eNVDs is an exemplar of this critical limitation. Information around breed, sex, age, health treatments, vendor vs non-vendor bred etc are all important sources of information that can be used to directly impact on both management and future marketing decisions. That information needs to be directly accessible from the NVD and then integrated into on-farm management software or included in future livestock transactions.

Putting these two observations together leads to a recommendation that ISC consider further developing the concept of a broader electronic livestock data sharing platform that allows for customisable data inclusion and extraction for a range of purposes in addition to the NVD. In essence, this would be a data harvesting and transfer architecture for the livestock industry. The eNVD would become one of the modules of an integrated system and could be rebranded – potentially still with NVD but as a '2nd generation' digital product (the 'DNVD'). This would allow ISC and other partner software providers to 'market' a differentiated product to that proportion of the industry that have already formed conceptual barriers to the eNVD.

Recommendation 13.	ISC and MLA should consider the development of a next-generation integrated livestock data platform that includes a 2nd-generation digital NVD module ('DNVD').

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Note: additional references that were considered but not directly referenced in the preparation of this report are included in Appendix 3.

8 Appendix 1. Rubric assessment of barriers to adoption of eNVD

A rubric has been prepared to provide a consistent approach to assessing each barrier considered during the consultation phase of the project. In developing this approach, 33 barriers were identified and assessed.

Each of the identified barriers was classified into one of the following seven barrier themes:

- Value proposition
- Data issues
- Infrastructure
- Policy and regulation
- Skills
- Social
- Technology.

The stage of the supply chain that is likely affected by the barrier was recorded using one of the following supply chain actors:

- Breeder
- Finisher
- Carrier
- Agent
- Saleyard
- Feedlot
- Processor

To allow a quantitative comparison between the identified barriers, five attributes were assessed and given a rating using the following table. Higher ratings indicate an expected poorer level of adoption. Varying these ratings can change the weighting of each attribute and the assessment levels for an attribute.

Table 13. Table of assessment standards and ratings for each of the attributes evaluated.

Barrier	Assessment standards				
Status of barrier	Existing	Emerging	Reducing		
Rating	2	1	1		
Vendor or Purchaser	Vendor	Purchaser	Both		
Rating	1	1	2		
Impact on Use	Minor (some inconvenience)	Major (significant inconvenience, impact value proposition	Total Blockage (Effectively stops use, move to NVD)		
	1	2	3		
Solution is identifiable	Solution is readily accessible	Solution is available, but with significant resource investment	Solution may be available, but requires significant investment	Unlikely solution is available	No feasible solution
	1	2	3	4	5
Value proposition	Obvious value proposition	Value proposition requires investment	No obvious value proposition	Value proposition not relevant	
	1	2	3	0	

The completed rubric with both the qualitative assessment levels and the ratings is presented in the following table. During the consultation phase of this project, this list of barriers will be reviewed, and extra barriers added, and then all assessments reviewed.

Table 14. Example of barriers identified with assessments and ratings. The assessments presented were given by the project team. During the project's consultative phase, these assessments will be tested along with any additional barriers that are identified.

Barrier theme	Barrier identified	Status of barrier	Impact point in the value chain	Vendor or Purchaser	Impact on use	Identifiable solution	Value proposition of eNVD vs NVD	Rating-Status of barrier	Rating-Vendor or Purchaser	Rating-Impact on use	Rating-Identifiable solution	Rating-Value proposition of eNVD vs NVD
Policy and regulation	Paper based system meets minimal standards	Reducing	Breeder	Both	Total Blockage (Effectively stops use, move to NVD)	Solution is available, but with significant resource investment	No obvious value proposition	1	2	3	2	3
Policy and regulation	Limited understanding of link between LPA and market access	Existing	Breeder	Vendor	Total Blockage (Effectively stops use, move to NVD)	Solution is available, but with significant resource investment	Value proposition requires investment	2	1	3	2	2
Policy and regulation	Access to information on ESI and WHP	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is readily accessible	Value proposition requires investment	2	1	1	1	2
Policy and regulation	Signing process to enable formal declaration	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is readily accessible	Value proposition not relevant	2	1	1	1	0
Infrastructure	Connectivity and access to internet	Existing	Breeder	Vendor	Total Blockage (Effectively stops use, move to NVD)	Solution may be available, but significant resource investment	Value proposition requires investment	2	1	3	3	2
Infrastructure	Cost of internet services	Reducing	Breeder	Vendor	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	1	1	2	2	2

Barrier theme	Barrier identified	Status of barrier	Impact point in the value chain	Vendor or Purchaser	Impact on use	Identifiable solution	Value proposition of eNVD vs NVD	Rating-Status of barrier	Rating-Vendor or Purchaser	Rating-Impact on use	Rating-Identifiable solution	Rating-Value proposition of eNVD vs NVD
Infrastructure	Reliable transfer of data at point of dispatch	Existing	Breeder	Vendor	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	1	2	2	2
Infrastructure	Capital costs of tags, readers, on-farm supporting software	Existing	Breeder	Both	Total Blockage (Effectively stops use, move to NVD)	Solution is available, but with significant resource investment	Value proposition requires investment	2	1	2	3	2
Infrastructure	Incompatibility between technologies and eNVD	Emerging	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	1	2	2	2	2
Infrastructure	Logistics of data collected required for eNVD	Reducing	Breeder	Vendor	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	1	1	2	2	2
Data Issues	Culture of data sharing	Reducing	Breeder	Both	Total Blockage (Effectively stops use, move to NVD)	Solution is readily accessible	Value proposition requires investment	1	2	3	1	2
Data Issues	Loss of data control	Emerging	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	1	2	2	2	2

Barrier theme	Barrier identified	Status of barrier	Impact point in the value chain	Vendor or Purchaser	Impact on use	Identifiable solution	Value proposition of eNVD vs NVD	Rating-Status of barrier	Rating-Vendor or Purchaser	Rating-Impact on use	Rating-Identifiable solution	Rating-Value proposition of eNVD vs NVD
Data Issues	Lack of perceived benefit in sharing data	Existing	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	2	2	2	2
Data Issues	Low use of data outside of compliance	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is available, but with significant resource investment	Value proposition requires investment	2	1	1	2	2
Data Issues	Loss of lifetime traceability	Existing	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution may be available, but significant resource investment	Value proposition requires investment	2	2	2	3	2
Data Issues	Unknown benefit of on-line access to eNVD	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is readily accessible	Value proposition requires investment	2	1	1	1	2
Data Issues	Linkage with third party software providers (data in and out)	Existing	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	2	2	2	2
Data Issues	Flexibility in data management and change	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is readily accessible	Value proposition requires investment	2	1	1	1	2
Skills	Traditional methods of knowledge transfer (farmer to farmer)	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is readily accessible	Value proposition not relevant	2	1	1	1	0

Barrier theme	Barrier identified	Status of barrier	Impact point in the value chain	Vendor or Purchaser	Impact on use	Identifiable solution	Value proposition of eNVD vs NVD	Rating-Status of barrier	Rating-Vendor or Purchaser	Rating-Impact on use	Rating-Identifiable solution	Rating-Value proposition of eNVD vs NVD
Skills	Low digital technology awareness and competence	Existing	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	2	2	2	2
Skills	Part-time livestock producers with smaller scale	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is readily accessible	No obvious value proposition	2	1	1	1	3
Skills	Fear of data collection	Emerging	Breeder	Vendor	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	1	1	2	2	2
Skills	Frequency of use, retained skills set	Reducing	Breeder	Both	Minor (some inconvenience)	Solution is readily accessible	Value proposition not relevant	1	2	1	1	0
Technology	Fully working options at point of dispatch	Reducing	Breeder	Vendor	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	1	1	2	2	2
Technology	Off-line ability	Reducing	Breeder	Vendor	Minor (some inconvenience)	Solution is available, but with significant resource investment	Value proposition requires investment	1	1	1	2	2
Value proposition	No incentive to invest in eNVD technology	Existing	Breeder	Both	Total Blockage (Effectively stops use, move to NVD)	Solution is available, but with significant resource investment	Value proposition requires investment	2	2	3	2	2

Barrier theme	Barrier identified	Status of barrier	Impact point in the value chain	Vendor or Purchaser	Impact on use	Identifiable solution	Value proposition of eNVD vs NVD	Rating-Status of barrier	Rating-Vendor or Purchaser	Rating-Impact on use	Rating-Identifiable solution	Rating-Value proposition of eNVD vs NVD
Value proposition	No direct benefit from market (purchaser or further in value chain)	Existing	Breeder	Vendor	Minor (some inconvenience)	Solution is available, but with significant resource investment	Obvious value proposition	2	1	1	2	1
Value proposition	Confidence in the eNVD system	Existing	Breeder	Vendor	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	1	2	2	2
Value proposition	Resource costs in linkage to other digital technologies and systems	Emerging	Breeder	Both	Total Blockage (Effectively stops use, move to NVD)	Solution is available, but with significant resource investment	Value proposition requires investment	1	2	3	2	2
Social	Trust in industry systems	Emerging	Breeder	Both	Total Blockage (Effectively stops use, move to NVD)	Solution may be available, but significant resource investment	Value proposition requires investment	1	2	3	3	2
Social	Producer attitudes to innovation and technology	Existing	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	2	2	2	2
Social	Agency network attitudes to innovation and technology	Existing	Agent	Both	Minor (some inconvenience)	Solution is readily accessible	Value proposition requires investment	2	2	1	1	2

Barrier theme	Barrier identified	Status of barrier	Impact point in the value chain	Vendor or Purchaser	Impact on use	Identifiable solution	Value proposition of eNVD vs NVD	Rating-Status of barrier	Rating-Vendor or Purchaser	Rating-Impact on use	Rating-Identifiable solution	Rating-Value proposition of eNVD vs NVD
Social	Linkage to differentiated value-add market	Existing	Breeder	Both	Major (significant inconvenience, impact value proposition)	Solution is available, but with significant resource investment	Value proposition requires investment	2	2	2	2	2

9 Appendix 2. Technology Scan

The table in this appendix is a preliminary list of digital technologies available to the Australian livestock industry. This list will be refined using information from the other Foundational Projects.

Table 15. List of livestock related digital technologies (Agtech) available to the Australian livestock industry.

Product or Service	Species / Comment	Description
Agriscan Veterinary Ultrasound http://www.agriscan.com.au/	Species: Cattle, Pigs, Sheep, Goats • RFID tags, reader • Reader connects to weigh-scale head via Bluetooth	Agriscan is a boutique supplier of quality affordable animal UHF RFID electronic id and ultrasound equipment. Our products include: 1. Agriscan - UHF RFID (RAIN) fixed station reader and UHF RFID Livestock tags for Cattle, Sheep, Goats and Pigs. 2. Agriscan - Livestock Ultra-sound devices for Cattle, Sheep, Goats and Pigs. (Pregnancy testing)
AgUnity App Axsari http://www.agunity.com/	• Transaction tracking along supply chain • Storage via Blockchain and cloud	The AgUnity App permanently stores transaction records between the various agricultural value chain stakeholders including smallholder farmers, cooperatives, processors and manufacturers. All transactions, including those between farmers and cooperatives, are securely tracked via a smartphone and recorded on the Axsari blockchain and cloud. This becomes a way for farmers to cooperate, store value, save money and easily buy products and services. Axsari is a platform which solves many of the connectivity and support issues companies face when deploying solutions in remote or regional locations. The Axsari platform is a modified and locked down version of the Android smartphone operating system specifically designed to address challenges faced in areas of limited connectivity or low-bandwidth telecommunications. Axsari employs a communication framework that resolves real-time connectivity requirements and provides alternative means of connectivity separate to mobile data plans. Where AgUnity also issues devices, each device is secured to an individual user identity at the OS level thereby increasing the overall system security. Axsari is

Product or Service	Species / Comment	Description
		substantially more secure platform than most mobile or internet banking platforms used in the industry.
Animal detection http://www.ninox-robotics.com/	• Cover large areas, act on real-time information, plan your future. • Distribution maps, Baiting plan, Coordinated hunting	Delivering practical and cost-effective aerial intelligence through leading edge Remotely Piloted Aircraft Systems (RPAS) services.
Asset Registration and Tracking - BeefLedger https://beefledger.io/	• Blockchain solution for global supply chains	Register your asset - whether its livestock or a box of beef - with a Unique Identity for security to our blockchain. Once registered, the asset can be tracked through events including loading and unloading as it is moved from place to place. Other asset attributes can also be updated securely on the blockchain to provide an immutable record of your assets throughout their life.
Automed https://automed.io/	• Beef, Swine, Sheep, Poultry • Medication dose control	automed is paving the way forward for livestock producers of all sizes. With one single system, producers can automatically calculate, deliver and record livestock treatments whilst effectively managing and optimizing their operation. The automed system combines a sleek and ergonomic medication delivery device with a simple and easy-to-use App, enabling both fixed and weight-based treatments. automed offers a range of Adapters (3mL, 10mL and 20mL) that are fitted to the delivery device to suit a variety of dosing methods (injection, intranasal, oral/drench and pour-on). The automed system integrates with existing livestock tools including most third-party weight-scales and RFID readers, and many farm management platforms. automed also offers a comprehensive inventory management system for tracking, requesting and managing stock in multi-site operations. Tamper-proof treatment records, animal history, and data analytics ensure that automed is the complete compliance and traceability system for medication in the livestock industry.
Beef Marketing Program from GrowSafe Systems	• Individual animal performance	The Beef Marketing Program provides our partners with the information they need to review individual animal performance, identify poor performers, and predict and

Product or Service	Species / Comment	Description
https://growsafe.com/	• Data platform • Analytics	monitor gain. The program runs on the GrowSafe Data Platform, which is an integrated data decision support tool that incorporates our GrowSafe Beef (GSB) hardware, software and advanced analytics, providing physical sensing, predictive analytics and cognitive computing. The GSB hardware measures individual animal partial body weights and watering behavior. Our software and predictive learning algorithms automatically mine this collected partial body weight data, along with frequency and duration at the water trough. It then analyses and learns individual and group patterns, reporting predicted individual animal live weight, gain and performance flags.
Bluebell Smart Ear tag http://www.smartpaddock.com/	• Individual animal monitoring – temperature, activity, location • Smartphone dashboard	The Bluebell tag which attaches securely onto the ear of each animal and monitors the temperature, mobility, and geo-location, which the producer can easily access from a web dashboard or mobile phone application. These tags are inexpensive, reusable and can transmit data over long distances in remote areas.
BodyTrace, FoodChain from Cedar Creek Company https://cedarcc.com/	• Traceability through abattoir • eNVD provider •	Cedar Creek Company's proprietary bodyTRACE is an essential component in providing traceability from live animal to carcase to carton. How it works The system scans and records each animal eID at the knocking box, correlates with the body NLIS number and the correct PIC on the kill agenda, then matches each carcase with a unique hook embedded with an RFID tag. Both hook and body travel through the whole production facility together – through the kill floor, chillers, boning room or via carcase loadout. Scanners in key locations allowing the collation of key data for each animal. This allows for improved pre-slaughter management and production decisions as detailed information per carcase is available in real time. Individual carcase correlation opens the door to value-add solutions such as: • automated chiller marshalling

Product or Service	Species / Comment	Description
		• automated animal health recording • un-staffed grading and assessment stations • removal of tickets • detailed inventory and product status control • web-feedback to buyers and producers to help improve growing FoodChain is Cedar Creek Company's proprietary software system which integrates on-floor processing data capture, production control and Head Office reporting. The modular applications address the unique demands of the red meat, poultry and perishable food processing sectors. FoodChain acquires and manages huge volumes of raw data in real time and features seamless data flow throughout its tightly integrated modules. It enables information exchange and aggregation across all plants and individual processing stations. This includes livestock purchasing; kill floor systems; boning rooms; carcase transformation processes; objective measurement; sales; inventory; warehousing; loadout; and export. The integrated systems represent the highest level of industry best-practice and are certified for regulatory and legislative requirements. CCC's FoodChain system is an accredited and licensed provider of Meat Livestock Australia's (MLA's) Electronic National Vendor Declaration (eNVD). The software allows for the electronic declaration of animal movements straight into the NLIS database.
Cattle Eye http://www.cattleeye.com/	• Cattle monitoring using AI	CattleEye's mission is to create the world's first autonomous livestock monitoring platform improving the lives of farmers and their livestock and revolutionizing the Protein Supply Chain. Its' deep learning AI platform is designed to interpret visual imagery of livestock from web cameras and extract valuable insights about those cows.
Cattle Watch http://www.cattle-watch.com/	• Wireless cattle monitoring	Remote cattle monitoring system, including: • LoRa (wireless) based solution

Product or Service	Species / Comment	Description
		• Large pasture open area • Location • Real-time theft alert • Belt removable/cutting alert • Hostile and Illness alert • Geo-Fence • Herd counting every X minutes • Cattle's behavior monitoring (walking, grazing, laying, in-heat) • Cattle's all-live history events file.
CattleLink http://www.herdlink.com.au/	• Cattle herd monitoring	CattleLink is user-friendly software designed for the management of Beef Cattle Herds. It stores and records details of animals at an individual level, assisting with herd-management, breeding and assessment of cattle performance. The Farmer Friendly Program which has all the features required for Full Herd Management recording. CattleLink is designed and built by beef producers. It will assist you with your Breeding Programs, recording joinings, including AI or ET. It will assist you with your LPA & EU requirements. As well as recording animal treatments, etc, including batch details, expiry dates, etc Animal Performance with the ability to also compare animals, progeny, dams & sires with their weights, daily weight gains and traits. CattleLink is compatible with BreedPlan and the Breed Societies for calf registration, EBVOs, etc. CattleLink will allow you to import your Scale or NLIS Tag Reader data to reduce typing. Tag Readers can also be used online. New animals can also be created from either Scales or Tag reader data. Basic Paddock information can be stored in the Paddock section of CattleLink. A scanned document sections allow you to store and setup a basic library of your scanned documents such as Vendor Declaration forms, Feed Declaration Forms, Breed Society registration documents, etc. CattleLink can be setup on 2 PCOs/Laptops and database sharing between the two.
Draminski Animal Profi 2 http://www.advancedfarmsystems.com.au/	• Untrsound pregnancy scanning	A Livestock Pregnancy Ultrasound Scanner suitable for Livestock Breeders and Commercial Scanning Operators. This scanner features the unique capacity to

Product or Service	Species / Comment	Description
		interchange the probes from Cattle Rectal Wand, to a horse probe or smaller animal abdominal probes making it an ideal for all a Livestock Pregnancy Scanning.
Escavox http://www.escavox.com/	• Supply chain tracking •	Our service provides low cost, easy to use, automated supply chain tracking. Utilising our blue-box trackers, which travel with the product, data related to temperature, time & location is collected and transmitted as the product makes its way through the supply chain from farm to retail shelf. This data is automatically collected and curated on a secure data platform where customers' access their data. Data is presented on simple dashboards that allow visibility of the conditions to which produce has been exposed, at different points in the supply chain. The smart analytics employed allow cool chain integrity to be demonstrated and any issues with individual shipment to be easily identified, so quick and informed decisions made about the management of product. Data can be easily aggregated to help identify systemic issues. Customers can choose to share data with other supply chain parties, within the secure environment, if they wish. Customers pay per track rather than buying the tracker. So, there is no need to worry about trying to get expensive trackers back from wholesale or retail customers. Escavox takes care of the return logistics of the tracker and takes the hassle out of collecting and analysing the data.
eShepherd http://www.agersens.com/	• GPS enabled cattle tags • Virtual fencing and monitoring	Agersens eShepherd is a world first IoT driven platform comprising a solar powered neckband and a cloud-based application which farmers can use to fence, move and monitor their livestock. Neckbands contain a CSIRO patented program that trains livestock to recognise and stay within virtual boundaries by using an audio cue and an electric pulse. Farmers create or modify a virtual paddock using a web application on their laptop or tablet. The virtual fence GPS co-ordinates are sent wirelessly to each animal's neckband via an internet connected base station. The neckbands then operate autonomously to train each animal. eShepherd provides the following benefits: 1. enabling automated controlled grazing programs to increase pasture utilization, pasture biomass production and deliver more kilograms of beef per hectare or litres of milk per cow

Product or Service	Species / Comment	Description
		2. reduce the cost of mustering cattle on large pastoral properties 3. reduce the labour units to move and monitor beef and dairy cattle 4. reduce the cost to build and maintain fencing 5. reduce the cost of riparian fencing 6. provide a flood and fireproof, wildlife fencing method for managing riparian zones and stock access to sensitive environments 7. improve animal health and welfare by 24/7 monitoring of individual cattle 8. increase calving rate by more effective stock control during joining season 9. improve soil health and nutrition by enabling rotational or cell grazing to be implemented on scale in large pastoral enterprises
Farmbot http://farmbot.com.au/	• Remote water monitoring through sensors for levels, leaks, pressure and quality	Remote monitoring solutions provides accurate and reliable snapshot of all your water sources. • Has remote sensors • Integrate farm dashboard • Alerts sent via SMS • Cost benefit calculator available on website • Strong testimonials of use.
Farmlab www.farmlab.com.au	• Digital agronomy and soil software • Track soil test, cropping and pasture information	• Mobile application • Creates zones and maps with NDVI, GAMMA and elevation • Comparative analysis between tests • Integration of soli maps with pasture performance and cropping yields • Sample testing protocols
FaultAlert https://www.agriace.com/	• Electric fence monitoring	FaultAlert reduces the pain and effort of constantly checking fault-prone electric fences and searching for faults. Simply attach a few wireless sensors to your electric fences then monitor them remotely from your phone or computer! You can even receive alerts when a fault is detected.

Product or Service	Species / Comment	Description
		No mobile reception needed.
FY3000 from eLynx Livestock management Software http://www.elynx.com.au/	• Cattle on Feed	For producers with 5000+ head on feed Features: • Records purchase, feed, production and disposal costs for every lot of cattle • Manages rations, customers, vendors, commodity contracts, pen maintenance and livestock movements • Interfaces with StockaID, FeedBunk3000 & Weighbridge3000 • Manages customer billing & export to accounting systems • Generates powerful reports for key stakeholders including 'Close-Out', 'Cash Position' and 'Gross Margin' Reports • Backed by a nation-wide technical support network
GrassGro, GrazFeed https://www.hzn.com.au/	• Cattle, Sheep • Grazing systems modelling • Nutritional requirements and growth rate	GrassGro allows the user to explore interactions between management decisions for a grazing enterprise and a given environment over many seasons. Questions can be investigated at the level of a whole enterprise, such as a self-replacing merino ewe flock or a beef herd producing yearlings for sale. GrazFeed is a decision support tool to help graziers improve the profitability of livestock production, through the more efficient use of pastures and supplementary feeds. GrazFeed is regarded as the benchmark for the nutrition of grazing animals in temperate Australia
H2OALERT https://www.h2oalert.nl/	• IoT monitoring of water quantity and quality for Cattle	H2Oalert, is the first and unique wireless (IoT) real-time water control (Management) system for dairy and beef cattle. The quality and quantity of the cattle drinking water is checked, real-time, 24/7, for pollution and possible malfunctions in the water supply. In this way, the H2Oalert system and the data obtained will result in a direct contribution to animal welfare, milk and meat production.

Product or Service	Species / Comment	Description
Hencol https://www.hencol.com/	• Precision livestock farming • AI and Big Data • Cattle	Hencol presents the next level of precision livestock farming with its big data and AI algorithms making it possible to give its customers an optimised decision support system in real-time and accessible from wherever you are via a smartphone, tablet or PC. It works as a standalone solution as well as being integrated in other Agri systems or platforms via API. It enables the digitalization of the entire value chain with significant benefits for all actors involved.
Inmarsat Remote Livestock Tracking and Monitoring https://www.facebook.com/InmarsatGlobal	• Cattle tracking • Connectivity in remote areas	Inmarsat works with the latest cattle tracking and monitoring technology to provide stations the ability to respond to events such as wandering, theft and hostile events and changes in physiological behaviour. Our global satellite network allows our solutions to work on the most remote cattle stations with no cellular internet coverage. We provide connectivity to technology companies wishing to work in areas of unreliable connectivity, as well as turn-key solutions to livestock farmers to remotely manage the herd. Our solutions remotely track cattle location, enable the application of geo-fencing limits and monitor activity levels to identify potential problems.
BlockBit from iTrazo http://www.blockbitsolutions.com/	• Traceability solution • Secure platform using Agtech	iTrazo, meaning 'information traceability', has been developed by BlockBit as its patent platform to provide end-to-end traceability of business and industry assets, transactions, products, and services. iTrazo is a secure platform built using a distributed ledger, IoT, digital identity, data science, security and backed by enterprise-grade support, maintenance, and training. iTrazo is changing the way companies approach e-commerce, supply chain, identification, compliance and much more.
iSperm https://www.avetsm.com/	• Mobile solution to sperm assessment	iSperm is a portable animal semen analyser that uses an iPad mini to assess sperm motility and concentration. Software available for bulls, stallions, dogs, boars and rams.
Jaguza Tech https://jaguzafarm.com/	• Cattle • Sensors	Jaguza Tech uses sensors, data science and machine learning to improve core aspects of farm operations to become more efficient, productive and sustainable. Jaguza is an offline and cloud IoT based Livestock Management System with features like Animal healthcare monitoring and recording using IoT sensors, Farm Management system,

Product or Service	Species / Comment	Description
		Animal livestock identification utilizing animals smart tag and QR code reading via wireless technologies. Our Livestock Farmers use drones to obtain an aerial overview of the area in which they keep their livestock. Thermal imaging and high definition cameras allow farmers to track and monitor their livestock remotely, identifying any issues in real time, thus enabling them to resolve issues quickly and efficiently.
Litams App https://www.litams.com/au	• Herd management	Animal and Herd Management in your pocket! The app includes functions to record Breeding and Reproduction, Weighing and Drafting, Treatments and Meds, Mobs, Sales (incl eNVD), Purchases and more (eg wool, dairy). Use the app on as many devices as you like. Concurrent use is possible. Open a browser and access your company's account. View data. Analyse performance. Create reports. Set selection standards, which are automatically send back to the app. This is the world's easiest tool for recording animal data, culling and drafting!
Livestock Solutions https://www.zoetis.com.au/livestock-solutions/	• Zoetis managed dashboard for managing animal health records and providing vaccination and drenching guidelines	Best management practices for animal husbandry, disease states and product solutions. With specific sections tailored for dairy, beef cattle and sheep
MaiaGrazing https://www.maiagrazing.com/	• Gazing management • Decision support	MaiaGrazing is an easy to use online grazing management tool that helps farmers maximise their pastures and profits in the good times and reduce risks when it's tough. More than a mere record-keeping program, MaiaGrazing is a decision support tool that analyses farm data to deliver meaningful and relevant information where and when it is needed. We understand that the biggest driver of grazing profitability is pasture utilisation.

Product or Service	Species / Comment	Description
		MaiaGrazing helps farmers make better pasture management decisions by capturing land, animal and rainfall information and providing an instant, real-time update on the farm's current and projected feed and stock position. The application is unique, with an analysis engine that continuously learns about each property using current and historical data about each paddock, mob and rainfall event. This enables farmers to understand and respond to paddock variability to optimise production and improve land quality. It shows a farm's true carrying capacity at a glance, in real time. MaiaGrazing does not just capture information to report on your past pasture performance - it forecasts the future, enabling informed decisions that maximise results. It requires no extra effort. Data can be easily entered via a mobile phone app, on the go, undertaking regular day-to-day pasture management needs on the farm, and it's all stored in the cloud so there's no need for backups or administration.
mNVD https://axichain.io/mnvd	• Mobile NVD	The Next generation digital paperless "mobile" National Vendors Declaration. (mNVD) Licensed by the MLA and approved by authorities. Features • Create compliant NVD with ease from your smart device • On and offline capabilities • Digital traceability and exclusive QR code technology to track animal movements • An end-to-end clean paperless experience • 100% ISC approved
Mobble https://www.mobble.io/	• Livestock Farm Management Software	Farm App Mobble Make farm & livestock record keeping simple. Stock numbers, mob treatments, paddock records, task management, chemicals, sales, compliance, audits and more. Mobble

Product or Service	Species / Comment	Description
		connects the team while keeping farm records safe. #1 farm app or software in Australia and New Zealand on Android and iOS.
Moonsyst https://moonsyst.com/home	• Dairy and Beef cattle • Uses a smart Rumen Bolus	Moonsyst is a smart monitoring system for progressive dairy and beef farmers. It collects different parameters of the livestock, helping farmers with real-time data to increase productivity and detect disease, stress and heat. Supported by cloud-based software with built-in machine-learning and notifications, the unique system enables better and earlier detection of various illnesses, enabling more efficient use of medications, improving animal welfare and prolonging animal life expectancy. The Smart Rumen Bolus is equipped with multiple sensors detecting movement, and other data. The bolus is administered orally into cow's rumen providing most accurate data real time 24/7 on temperature for illness detection, movement for heat detection and/or rumen pH value for feeding control. Moonsyst bolus is safe, reliable and resistant.
Moovement https://www.moovement.com.au/	• GPS tag technology for cattle	The GPS Ear Tag allows tracking and tracing of cattle over long distances, even in remote areas without mobile coverage. They are the size of a standard management tag and can be tagged using a normal applicator. The reusable GPS ear tag is powered using a battery and integrated solar panels.
MyOrigins http://www.myorigins.com.au/	• Trackability, traceability • Merino industry	MyOrigins Technology is a technology led services business that supports the Australian merino wool industry. Aiming to drive convergence across farm standards, data collection and reporting, enabling growers to meet their external compliance requirements for regulatory, animal welfare, environmental and brand led processing standards. MyOrigins Technology delivers solutions for livestock and wool products. Livestock • OriginsTNT: National and International livestock Track and Trace • OriginsInsight: AI/ML analytics and real-time alerts

Product or Service	Species / Comment	Description
		• OriginsBio: Epidemiology and Biosecurity Wool • FibreCert certification of grower's production systems to meet global consumer standards • FibreSource connecting Brands with growers of premium, ethical and sustainable Australian merino wool • FibreChain supply chain assurance platform licensed to brands and available to end users.
Phoenix Livestock https://www.agdata.com.au/	•	If you are looking for a product that will give you detailed weight gain performance analysis across individual animals or mobs that is compatible with all electronic weighing and RFID devices - Phoenix Livestock has you covered with its extensive record management and reporting systems. Phoenix Livestock enables you to collect cost of production information and turn it into usable information that you can act on. It interacts with the NLIS database making electronic tag reconciliation a simple process. A new feature in Phoenix Livestock turns DEXA and processor kill sheet data into meaningful information to immediately see trait trends within your herd or flock. Phoenix Livestock also provides you with tools to help you analyse and make decisions about carrying capacity, stocking schedules, grazing rotations and paddock recovery periods. These land grazing features play well into the hands of those who identify as sustainable grazing land managers.
Roper https://www.ropertag.com/	• Beef cattle • Smart tag • Real time health and movement monitoring	Roper is revolutionizing beef production with a solar-powered GPS ear-tag and companion mobile app. Roper's proprietary technology provides geolocation and health monitoring of cattle at pasture, enabling producers to cut management time by 30% and maximize fertility and nutrition, sustainably manage grazing, and pinpoint cattle that are

Product or Service	Species / Comment	Description
		sick or distressed. Roper's real-time information empowers producers to overcome the estimated $20B (US) annual loss due to disease, death, and fertility shortfalls.
Software and Automation http://www.sapiusa.com/web/	• Beef cattle • Software	Client Specific Software & Hardware Automation and Development. Full ERP (Enterprise Resource Planning) for fully integrated Beef Cattle Organizations. Also develop specific modules such as accounting, inventory, sales and order management, QA, traceability, CRM, production, costing, etc..
SimplyFarm – Smarter farming and Agri-business with IOT http://www.simplyfarm.net.au/	• Agtech / IoT	SimplyFarm™ is integrating Australian Farms, Agri Businesses and Communities through the Internet of Things (IoT). Farmers are saving time and money with SimplyFarm™ alerts using the most user friendly wireless IoT smart farm solution yet. Long drives for routine work and inspections wastes time and resources. Even small improvements in prioritisation of work can reap massive benefits. Early warning of a leaking water pipe or undesirable movements of stock can reduce costly incidents by allowing you to remedy the situation as soon as possible. We have proven track record and reference sites in production for IoT solutions implemented in Western Australian Farms today. Talk to us today!
SmartShepherd http://www.smartshepherd.com.au/	• Sheep • Maternal/offspring relationships • RFID collars • readers	SmartShepherd collars are used on livestock for 48 hours to determine maternal/offspring relationships. The collars are robust and do not require access to networks or phone systems to work, so can be deployed anywhere. A handheld RFID scanner is used to allocate collars to animals, speeding up the process (up to 120 animals / hour). The results are generally provided within 48 hours of the data being collected from the collars (compared to 3 months for genomic parentage testing). SmartShepherd is provided in Australia by Sheepmatters - service providers train the user and then the system is rented for as long as required rather than being directly purchased. If you are differentially feeding twin-bearing ewes, the SmartShepherd solution allows you to quickly identify non-performing animals so they can be removed from getting access to

Product or Service	Species / Comment	Description
		excess feed. Longer term, distinct maternal genetic differences can be identified to reduce lamb losses and increase productivity. The system can easily be deployed on mobs up to 700 animals by two operators.
StockaID from eLynx StockMate from eLynx http://www.elynx.com.au/	• cattle	StockaID is a critical livestock management tool for feedlots. It captures individual animal data, from purchase through to exit, generates numerous performance metrics and delivers exceptional reporting power. FEATURES • Interfaces with production hardware RFID readers, weigh scale indicators, auto-gates, temperature sensors, barcode readers, treatment applicators, etc • Records animal ID data, session measures, movements, treatments, withholds, etc, and applies costs to every animal • Manages feeder, vendor, buyer, purchaser, financial and abattoir detail • Is used crush-side, in the yards and in the office • Imports data from the NLIS database, saleyards and processors • Records support NFAS and LPA accreditation • Generates powerful, customisable reports • Can also be used in backgrounding contexts. • StockaID Hospital provides comprehensive treatment options and reporting tools for sick livestock pulled from pens. StockMate is an exceptionally powerful mobile livestock management App. It addresses the needs of the largest pastoral companies in Australia, and yet is an affordable and viable option for smallholders. Work in the paddock on an Android tablet; interface with your management hardware; capture data, check histories; draft animals and record all movements; apply treatments and then upload it all to the cloud when in range. • TRACEABILITY & INTEGRITY SYSTEMS. Records paddock, mob and individual animal movements. Integrates with NLIS database. • Full treatment history, apply treatments, record notes & follow-ups and add to animal history • Integrates with RFID readers and weigh scales

Product or Service	Species / Comment	Description
		• PERFORMANCE MONITORING & FINANCIALS - bull weight and performance history - calculate average daily gain • Record and report on costs, earnings and profit for individual animals and groups • Property data at a glance • Integrated paddock mapping shows stock numbers & distributions • BREEDING Record pregnancy and lactation status - Parentage, calving and performance traits, etc • REPORTING & MANAGEMENT - includes powerful reporting and export features: Customisable reports - Stock-on-hand, movements, treatments, performance, breeding, financials, etc Data filtering and sorting tools. • Weight and exit date forecasts • Full multi-level user management • Works in multi-property contexts with multiple tablets • NVDs (coming soon), auto-gates etc
TWR-5 Weigh Scale, Data Collector & EID Tag Reader https://am.gallagher.com/en-au	• Liveweight weighing and EID	TWR-5 is the next generation of the Touch Weigh Scale (TW)- family of Weigh Scale and Data Collectors and includes a fully integrated EID reader. In addition, the TWR-5 supports the simultaneous recording of up to 9 traits and life data recording. The user interface is easy to use and simple to understand.
Ag360 www.Ag360.com.au	• Forecasting tool for rainfall, soil moisture, pasture and animal growth rate. Risks for animal health and cold.	Ag360 is the successor to ASKBILL that was developed within the Sheep CRC. It records farm management as well as predicting rainfall, soil moisture, pasture growth, animal weight and health risks up to 6 months in advance.
Optiweigh https://www.optiweigh.com.au/	• Real time recording within paddock conditions	Platinum Agriculture has developed an automatic in-paddock, patented weighing system called OPTIWEIGH. This smart weigher provides an affordable hi-tech solution designed to save farmers time and money by providing regular weight data and analysis to help improve stock management and identify the best time to sell stock.

Product or Service	Species / Comment	Description
VIAscan http://www.cedarcc.com/	• Carcase assessment • Lamb, Beef	The VIAscan® Carcase System uses Video Image Analysis (VIA) technology to objectively assess carcase quality and yield. It is a non-intrusive, in-motion, complete station, situated prior to grading at the end of the slaughter floor. Throughout 2018, the systems were successfully used to make commercial processing and carcase payment decisions on over 14 million sheep and more than 500K beef sides. The system does not pose any OH&S risks to the operator or carcase and has a small footprint, so it requires minimal space on the slaughter floor. VIAscan takes a series of precise measurements and processes these through the proprietary host software, to predict saleable and lean meat yield. The system also measures a series of other specific characteristics in real time which can be used towards objective grading standards.

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