Final report

Transforming beef supply chains through digital integration and value-based marketing

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Abstract

In large expansive operations in Northern Australia data connection, connectivity and traceability of an individual animal through its lifetime is typically regarded as difficult to achieve.

This project connected 16 different databases containing data about individual animals from branding through to processing. Using this data, linked with market analysis of what consumers are interested in and willing to pay for, a market orientated value based supply chain was developed to create a more efficient and profitable whole of chain business model. Data based decisions requires development of business processes and data governance as well as alignment of systems for example standardised naming conventions. The integration of digital data achieved using Opt[io]® Interchange enabled new analysis and previously unrealised insights to be generated support raising claims, NLIS and NVD traceability.

Linking the value of individual primal cuts and their attributes to an individual carcase and the cost of production of the individual animal provides previously unavailable data from which to base decisions and improve business and supply chain profitability. The within breed genetic variation offers opportunities to select animals and their pathways to optimise sustainability and profitability.

Executive summary

Background

What are the value based decisions which enable the combined outputs of the beef supply chain to be marketed in the most profitable way? Value based marketing (VBM) is a significant industry-wide opportunity to align livestock genetics, animal management, feeding systems and product attributes (cut breakdown, packaging, value adding) with consumer requirements. This requires visibility, information sharing, joint decision making and traceability along the supply chain. Through the digital integration of a commercial supply chain, the financial and technical viability of VBM was analysed and validated.

Objectives

This project tested and validated the value accretion that can be achieved for extensive livestock production enterprise through the integration of:

1. On-farm digital technologies (IoT)
2. External databases; and
3. Industry systems to support enhanced decision making and to facilitate collaboration towards VBM

Methodology

Across the supply chain from breeding property to backgrounding to finishing, processing plant and consumer preferences the steps followed were:

(1) Data Collection
(2) Data Integration
(3) Data alignment with business reporting processes
(4) Analytics
(5) Information generation
(6) Data based insights
(7) Actions and Decisions: Business process change; Planning; Monitoring; Feedback.

Training and staff capability building was undertaken at each step, with a focus on data collection to ensure accurate and reliable data was collected at source.

Results/key findings

Analysis was undertaken and new insights generated as a result of integrating data from multiple points in the supply chain. Aligning the supply chain to the consumer and value creation provides opportunities to streamline production processes and enhance efficiency.

Benefits to industry

Integration of individual animal lifetime data supports traceability, raising claims, provides checks and balances to the NLIS system and provides opportunities for detailed analytics on lifetime average daily gains and link value attributes such as marbling score to genetics, management practices and feeding systems.

Future research and recommendations

Digital integration and value-based marketing requires a change management process at a business unit level, firm and across the entire supply chain. Research is required into the change management process beyond an integrated supply chain to understand how to communicate and encapsulate what the consumer values to the firms in the supply chain.

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1. Background

The northern beef industry has traditionally been a low input system with a focus on *Bos indicus* content. As technology, internet of things (IoT) devices and internet connectivity has developed capabilities to suit the remote and extreme conditions, adoption has meant an increasing amount of data is being collected on individual animals and within the business. Stanbroke are at the forefront of testing and adapting new technologies to better support decision making which addresses their strategic objectives.

Stanbroke's strategic objectives are best described as visibility, traceability, and supply-chain pathway planning.

Visibility: asks where each animal is, in the present. This is for producers and processors to manage their herds and product pipeline.

Traceability: asks where each animal has been, what happened to them, and when. This is for raising claims certification, and consumer marketing.

Supply-chain pathway planning: summed up as a mission statement, 'put the right animal, in the right point of the supply chain, at the right time.'

As a vertically integrated business, the different business units from property to backgrounding to feedlot and processing plant can align their business processes to optimise the value a consumer is willing to pay for an animal, and then make decisions including genetic, animal management and cut breakdowns to secure as much of the value as possible.

What are the value based decisions that enable the combined outputs to be marketed in the most profitable way? This requires visibility and traceability to be functional in the supply-chain. VBM and value creation is taken from the view of the consumer.

The customer and consumer determine how much they are willing to pay based on the perceived value that the product provides where value equals the ability to meet their needs through perceived quality, ambience (environmental influences), taste, convenience, provenance, status, customs, and beliefs.

Value based marketing (VBM) is a significant industry-wide opportunity to align livestock production and consumer requirements. This project demonstrated through the complete digitisation of an integrated commercial value chain, the financial and technical viability of VBM while achieving productivity gains.

Value is defined as:

- Increased revenue
- Decreased expenses
- Ability and social licence to continue to operate within chosen markets
- Supporting a competitive advantage
- Building a preferential and repeatable customer base
- Retention of skilled staff
- Optimisation of inputs from the right vendors

This project tested and validated the value accretion that can be achieved for extensive livestock production enterprise through the integration of:

1. On-farm digital technologies (IoT)
2. External databases; and
3. Industry systems to support enhanced decision making and to facilitate collaboration towards VBM

Realising VBM requires integrated decision making from genetics, production, processing, integrity through to market and consumer drivers. The implications of complex decision making along the chain is not well understood, nor has there been previous research to prove desirability, feasibility, and viability of VBM on a commercial scale. Existing industry economic forces and cultural practices impede change. As a result, the rate of VBM adoption is slow and will continue to hinder the value creation that technologies might otherwise deliver in traditional supply chains.

Digital feedback and feed forward mechanisms to enable alignment of value across sectors and to consumers is required to achieve VBM at scale. IoT devices present data in isolation which doesn't support integrated enterprise and supply chain decision making. Commercially available applications aren't designed for extensive and expansive vertically integrated enterprises. This project developed a connectivity through a bespoke application, Opt[io]® Interchange which can bring together SQL databases, Microsoft office files, CSV's, scanned documents and PDF's.

Dashboards, which present results in graphic format, can be quickly applied once the data sources are centralised. Dashboards and reports can be tailored to the decisions and information requirements, and to the user making the decision.

The commercial pastoral enterprise in which this research was undertaken comprised two value chain structures: (1) company owned pastoral livestock, (2) purchased livestock, grown through feed-lotting to vertical processing facilities. The project methodology investigated and implemented a range of requisite on-farm and market signal technology and data systems to experiment, optimise and demonstrate the differences in value that can be realised within a commercial environment and how to overcome barriers to wider adoption of VBM. The business represents a vertical value chain structure which provides technical and financial validation of value-based marketing opportunities across the value chain.

This project quantified the magnitude of value and trade-offs on digitalising value chains, the opportunity and value of integrating them to the wider industry data networks and the opportunities this creates for value-based trading through to the customer for each value chain model.

Stanbroke with its vertical integration from genetics through production, feed-lotting, and branded boxed beef to domestic and export markets across a range of production systems in Australia, provided a unique opportunity to connect elements of the supply chain within an enterprise.

This project originated from challenges associated with optimising profitability across the entire pastoral production business, looking beyond individual sections of the business to connect to higher value market opportunities, reduce overall costs in the chain while increasing live animal productivity.

Specifically, the challenges included:

Complex systems operating in isolation - The many complex pastoral environmental interactions such as land type, rainfall, biomass, animal health, genetics, livestock type, current/future body condition scores (BCS), and asset management all impact on these productivity opportunities.

Integrated approach - Managing risk in implementing productivity and profit opportunities is difficult due to the interconnectedness of components. This is due in part to isolated decision-making that lacks information required to make smart, fast, profitable decisions across all areas together, including connection of on-property decisions with downstream supply chain drivers.

Integrating emerging technologies and capabilities - Realising the productivity and product value uplift required a concerted effort to connect numerous databases, IoT devices and data from third parties for example emailed kill sheets and SNiP data.

Supply chain collaboration – At a transactional supply chain level simple information (not yet shared) around value-based pricing and forward supply could incentivise production practices. Ultimately, the best medium- and longer term decisions on-farm need to align to the consumers demands if benefits are to be sustained. This is because the changing demands and social trends from consumers, and the way they interact with the value chain, needs to be planned and integrated into on-farm digital system investments such as quality assurance, traceability, welfare, and sustainability reporting. Alignment of production decisions to consumer requirements in the market including factors additional to eating quality such as traceability, animal welfare and environmental stewardship are also critical.

Process change - Coupled with implementing new technology is facilitating process change to support staff making data driven operational and strategic decisions.

Project hypotheses:

- Profitability in the Stanbroke business will increase from VBM business models across their value chains.
- Customer feedback will improve decision making for improved livestock production.
- Customer 'willingness to pay' data will change current industry pricing mechanisms.
- Gains in productivity and supply chain efficiency will result in greater profits, provided Value Proposition is aligned to customers willingness to pay.
- Digital technologies that support more accurate production decisions will improve productivity and better risk management will enable VBM.
- Building people capability for decision making with decision support tools will increase the rate of adoption of VBM.

2. Objectives

The project explored and quantified the impact of attributes which contribute to VBM viability and adoption including:

- Enhanced decision-making increases on-farm productivity and value
- Development of value-based marketing approach for carcase value traits
- Adoption of data for decision making by building people's capability
- Value of IoT as inputs to a more strategically integrated operational data driven decision-making process
- Value generated on-farm by integrating external information and consumer signals for production decisions.

The goal is to assign a pre-determined supply chain path to an animal at weaning based on the animal's attributes in alignment with market specifications. A market orientated approach applied in VBM inverts the typical supply chain where producers produce and look for a market. Operating on VBM principles means data recorded is focused on consumer information requirements and marketable products rather than just operational and production information.

2.1 Project outcomes

Systems and Data Connectivity Outcomes:

- Enhanced producer feedback – reporting systems to address various needs on carcass performance to market in conjunction with producer profitability, considering appropriate genetics, station profiling and interactions across Stanbroke properties.
- Value created from development of holistic supply chain strategies was modelled to provide the confidence to invest in VBM activities.
- Improved pastoral management through connection of on-farm data between different science disciplines that reflects biological interactions and their effect on production.
    - Linking multiple properties and locations together with stock on hand and future feed requirements to optimise natural resource management to main land condition scores.
- Decision support analytics that integrate on-farm inputs with pricing, compliance, and profitability.
- Understanding the on-farm value created by IoT including improved visibility of cattle movements, stock handling, productivity and feed availability for livestock and finance managers.
- Improved data entry and data collection with IoT technologies resulting in improved accuracy.
- Successful trial using eNVD's were undertaken.
- Direct linkages through an API were established with the Integrity Systems Company (ISC) National Livestock Identification System (NLIS) database. The inter-connected data in Opt[io]® Interchange facilitated individual animal whole of life traceability. This enabled animals with incomplete traceability due to equipment not reading the eID when being unloaded to be updated in the NLIS database. For example an animal that went from the northern property to backgrounding then to feedlot, the animal management system scans show the animal leaving the property and entering the feedlot. Weight scans through the animal management system identify which backgrounding property the animal was located enabling the NLIS system to be updated.

- Animals can be tracked as a mob movement by NVD as the new system shows NVD numbers against individual eID's in the NLIS database.

Process change outcomes for VBM:
Normalising cattle type categories and aligning these with marketing specifications is one of the changes required for VBM. Cattle type normalisation was required to improve the quality of forecasts improvements including marble score, days on feed (DoF) and quantity (number of head, packed product weights).

Market orientated sales strategies are linked with value-based transaction drivers through:

1. Supply chain traceability to guarantee raising claims (HPG free, Grassfed, Organic)
2. Collection and analysis of data-driven evidence through the value chain

Marble score is the key driver which customers and consumers are willing to pay for in the Wagyu branded market. Customers who aren't focused on marble score as core value creation were interested in raising claims. However, there is little indication they were willing to pay premium prices, rather customers and consumers were interested in reassurance through a traceable and transparent supply chain.

The connectivity between stations, backgrounding, feedlot and processing plants helped to improve communication, provide market insights and feedback loops both between properties and up-stream and downstream within the supply chain.

Market Alignment Outcomes:
- Price and logistics network analysis was undertaken to support selling decisions using digital analytics that integrates to the supply and processing sections of the business.
- Selling support tools and analytics that consider seasonal supply chain prices and availability fluctuations will be used to help support longer term pricing strategies
- Complete supply chain visibility of the number of head destined for the different market segments and their location in the chain provides insights to align the animals in the value chain with the best market outcomes and ensure they are fit for purpose.
- All elements in the business are able to optimise use of resources in line with market requirements for example breed, age, intermuscular fat (IMF), DoF and raising claims.
- The value increase through alignment of supply with consumer insights was quantified using project data to support improved input utilisation and balance supply and demand.

3. Methodology

The project encompassed the entire value chain from property through to consumer with data collected from and integrated across the entire chain. Where data gaps where identified data collection activities were initiated. The project was undertaken in planned phases starting with on property to feedlot to carcase cut breakdown and the consumer.

The core program of work followed the model of:

Figure 1: Digital integration process

3.1 Digital collection

The initial focus was on collection of individual animal health and management data across all the breeding properties. Processes were documented and procedures implemented to collect individual animal data including sex, weight, breed, branding year, health status, husbandry practices and paddock location. Digital collection of records required infrastructure upgrades and purchase of hardware to facilitate collection of data directly into laptops when working at the yards. A programmable keyboard system was implemented to reduce data entry errors.

Capacity building for staff was undertaken at a property level to facilitate improved and new data collection. Training to station hands, team leaders and managers was provided by industry experts in the areas of pasture measurements, pasture and weed identification and in the collection of crushside and animal health data. Standard operating procedures were developed by Stanbroke's key personnel championing the project. Training and day to day support was provided to the front line staff when IoT data collection systems didn't connect and work as expected.

On property activities where data is typically a hard copy for example paddock movements and supplementary feeding were reviewed with the view to move to a digital system of collection and collation. Offline forms and excel templates were created to collect data. Farm management

applications used in southern Australia where mobs of animals can be shifted to a new paddock are not (yet) suitable for northern Australian conditions due to internet connectivity requirements.

A trial was undertaken with electronic National Vendor Declarations (eNVD's) on one property. Feedback from this trial helped refine the eNVD with pre-loaded details and saved templates. A trial of one property was undertaken with Cibo Labs to understand the additional required data points needed to validate the calculated Food on Offer (FOO). A trial with paddock weigh scales was implemented to understand the opportunities, limitations and applications in the Northern enterprises that paddock based weigh scales will have.

The existing data collected and the feedlot and processing plant were utilised with no additional data being collected at these points of the chain. Consumer pricing data was collected using domestic retail prices for cuts based on similar specifications for Stanbroke branded products.

3.2 Digital integration

The integration process involved steps as described in Figure 2. Phase A – Review of current systems and processes included activities to identify the location, type and accuracy of data.

Phase A: Map current data state:

1. Identify what data is being manually collected at the different points of the chain, who is collecting this data, what form is the data and where the data is stored
2. Map all the Internet of Things (IoT) devices which are automatically collecting data, how this data can be accessed, who has access and who is using this data
3. Map what data cleansing is occurring, if it is manual or automated, who has access to the data and how the data is currently being used
4. Map the frequency of data collection, the accuracy, reliability for all the data collected along the supply chain including external organisations.

Undertaking these activities identified the current data available for integration and areas where attention was needed to facilitate the integration process.

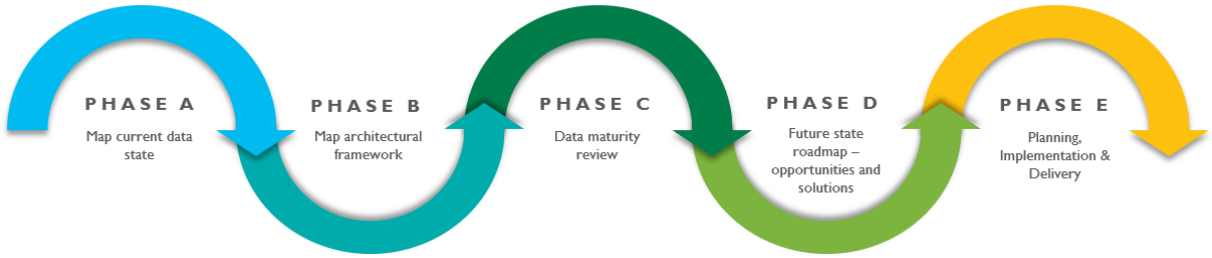

Figure 2: Phases in architectural roadmap

Phase B: Map architectural framework

Beginning at 'Business Decisioning' the business decisions were mapped, the business processes documented, the data identified, the applications and systems mapped and the infrastructure viewed and upgraded as required for the chain. The mapping was conducted at a higher level for the feedlot, processing plant and marketing. The mapping was undertaken at a detailed level for properties as the on property data was the lowest level in terms of data maturity.

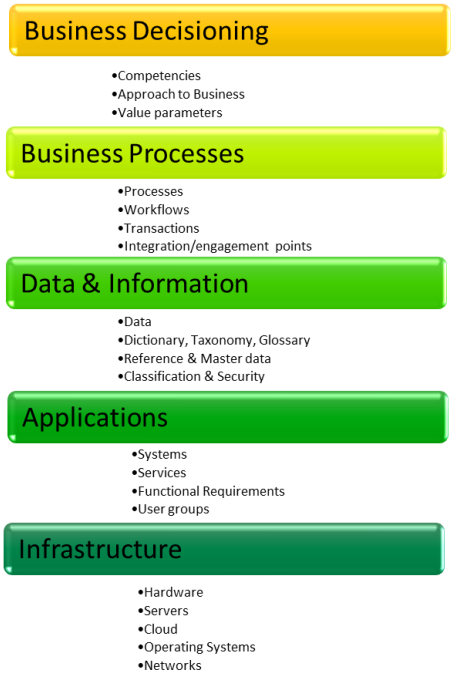

Figure 3: Business architectural framework

The decisions at each point in the chain and reporting requirements were linked into a data system map. An example of business process mapping is shown in Figure 4 which outlines the decisions required to muster, pregnancy test, cull, keep and which paddock to put into. Figure 5 steps through the drafting decisions based on that pregnancy data. These figures demonstrate the complexity of data systems when applied to livestock. Figure 4 is required to arrive at Figure 5, highlighting the interactivity and linkages in decisions on property and across the supply chain. Intuitively, systems this complex have hidden opportunities for uncollected data, unreported KPIs, and unknown decisions. By fully mapping them, as in these two figures, these hidden opportunities can be revealed and quantified. To reduce confusion over repeated names, multiple aliases per data point, and improve communication between systems like these, the whole system must be mapped so data and methods to collect the data can be standardised across the enterprise.

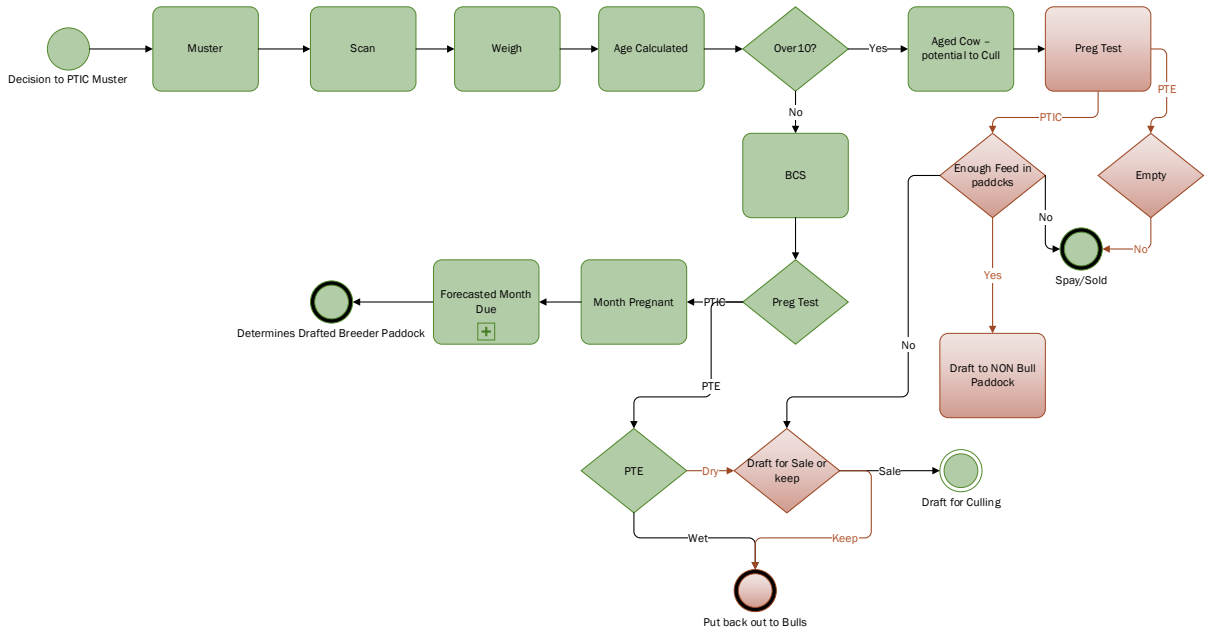

Figure 4: Pregnancy testing decisions and data points

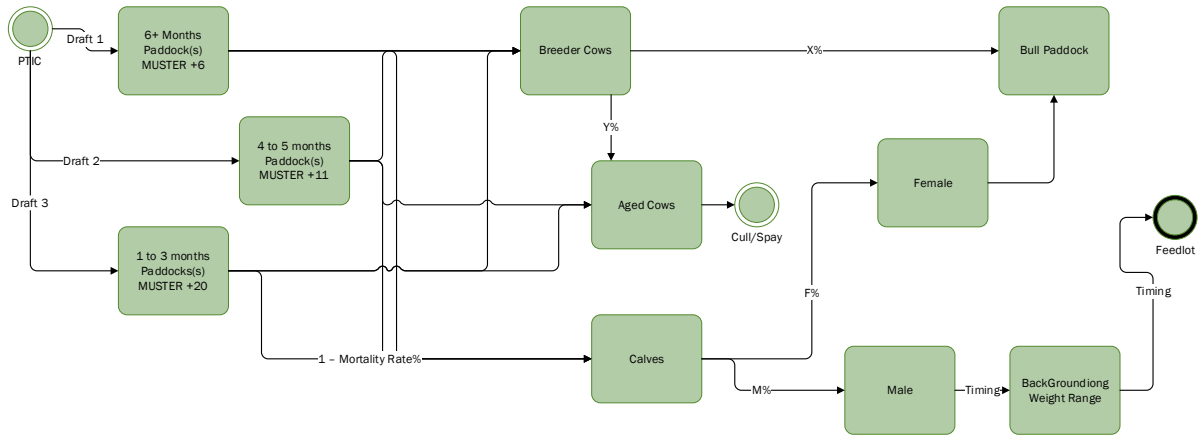

Figure 5: Pregnant drafting

All data currently collected needs to come under review in the context of decisions made and KPIs reported. Elements which are critical to the success of the business and the businesses priorities have been identified as part of strategic decision model development. It is critical to identify:

1. Stakeholders, gate keepers, decision makers, doers
2. What needs to be modified, improved, reinforced, reaffirmed to support the strategic plan.
3. Key items which deliver value and value propositions.
4. What is currently regarded as important but does not deliver value?

This mapping was undertaken to understand:

- The pathway points in the chain?
    - Could be a decision (e.g. join dam 357 with bull 8)
    - A probability based event (e.g. dam does not fall pregnant)
    - A required step before a result (e.g. muster, scan, collect weight and age, before decide to cull or breed)
- How pathway points connect with each other?
    - Direct connections (e.g. 'join dam 357 with bull 8' and 'does not fall pregnant' creates data about the dam and bull)
    - Pathway connections (e.g. 'dam 357 produced a marble score 7+ steer on 100 day feed' means 'join dam 357 with bull 8' might be a good decision)
- What frequency is each pathway point passed?
    - Could 1,000 per day for a week, then nothing for 6 months (e.g. cattle weigh station)
    - Could be 1 per week (e.g. rainfall gauge)
    - Could be 12 times per year e.g. monthly reviews of Cibo Labs feed on offer

Issues should be identified. Potential issues include:

- Data author is unknown
- Data location is unknown
    - Recorded, but stored somewhere unknown
    - Unsure if it is recorded
- Data is inconsistent with best practice
    - Data is incomplete (e.g. no matching date)
    - Data is incorrect (e.g. reports the wrong date)
    - Data quality is intermittent (e.g. reports date through internet connection)

The mapped system showed that different Stanbroke properties called the same animal different names. This increases the data processing resource requirement. Through the project initial steps were undertaken to define:

- terms,
- what each data point means and is useful for,
- what is intellectual property (IP),
- what software and hardware are used for, and
- who is responsible for each part of the system must be documented.

This keeps the system functional, but also keeps consistent and clear communication outside the system to service providers, clients, and industry. Because of this communication, marketing can also be clear and consistent, and the producer can inform feedlots what genetics they have selected according to the supply chain pathway they aim for.

These issues, and any others which weaken the mapped connection between data points directly, or along the pathway, must be resolved before integrating the data across the supply chain.

Because this is vertical supply chain data integration, data sources must produce standarised data outputs for a data warehouse (Opt[io]® Interchange). Improving data integration for decisions begins at shifting from manual data analysis to automated tabular outputs at operational, tactical and strategic levels. The analysis was designed with the view to be automated from the data warehouse Opt[io]® Interchange.

Phase C: Data maturity review

A review of the data maturity for the entire business and each section of the business was undertaken using the data maturity assessment tool three months after the project started and upon completion of the project activities to identify areas which needed support and to track progress and change.

Table 1: Data maturity matrix overview

LEVEL	1	2	3	4
Business Strategy	Data is used solely for reporting purposes	Data insights are used to inform business decisions	Competitive business strategy is built from data	Data informs a continuous evolution of business strategy
Data	The firm uses solely uses its own internal data	External data sets used to enrich and supplement own data	Third party data used as a differentiator	Firm looking to leverage new data sets from non-obvious sources.
Culture	The use of data and analysis is left up to the individual	Data used to measure results. No used in planning or vice versa.	Decision makers are enabled with the results of data analysis to optimize business outcomes.	Firm using algorithms to adapt and improve.
Architecture	No cohesive data architecture	Basic architecture of data flows	Architecture is mapped and enables all staff to be data driven.	Architecture is built for large volumes of data.
Data Governance	Governance is largely manual and lacks consistency	Some processes in place to ensure data quality	Confidence in data and resulting insights	Data governance is integrated into all business processes.
Procurement	Ad-hoc basis	Individual departments are responsible for procuring own data.	Streamlined process for data procurement	Data procurement team sources new data.
	No clear understanding of where data is stored and who has access	Some policies and procedures in place which are reasonably well defined and adhered to.	Adopted and enforced data management policies and processes.	All staff are responsible for data management and data is managed as an asset.

Phase D: Future state roadmap- opportunities and solutions proposed

After mapping the current systems and processes, the project team considered the future state where data is integrated across the supply chain and supports decision making. The future state roadmap considered how data would be applied to make effective decisions – how is it presented, analysed, interpreted, what decisions are possible (operational vs. strategic) and dividing decisions according to the bits of data required, and level of detail. Sensitisation was undertaken to understand what needed to change and why, to ensure continuity of process change beyond the project.

The future state roadmap included:**Error! Reference source not found.**

- Operational and strategic decisions made at each point in the supply chain by staff, management and senior management?
- KPI's and reporting activities required for the different sections of the supply chain and the different levels of management
    - What data frequency is required for delivering these outputs?
    - What data quality is required for delivering these outputs?
    - Do the current data, analyses and infrastructures support those desires?
    - What data is currently not collected but is required for decision making and or reporting?

The roadmap for data integration:

1. Identify data cleansing processes needed.
2. Identify data reliability improvements at:
    i. data collection,
    ii. post data collection,
3. Determine if different devices, technologies or collection practices are required.
4. Detailed mapping of decision processes at operational, tactical and strategic levels throughout the supply chain.
5. Identify data points throughout the chain:
    i. which can now be analysed to provide previously unrealised insights
    ii. analysis can be automated where it was a manual task
6. Update policies, procedures and human resource requirements to best leverage the automation of data analysis. Data for decisions is a foundation to understand what, why, how and who makes versus should make decisions. Development of decision frameworks was undertaken to support:
    i. data creation,
    ii. connection,
    iii. analysis, and
    iv. reporting.

3.3 Data alignment with business reporting processes

Performance reporting (KPIs), operational and strategic decision-making drives data collection. Collected and analysed data needs to align with a business decision or Key Performance Indicators (KPIs) impacting the triple bottom line (people, environment, profit), and unused wastes resources. Industry KPI's as recommended by the MLA funded NB2 and Cash Cow programs were identified and mapped to data points to ensure the appropriate data is being collected.

Table 2: Standard Industry KPIs

KPI	Unit measurement
KPI #1 – Annual net Liveweight production per breeder	kg/cow/year
KPI #2 – Weaner Production per Breeder	kg/cow/year
KPI #3 – Liveweight production ratio based on stocking capacity	kg/kg cattle/yr.
KPI #4 – Annual Pregnancy Rates	%
KPI #5 – Annual Pregnancy Rates P4M	%
KPI #6 – Foetal/Calf loss rates	%
KPI #7 – Contributed a Weaner	Y/N
KPI #8 – Breeder Mortality	%
KPI #9 – Breeder Liveweight at time of Pregnancy Test	kg

Industry KPIs and decision were mapped to the data required to calculate and contextualise the KPI as shown in Table 3. For example, fertility requires weaning rate and contextual data of mortality rate and weaning weight to be meaningful.

3.3.1 Data system map

The current reporting metrics were compared with the preferred state. An internal review was undertaken on the reporting data points for the livestock business to validate the minimum quantity and quality of information the user needs to make a rational, informed decision, who and how often the decisions will be made and what different decisions will be made on the new information being generated.

Figure 6 presents a documented summary of the current data network map, with the desired data network map. Note that the mapping of data for multiple levels of decision-making would also require multiple levels of data mapping. These were:

1. Enterprise level data
2. Paddock/lot/mob-based
3. Individual animal-based

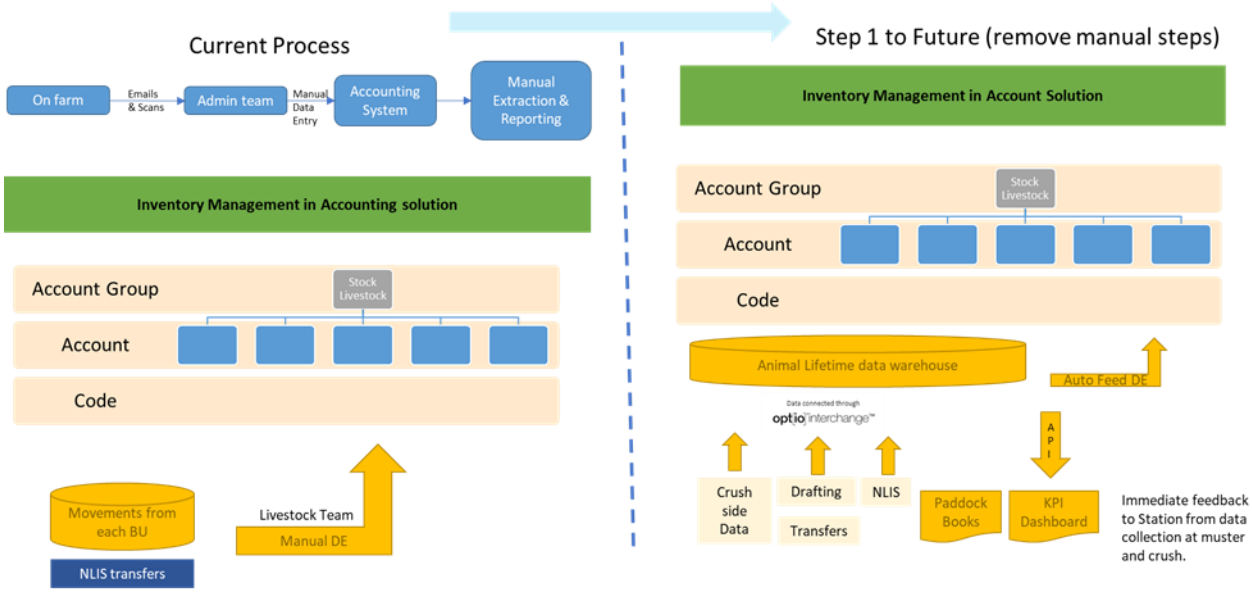

Figure 6: Current vs. desired system data network map

The desired network which was built and developed in the project comprised interconnected systems with a data warehouse (Opt[io]® Interchange) to receive automated crush-side data, transfers and NLIS information to validate paddock bookkeeping. Feedback would be provided through an API to dashboards for station managers and senior management. The data warehouse would contain and update lifetime data of each animal, including data on environmental factors, supplementation and pasture state.

Table 3: Determinants of Industry KPIs

KPI 1	KPI 2	KPI 3	KPI 4	KPI 5	KPI 6	KPI 7	KPI 8	KPI 9	Determinants
1									Fertility – Weaning rate
1									Mortality rate
1	2								Weaner weight
	2								Calves weaned
	2								Retained cow numbers
			4	5		7	8		Country Type
			4	5	6	7			Breeder Age Class (Year)
			4						Cow reproductive outcome in previous year
			4	5					Body condition score category at Wet/Dry (WD) muster
			4						Average pasture Dry Matter Digestibility % (DMD%) in the Dry season
			4	5	6	7			Average Wet Season crude protein to Dry Matter Digestibility ratio (CP:DMD) and Faecal Phosphorous to Metabolisable energy ratio (P:ME)
				5	6	7			Hip Hieght – Short Cows (better outcomes) vs taller Cows [<125cm, 125 - 140cm, >140cm]
				5					Breeder Bos Indicus content – reduced Bos Indicus resulted in better outcomes
				5					Bovine Viral Diarrhoea Virus (BVDV/Pestivirus) seroprevalence
				5			8		Estimated period of calving in previous year
				5			8		Body condition score at previous Pregnancy Diagnosis (PD) muster
				5					Change in body condition category between previous PD muster and the WD muster
					6	7			Lactated in previous year - Yes or No
					6	7			Body Condition score at prenancy diagnosis muster
					6	7			Mustered -1 to +2 months from expected calving date (Yes or No)
					6	7			Days in calving month with Temperature Humidity Index (THI) >79 (<15 days, >=15days)
					6	7			Mustering efficiency - -90%, >90%
							8		Available dry seson biomass
							8		Days to follow up rain after wet season onset
							8		Interaction between BCS at pregnancy diagnosis muster and available dry season biomass

3.4 Analytics and insights

3.4.1 Digital integration and market alignment

The value adding and marketing opportunities were identified through desk top analysis and reviewed and refined through interviews with wholesalers and in market connections and Stanbroke sales and marketing team. To understand how best to maximise value creation through data driven decisions analysis of the data collected along the supply chain at an individual animal level was undertaken. The connected data include wholesale market prices per breed, DoF and marble score, processing plant, feedlot backgrounding and property.

- Individual data tables from databases across the entire supply chain were connected using the individual animals RFID (NLIS tag). Code was written in SQL to allow queries to be run per individual animal RFID, per group, per property of birth, backgrounding location etc.
- Queries were created for data.
- Industry average cut prices were obtained for marble score 1-9 for Angus and Wagyu.
- Analysis was undertaken using marble score and a range of variables across the animal's life. Data analysis was undertaken on multiple supply chain pathways for DoF input costs compared to return per animal. Three scenarios were modelled:
    1. increase average marble score by 1 grade,
    2. decrease DoF to 120,
    3. combination of increase average marble score by 1 grade and decrease DoF to 120.
- Gross margins were calculated per head on the value of the animal at feedlot induction based on DoF and marble score with algorithms predicting the HSCW and saleable meat yield based on feedlot entry weight and genotype.
- Analysis for KPI reporting was undertaken to understand, map and prioritise the missing data points, data cleansing which was required, the level and type of reporting required for different positions relative to staff roles and responsibilities.

3.4.2 Information sharing

As tactical and strategic information is shared within and between firms, it was important to ask what impact new information will have, before sharing information.

- What information should be shared from a confidentiality and absorptive capacity perspective with the target audience?
- What information will have an impact?
- What is the cost, time, effort and benefits of sharing?
- Is it showing people they are doing a good or bad job and if so what does this mean for staff engagement, staff morale, training and system changes?

Senior management meetings were held to identify which data would be shared with whom and the implications of improved visibility of data. A change management process was developed to support staff engagement to help people understand the purpose of improved data and analytics is process improvement rather than to be used for denigration.

Data analytics were undertaken to create information which was then used for monitoring and reporting purposes at a management level. Information was compared to the actual performance

with a baseline and forecasted performance based on seasonal influences and shared with managers. Information was shared with staff to provide feedback on how the business unit was tracking against forecasted performance for example number of head turned off.

3.5 Summary

The standard methodology was undertaken at each point in the chain where the existing data was bought together into a data warehouse (Opt[io]® Interchange), installation of new data capture processes and methods as required to enable data based decisions rather than guestimates, business processes and reporting requirements were mapped which provided the platform for scoping the analytical calculations required for by the business unit and entire value chain. Value based marketing scenario modelling was then undertaken utilising the connected data across the entire chain.

4. Results

4.1 Overview of delivery

Milestone 1 established the project framework, Milestone 2 mapped current data systems and links to develop the Architectural Roadmap and Milestone 3 resulted in the installation of new data capture technology, staff employment and prioritisation of data connectivity for decisions. Milestone 4 identified detailed decision flows and data sources, mapped data flows, reports and information required from the data. This prepared for Milestone 5 which physically connected data points from unique sources and formats to produce the required information and reports. The long-term goal removes manual data processing which is possible when the data is standardised, enabling automated analysis and reporting.

Milestone 6 focused on capability development and improved data collection, Milestone 7 on new data creation, Milestone 8 on developing reports and KPIs reflecting operational and strategic decisions and Milestone 9 on preliminary market mapping and analysis for VBM. Milestone 10 reviewed and implemented industry quality assurance system connections, including NLIS, MSA and LDL.

Milestone 11 analysed the connected supply chain data from a VBM perspective centred on value propositions and lifetime traceability to support and verify raising claims. The connection of the data using Stanbroke's internal data has created a lifetime animal health record which is traceable from branding (NLIS tag) through to the boning room. Milestone 12 reconciled supply chain data mapping and developed livestock reporting, reporting against KPI's and production improvements. Milestone 13 developed a value base strategic plan to optimise value creation along the entire chain.

4.2 Data systems and availability

4.2.1 New Data

The output has been a single dataset for animals throughout their life. The following is a key list of data (further grouped in Table 4) that has been extracted for each sector in the chain:

1. **Station**
   - Pregnancy results
   - Individual production records
   - Animal locations throughout their life
   - Paddock based production records
   - Exit date & location
   - Animal treatments
2. **Backgrounding**
   - Induction date
   - Exit date
   - Individual production records
   - Animal location
   - Animal treatments

3. **Transit / transfer data**
   - Origin Property Identification Code (PIC)
   - Destination PIC
   - Destination type
   - NVP/shipment number
4. **Feedlot data**
   - Induction date
   - Exit date
   - Individual production records
   - Average feed intake per animal
   - Animal treatments
5. **Abattoir data**
   - Carcases data (MSA and hot grading)
   - Carton data
   - Carcase type
   - Animal health
6. **Genomics information**
   - Snip results

Additional mapping is required per paddock and mob to utilise additional data. This data includes lick feed out volumes, biomass data, feedlot ration deliveries etc. The data is available for all animals per paddock by class to allow for calculations to be performed once feed intake data has been included, made possible through databases. Data for dashboards will be created by running queries between connected databases. Future data capture in the boning room on a market basis will enable a value differential to be created by cuts from individual carcases to link the value of the animal back to the branding cradle. Currently this analysis can only be done per boning room run as cuts are not tracked to carcases. Additional analytics and data capture can add saleable meat yield data to support supply chain decisions around genetics, feedlotting and off-cuts generated.

Table 4: List of data records mapped through the project to date.

Database/dataset	Data level	Number of assessments
Station data	Individual animal	1,640,000
Backgrounding data	Individual animal	622,065
Feedlot data (Older)	Individual animal	185,988
Feedlot data	Lot based	
Back office	Individual animal	205,022
Transfer data	Individual animal	997,000
Genomic data	Individual animal	39,555
Feedlot	Individual animal	892,844
Plant Data (Animal health)	Individual animal	100,000

New data points:

1. Ground cover, Total Standing Dry Matter (TSDM) and Pasture condition for the northern Gulf properties
2. Trial of CIBO labs for one property
3. Branding weights and transfer weights
4. Paddock locations for individual animals linked to drafted animal groups
5. Optiweigh scales

New data collection processes:

1. Specialised programmable keyboard to help lock down free text cells to reduce the data cleansing required to address mis-spelling and mistakes in data entry
2. API access for NLIS, multiple Individual Livestock Management Systems, Optiweigh and CIBO labs data with MSA on stock processed elsewhere pending

New data generated through analytics:

1. Average Daily Gains (ADG) across an animal's lifetime
2. Range of marble score actuals verses predicted marble score
3. Distribution and quantity of calves born per month based on pregnancy testing data
4. Adult Equivalents each paddock can stock based on TSDM

Data detailing:

1. Ground cover, Total Standing Dry Matter (TSDM) and Pasture condition for the northern Gulf properties
    a. This data was accessed using the Long Paddock new Forage reporting function based on location or lot plan for each of the Stanbroke properties https://www.longpaddock.qld.gov.au/forage/
2. Trial of CIBO labs for one property
    a. For one property CIBO labs was established with watering points and boundary fences in **Error! Reference source not found.**. Reports were then received on Food on Offer (FOO) and TSDM. New data capture technology has been deployed as shown by the Cibo Labs map of a paddock shown availability of Total Standing Dry Matter (TSDM) in **Error! Reference source not found.**. TSDM is categorised as Low, Medium or High. Satellite mapping results will be validated and compared with ground data. Work continues to identify desirable and palatable species and develop systems to make large volumes of data useable, from which station managers can make operational and tactical decisions.
3. Branding weights and transfer weights
4. New weighing systems were installed and management practices undertaken to weigh at branding, weaning and when being transferred between properties.
5. Paddock locations for individual animals linked to drafted animal groups
    a. When animals drafted and sorted based on specific characteristic and these animals were mobbed in a paddock was recorded in the individual livestock management system, with individual paddock records.

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    <Name>              Name>
  </Property>
```

Figure 7: Sample animal showing paddock movements

6. Optiweigh scales
    a. Scales have been purchased and located in 4 paddocks to sample animal weights.

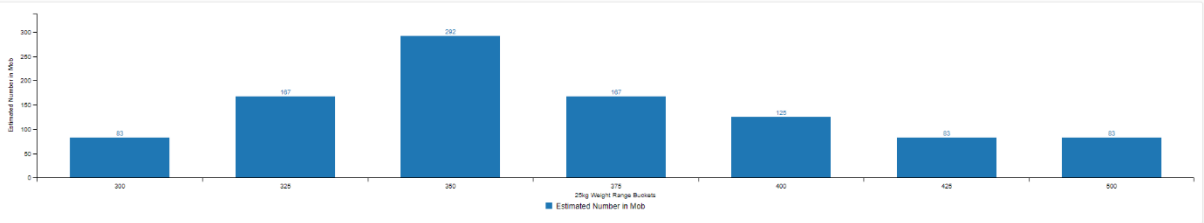

Figure 8: Sample data showing Optiweigh results

7. Average Daily Gains (ADG) across an animal's lifetime
8. Range of marble score actuals by Wagyu % based on SNIP data
9. Distribution and quantity of calves born per month based on pregnancy testing data
10. Adult Equivalents each paddock can stock based on TSDM

4.3 Data for decisions

Contrary to this simplification, every Internet of Things (IoT) device adds another level of complexity, further incentivising automated:

- integration,
- keeping track of who has access to passwords,
- version maintenance, and
- connection with existing data points to join data driven decisions.

General work was undertaken alongside Stanbroke training to:

- clarify data requirements,
- secure API access to external databases and reviews of reports,
- customer trends,
- lifetime traceability,
- data digitisation and manual process streamlining, and
- lay a foundation for ongoing system design and implementation.

Stanbroke's Cloncurry staff met with service providers, data experts and industry representatives to receive training in data collection and interpretation, understand data implications for system

function, and create a 2-year roadmap to address the issues with adoption of structured data systems.

The same can be said for data collection for pasture measurement and assessment – an extreme level of pasture assessment identifies each species, prevalence, ground cover %, stage of growth and soil type however, it is important to be able to measure and assess pasture without this extensive knowledge.

4.3.1 New data management

There are operational decisions throughout the beef production supply chain, requiring a whole of system perspective for effectiveness and profitability. Figure 9 shows system considerations at a production ecosystem level. Decisions which reveal their impact 3+ years later are considered strategic decisions (rather than operational), and the data which supports these decisions is similarly strategic. Namely:

- Genetics
- Reproduction
- Health (considering growth, environmental resilience and etc.)

Not only that, data which supports animals scoring well in these areas e.g. improved feed availability, for cattle gaining weight easier, drives operational decisions which support strategic objectives.

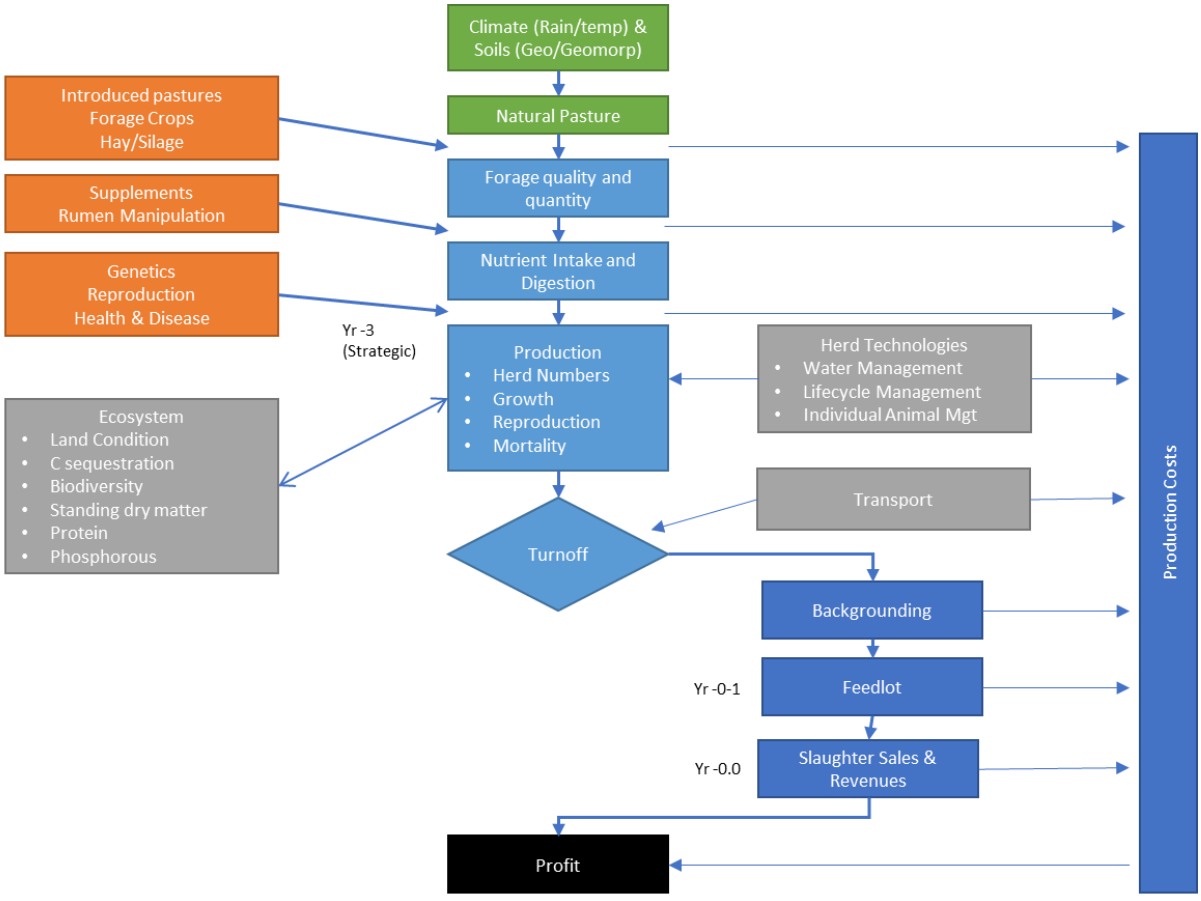

Figure 9: Decision framework Adapted from Ash et al. (2015)

NLIS – Stanbroke currently manage their NLIS tags, biosecurity updates and existing eNVDs through Integrity Systems' MyMLA portal. They manually compare animals in the NLIS system with their animal management systems. They would like to increase eNVD usage, but this requires station manager buy-in, as they prefer paper-based systems. Stanbroke is currently undertaking a review on the use of eNVD's and digitalisation of information and data.

An API was developed to establish seamless reconciliation between the NLIS database and internal company records. This program of work supports the R&D required to move from mob-based traceability to animal traceability, moving away from manual comparison.

This has been identified as an opportunity to increase animal lifetime traceability coverage within the supply chain. For example, if transaction records from the NLIS data are missing due to a scanning error when loading or unloading, once the error is identified, the missed transaction can be backfilled from the sending property's details by centralising the data and reconciling data sources, even when they may have been missed by one link in the chain. This enables analysis of animal performance, ADG, and general statistics, and has created a lifetime animal health record which is traceable from branding (NLIS tag) through to the boning room.

MSA - Currently all MSA data collected at the plant owned by the supply chain is integrated to their own operational databases. This data was integrated into the lifetime records of the animal. This enables any location throughout the supply chain to access animal-to-carcase quality and quantity feedback. Cattle that have been slaughtered through a non-company processing facility currently do not have MSA data linked to their lifetime traceability. Work has been performed with external processors to access this with kill sheet data and link to lifetime traceability records. MSA data connections provide opportunities to enhance decision making through feedback. VBM metrics have the potential to improve value propositions for industry through data analysis comparing similar animals against a benchmark, each other and over time.

Total Standing Dry Matter (TSDM) - A property profile was being built based on photos of land type for a range of TSDM. This builds staff training capability to compare pictures and visuals to give a condition score 1-5 stars and use the Land Condition ABCD Framework.

Cibolabs data has been accessed for one property as a trial of automated TDSM assessment. Figure 10 is a high level overview of Total Standing Dry Matter (TSDM) for part of one station. The overview provides indicated what dry matter was available on in September 2022. This map is of interest during seasons of scattered storms.

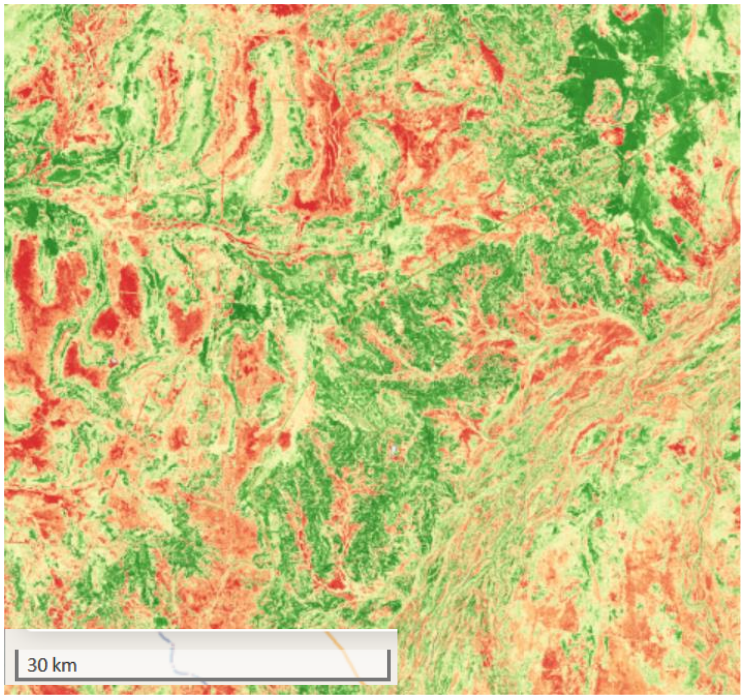

Figure 10: CiboLabs snapshot - TSDM for part of one station

Figure 11 and Figure 12 have 3 kilometre water point diameters identified as well as fence lines for individual paddocks and TSDM zones. Per paddock compared to paddock books allows cross referencing to check when paddocks are spelled, need destocking or don't meet their Adult Equivalent capacity based on the TSDM.

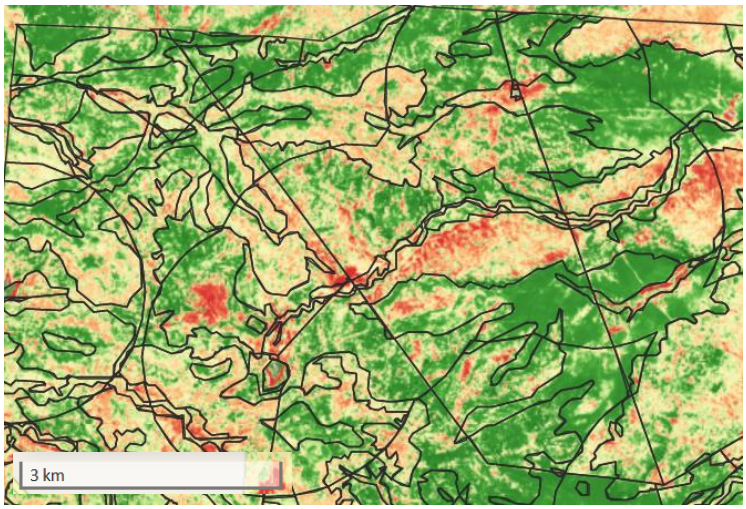

Figure 11: Closeup of TSDM in the same property

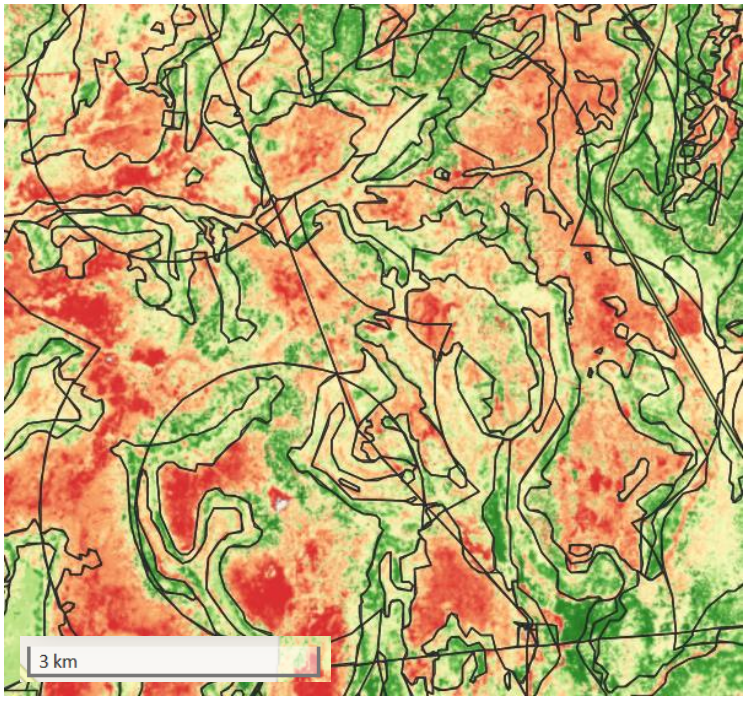

Figure 12: Close up of TSDM of same property with areas of low TSDM

4.3.2 Global market choices

Research identified increased uncertainty throughout the supply chain as the operational status quo was disrupted (due in part to the global pandemic). Many points in the chain include:

- animals into processing plant with flooded roads,
- processing capability with limited staff availability,
- access to containers and shipping capacity,
- delays with unloading and transhipment to near end consumer,
- restaurant closures, and
- unpredictable customer numbers

which result in difficulties managing use by dates and perishable inventories. Shipping times have a big impact on chilled shelf life and resulted in increased interest in Individual Quick Frozen (IQF) products. Moving to a frozen product eliminates issues with perishability, while individual portion size helps reduce waste with variable customer numbers and shut-downs with short notice. IQF provides a value proposition at the retail and quick service restaurant (QSR) level. IQF is a product characteristic which then needs to be aligned to the product which consumers are purchasing at the retail and QSR.

Supply Chain Decision, Vertical Impacts - Supply chains must be profitable. However, market orientation doesn't mean all the needs and wants of customers are met. The supply chain must consider which target markets can be serviced profitably, including 'near enough is good enough' segments to ensure there is sufficient demand to service it.

The characteristics (flavour, convenience, shelf life, etc.) required by each value chain customer are market drivers, and these need to be correlated to product specifications, correlated to traits in a live animal. Linking back to live animal decision-making to improve compliance with consumer

requirements per branded product is required for VBM to be successful. It is important to increase the number of animals inside target specifications. Science can identify the cause and effect of live animal decisions on live animal outcomes, but operational variables, benefits and likely commercial response make supply chain outcomes harder to predict. This will be achieved by developing a shared understanding of what the target live animal specifications are, giving feedback on outliers, working through reasons animals don't meet specifications, and giving practical steps to achieve or remedy target specs.

Interviews were conducted with meat wholesalers who trade with Stanbroke and products such as OBE and Cape Grim to understand market demand, trends, competitor pricing and potential new value to be gained. Interviews were held with the Stanbroke sales team as well as processing and product development representatives. A representative from Greenleaf attended IFFA in Germany to investigate trends in food technology, individual quick frozen (IQF) technology, thin-slice processing, and packaging. Desktop research was undertaken to investigate VBM activities.

4.3.3 Marbling score analysis across supply chain variables

This analysis provided insight into existing supply chain pathways and the potential for industry to extract new premiums from low marbled products through value-adding. The analysis is based on a snapshot of data through the Stanbroke supply chain in 2022. Data analysis centred on marbling score and

1. Source property (where backgrounded)
2. Breeding property
3. Supply chain
    i. Property
    ii. Backgrounding
    iii. Feedlot
    iv. Processing plant (same plant)
4. DoF
5. Feedlot Entry Weight
6. Hot Standard Carcase Weight (HSCW)
7. Carcase Value ($) based on HSCW and average prices per Marbling Score
8. Angus v Wagyu (breed)

New sales opportunities and maximised supply chain profitability were the target of this analysis. Commodity traded Wagyu and Angus prices are critically influenced by marble scores, and the markets are well-defined. Capturing new value begins with considering VBM (separating from commodity beef), looking at individual cuts within the carcase rather than averages across carcases This would be achieved through unifying the steps of the value chain from conception to consumer to optimise marble score for its target market.

VBM requires an understanding of the complexity of market driven attribution of value. Livestock marketing (in a vertical supply chain) aims allocate parts (i.e. cuts) of the product (i.e. carcase) to the highest paying consumers, and this allocation needs to be a key part of the solution. This drives a particular focus on identifying which cuts are best suited to drive higher margins for premium products and value-adding, for improving on-farm data accuracy, data driven selection of animals and creating customer value through sustainability, traceability and eating quality.

Developing a market orientation to undertake VBM requires a change in mindset at the different segments of the supply chain. Having a marketing orientation means starting with the consumer. The first step is to define what the consumers and near end consumers value and are willing to pay for. Then quantify these into defined market segments which the integrated supply chain can supply profitably as market defined product groupings.

Figure 13 shows the HSCW per marble score versus DoF. Note marble score 9 animals have a lower HSCW than marble score 8 animals. This, and the impact of HSCW on marble score in general, requires further investigation to support VBM research. It is unknown if marble score records higher due to physical perception of graders because the size of the cut is smaller or if the animals were of a higher Wagyu % and were smaller animals.

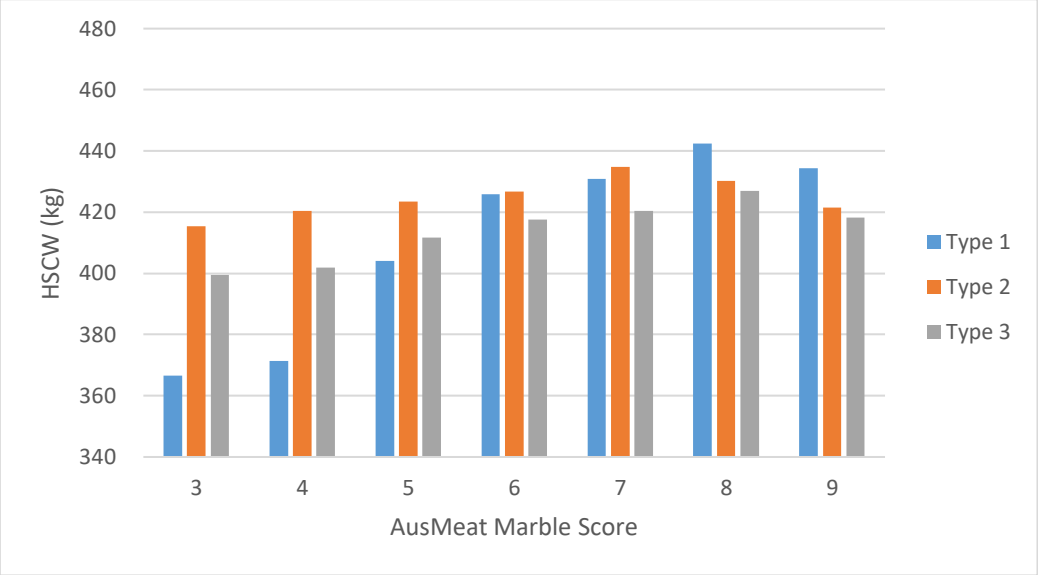

Figure 13: Average HSCW at feedlot, by marble score

As well as supply chain, specific properties have different impacts on profitability. Table 5 highlights a significant difference in profitably between the 9 highest volume Wagyu feeder-steer properties (pre-feedlot property, not birth/breeding property). Table 5 shows the distribution of marbling from the purchase property directly prior to feedlot induction and processing. It also highlights the marble score bell curve (as bold text) would push animals from Property 3 and 5 above marble score 9, prompting investigation of marble scores above 9 to capture the value of a more marbled animal.

Table 5: AUSMeat marbling scores % per source property into the feedlot

	2	3	4	5	6	7	8	9
Property 1	5%	**20%**	**21%**	**27%**	**12%**	8%	4%	3%
Property 2	1%	5%	13%	**26%**	**20%**	**18%**	9%	9%
Property 3	1%	0%	5%	10%	**16%**	**25%**	**22%**	**20%**
Property 4	0%	4%	10%	**39%**	**20%**	**18%**	6%	3%
Property 5	1%	4%	6%	**22%**	**19%**	**16%**	**15%**	**17%**
Property 6	2%	6%	16%	**29%**	**18%**	**15%**	8%	5%
Property 7	0%	7%	**16%**	**33%**	**15%**	**13%**	9%	8%
Property 8	1%	11%	**19%**	**39%**	**19%**	8%	3%	1%
Property 9	0%	6%	9%	**23%**	**12%**	**33%**	8%	9%

4.3.4 Raising claims certification

The connection of animal lifetime health data and record of all PICs where the animal has been is the foundation of lifetime traceability. This now guarantees raised claims certification. Claims certification has been based on statutory declarations (.e. trust and 'to the best of the final vendor's knowledge'. Mob-based claims can now be per animal, which potentially upgrades raised claims in the eyes of the consumer.

4.4 Data based decision support

4.4.1 KPIs and strategic goals

The overall Key Performance Indicators (KPI's) for the Stanbroke business are based on the 5-year strategic plan which focuses on enhanced productivity through digital capability, from animal conception through to customer delivery. The vision is to create a supply-chain feedback loop to breed animals to be fit-for-market, managing each animal individually aligned with the designated market and managing individual paddocks to optimise asset and land use.

4.4.2 Reporting

Throughout the supply chain, management was interviewed to discuss what information is available, required but not readily available, key decisions at strategic and operational levels and weekly and monthly reports. These were reviewed to identify KPI's they report against. Each business unit (point in the value chain) reports on key metrics and KPI's once a month. Feedback reporting loops were identified and strengthened to help better inform future decisions. Key operational reporting provides an overview of the number and type of animals at each point in the value chain. At a pastoral level, reporting also views feed availability per head for each property to identify if the animals will be supplied until a month after the first summer storms.

Table 6: Summary of users and data-based decisions

User's Role	Data based decisions and feedback loops
Chief Financial Officer	Identification of overall company profitability, sector profitability and trade-offs in profitability as operational decisions are adjusted within each sector. Tracking, potential areas for improvement, what's going wrong or right and financial implications. Improved integration of life-time data and associated operational performance metrics into budgeting and scenario modelling.
Plant Manager	Did actual yield and cartons match expected each day and each week. Ability to have a holistic approach to plant yield performance and communicate areas of improvement effectively to the on-plant team as well as communicating summarised reporting to senior management.
Boning room Manager	Live monitoring of boning room performance to allow feedback to staff
Value Add Manager	Identification if staff are able to perform certain cuts based on yield gains and losses. Impact of cut configurations on profitability based on staff accuracy, yield, quality requirements and prices.
Human Resources Manager	Identification if staff are meeting targets, gaps needed in further training.
Quality Assurance Manager	Ability to demonstrate from an auditing perspective, end-to-end traceability and system compliance.
Sales Manager	Use data to run scenario modelling on where changes to cuts in different carcase types impact to realise more value. Run scenario modelling on lower priced cuts to see implications on value adding options? Increased vision to determine best possible sales outcomes based on particular stock. More visibility on livestock supply from properties through feedlot for sales planning that matches livestock supply by quality grades.
Livestock Analyst	Review marbling scores and lean meat yield variances to make informed business decisions and predictions. Linkage with end to end livestock ideally provides real-time visibility of livestock pipeline and decision options for different growth paths/market destinations depending on environment and market conditions.
General Manager – Properties Livestock	Reviewing lean meat yield per animal types and days on grain to underpin genetic and management decision making.
Finance Manager – Primary Production	Review profitability of Waygu F1, F2, Angus at different marbling scores based on lean meat yields. Strategic decisions around production/growth pathways. Impact of these decision options on Primary Production profitability. Joint conversation with Operations and Marketing on whole of supply chain profitability.

5. Conclusions

5.1 Key findings

Change and data usage and maintenance are driven or blocked by individuals

Company culture, progress updates, and reports should be upgraded and applied with each change to support individual morale, bringing them on-board to support the change. The company consists of individuals – change must be considerate of the individual, with support provided if a company mandates a change in data collection, management, analytics and decision processes.

The decision to share *or not share* operational, tactical and strategic information within and between firms depends on the KPIs an individual is evaluated on and their mindset. It is important to consider the culture, specifically the attitude of the organisation and its employees toward data, information and change.

Beyond decisions and KPI reporting, graphical data representations can communicate personnel capability. Visualising what cattle have been loaded, processed, weaned and branded boosts staff morale to see their achievement. A planning graph helps staff see how many have been transferred and what mustering/transfers are ahead of them. This also provides information enabling planning of:

- Human resource requirements,
- Feed needed in the yard,
- Truck bookings and movements, and
- Day-to-day station management.

Frequent, timely updates enable staff to see why accurate data collection is important. Showing missing data in reports and the impact on generating accurate reports helps staff understand the bigger picture of why their job collecting and entering data is critical to business processes.

Data integrity, reliability and accuracy continues to be a challenge from internal sources as well as external

Reliance on third party data collection requires business rules on how this data is to be treated and managed regarding accuracy, timeliness and reliability. The creation of information requires data aggregation. Knowing what granularity of data is required, what can be averaged, what data to collect and what data to report on is pivotal for the industry going forward. Improving the whole red meat industry data maturity and understanding on the impact that data inconsistencies have will help support data-based decision making.

Each KPI, report or dashboard must to support at least one decision, or is required to monitor or evaluate performance, now or future

Collecting data, incorporating historical data, analysing it, maintaining databases and generating eye-catching, graphical representations consume resources (time, personnel, money). It is expensive and wasteful to perform any of these operations without a direct gain or benefit. When mapping inputs and outputs, there may be highly useful KPIs discovered which are not currently possible to report on, but may be in the future reportable in the future as technology and data develops.

Updating to eNVD's will be influenced by digital capability within industry – The barriers of internet connectivity have been partially solved by being able to work offline. The technical capability barriers have been addressed by pre-loading favourites and QR codes. The barrier to adoption is people and change management. For more technically advanced supply chains, making it compulsory with training and support facilitates adoption.

Unlinked data will continue to be collected

Data will continue to be collected by members of the chain which isn't linked into an integrated system, which could be seen as 'wasteful' under ideal circumstances. Aligning and integrating this data to individual animals, mobs, paddocks or properties requires considerable capability and investment. The capability to process this data which comes in formats like PDF, CSV and email requires more resources than what a standardised data system requires. However, integration with these external industry sources is possible. Integration with paper based data requires additional resources to collate and integrate. Developing systems to collect data via digital forms (offline) and other digital methods will support digital integration of beef supply chains.

NLIS: Direct connectivity to the NLIS records to update animals after a bang tail muster to align property records with NLIS records is of benefit. Some animal management systems have developed functionality with direct linkage to NLIS systems allowing the user to choose to manually update NLIS records based on user directives (dead, new animal, retag). Records of animal movements and animals at each PIC were accessed via API and downloaded into Opt[io]® Interchange, with animal management system movement records allowing gaps in the NLIS database due to mis-scans to fill in.

Documentation, policies, procedures, and data and reporting frequencies should be simplified and mapped for all decisions, operational to strategic

To bridge the gap between trained and transient employees, management staff and executives, complex operations should be mapped so a person can use a simple understanding of how to operate and make decisions in consideration of the impact on other decisions.

The marble score 1-9 system prevents accessing 10+ score as a market – The marbling distribution for two supply chain pathways identify that animals are marbling above marble score 9. The current grading system of 1-9 is bypassing the opportunity to sell animals at marble score 10, 11, and 12. This highlights the need for adoption of technology and industry standards which support grading verification beyond marble score 9.

Marbling capability – The data demonstrates animals on less than 200 DoF can marble with scores up to 7, 8 and 9, and that animals on 300+ DoF can marble down to score 3. This has implications for improved carcase and supply chain profitability, shorter feedlot throughput cycles, and reduced carbon produced per kilogram of beef consumed.

Decisions made at the marketing end of the supply chain impact extracted value - Each cut receives a different premium for marble scores. Cut breakdown at different marbling scores has a different premium with value added products offering another value adding opportunity particularly for the cuts with a marble score 3 or less.

Value-added product is a significant marketing opportunity for low-value cuts – Marble score and animal origin are important factors of Wagyu price, but there are marketing opportunities that can trade on the Wagyu name, without the marble score to back it up, or high desirability. This requires

the processor to focus on value added and convenience products, where large margins can be achieved in high-value cuts.

5.2 Benefits to industry

Total supply chain visibility is achieved by connecting kill sheet and MSA data, and NLIS with producer, backgrounding and feedlot records – Connecting to NLIS via API refers to NVDs included in per head data, which allows mob movement tracking. This means lifetime productivity can be assessed per animal, and each animal, paddock and genetic line's performance can be assessed from a whole supply chain perspective. It has also enabled feedback from processors to producers per animal. This is an opportunity to improve decision response time to productivity and profitability changes across the chain.

Lifetime animal data automates vigilance over animal health and biosecurity risks – The ability to create a lifetime animal health record connecting live animal data (vaccinations, treatments, procedures) together with carcase data provides an opportunity to increase vigilance regarding animal health status linked to cattle movements per animal. This ability to track at an individual level has implications for verification of raising claims.

Lifetime animal data enables verification of raising claims – This is independent verification of NVD declarations, and communications between producers and customers are reinforced by this data.

The list of technology providers, systems and product offerings has been developed and refined – Field trials in Northern Australia enabled this refinement. This included walk-over-weigh scales, Cibo Labs and cattle management systems.

6. Future research and recommendations

Communicate adoption, benefits and risks through peers – When hearing adoption good news stories, lessons learnt and benefits across the industry, people prefer to hear from their fellows, who are 'in the know' about their difficulties. Producers prefer to hear from and learn from other producers. therefore, using peer to peer learning is important.

6.1 Supply chain data integration to enable data based decisions

6.1.1 Critical elements of the data digitalisation process

Identify the decisions being made, from operational to strategic impact – Map out what data and analytic results are needed to make informed decisions. Understand what an effective decision-making process looks like, and how results founded on data can support decisions made with any frequency, from daily to annually.

Begin with the end in mind. Before collecting data, designing procedures, or reporting KPIs, determine who needs it, and how much detail is required – Consider who is accessing information and what level of detail is required by the person using the information. It is important to segment data analytics outputs according to who will find them useful for operational through to strategic decisions. This influences the detail and frequency of information required. The person could be anyone from a station manager, to a company board member, to a supermarket sales representative to a consumer. The information could be anything from '100 % HGP free, 8 rib rack' to '3 kg TSDM per head in paddock 5'. Matching the information with the person could mean a consumer buys your product, or the station manager communicates with the region manager to shrink the herd. The point is that value is maximised by aiming for the final recipient and changing activities to support the final recipient.

Data governance and security should be reviewed and established according to company requirements – The robustness of a company's data governance must be proportional to the complexity of their systems. If poorly governed data can still deliver the desired result for a prolonged period of time, that is the necessary level at the time of review and should be maintained to keep the costs of governance low, at their efficient level. The strength of a company's data security must be proportional to the impact a security breach would have on their operations. If a breach would not disrupt operations, risk client agreements or frighten stakeholders, then little security is required, and it should be kept low, at the efficient level. However, if poorly governed data, or a data breach, would disrupt business for any length of time, or cost any amount of resource to recover, an equal cost should be made available to govern data, and defend company systems. And if state of the art governance or security costs less than the cost of failure, then go with state of the art systems.

6.1.2 Facilitation of supply chain data integration

Information sharing within and between firms must be automated, to enable each member of staff the volume of information they need to perform their job on time, completely – With many KPIs requiring similar information, depending on who reports that KPI, data needs to be shared between the personnel collecting the data, and the personnel using it. When data is created in high

volumes, it is not feasible to share and process it manually, and so must be done automatically. When data is created by outside entities, it is not feasible to ask permission to access their data (NLIS, for example) every time it is needed, and so the permissions should be assigned and processed by software automatically. By freeing up FTEs spent on data management, automated data sharing brings massive value to data-driven company decisions.

Where possible, capture who is talking to who, when and what information they are seeking at all decision levels. Map data which is needed, desired but unavailable, and collected but unutilised. Before developing an information sharing system it is important to understand along the supply chain what information is important to whom and when (timeliness) to enable others in the supply chain to make timely decisions based on available data.

Sharing should be two-way, timely, and easy to access for a range of management levels. Adding to the complexity of information sharing and dashboards is dealing with limited or unavailable data transfer abilities, especially with the 3G mobile network.

Data consistency must be supported by thorough staff training and restrictive hardware controls – For consistent process and outcomes, it is recommended that policies and standard operating procedures be created and shared to ensure all field staff are trained up in the appropriate fields, including data collection. Controls should be put in place where possible to restrict what can be entered/recorded.

Data availability matches requirements – Each data point and report should be appraised for how often it is required. This will impact how frequently data needs to be analysed and presented. If a report is made on a weekly basis, it does not need to be updated 'live' and resources can be saved.

6.2 Value based marketing

Align terminology and focus across the supply chain to what the consumers value and are willing to pay for – The characteristics (flavour, convenience, shelf life, etc.) required by each value chain customer must drive and be correlated to product specifications, back to a live animal and pheno- and geno-typic choices. Linking back to live animal decision-making to improve compliance with consumer requirements per branded product is required for VBM to be successful. This requires developing a shared understanding of the target live animal specifications to focus on practical steps to deliver value.

Wagyu consumers are interested in eating quality attributes including tenderness, flavour, juiciness and mouth feel as well as provenance, consistency and convenience. The breed reputation is one of high marbling associated with eating quality characteristics. To support value-based marketing consistent terminology and attributes across the supply chain which are consumer focused is required.

Enhancements in genetics and environmental influences can result in Wagyu's marbling without needing 300+ days on feed. The branded marketing focusing on 300+ days on feed needs to be considered from the perspective of the consumer attributes which they value and are willing to pay for – marbling, tenderness and flavour.

6.3 Change management

Data analytics results need to be filtered through a change management process – A meaningful result may be contrary to people's expectations e.g. they are doing more poorly at their job than they thought OR the person should be doing more XX and less YY to support profitability but they enjoy YY more. Change management should support staff engagement with results, maintain or improve staff morale, deliver training where needed, and change systems of work as necessary.

Communicate using graphs, tables and other simple, digestible information sources where possible – Information can be condensed or summarised in graphical formats. Where referred to frequently, the decision-maker will learn the format, and be able to understand what the figure is communicating quickly.

6.4 Research and development

Incentivise supply chain performance with VBM initiatives – Consideration needs to be given to VBM as more data and information becomes available through digitally integrated supply chains. Presenting information back to the supply chain with VBM incentives will focus decisions on whole supply chain profitability and high value consumer products.

Investigate all variables vs. marble score for profitability – Since DoF has been shown to not be the sole driver of marble score, all variables with a potential impact on marble score and HSCW must be investigated. If the key drivers are discovered, the value of red meat will increase by increased marble score. The initial variables to investigate are genetic base, pasture quality, ADG across lifetime and animal age. The findings from this research should be made to the wider industry in support of the marketing activities which will seek to depart from DoF as a driver of price premiums.

Analysis summary – The connections with NLIS, feedlot and processing data identified opportunities to improve profitability in line with VBM. The analysis identified:

1. Large population variations with some animals marbling at scores 7,8,9 on short feed programs. These animals offer incredible value creation, profitability, carbon reduction and efficiency benefits if their genetics can be identified and environmental influences understood.
2. For VBM, higher marbled Wagyu animals is the key "product" to create value in the eyes of the consumer.
3. Identifying which properties and breeding locations have higher marble score and why will support repeating their method.

Further analysis is required to understand the statistical implications of the findings:

What variables impact carcase quality produced?

a. Vendor
b. ADG throughout the life of the animal
    i. Any periods which the animals lost weight or were at maintenance.
    ii. Backgrounding, feedlot, breeding property performance.
c. Feedlot induction weight
d. Subcutaneously fat distributions
e. Genetic base
f. Diseases throughout life

This will find the key drivers to increase the value of red meat within the supply chain and reduce the cost of feeding animals.

Cost benefit analysis on grouping of marble scores – By grouping marble scores into groups as is currently the case for example 4-5, 6-7, 8-9, the value of higher marble scores is not extracted i.e. MS 5 is sold as MS 4. The cost of separating the cuts into individual marble score groupings is currently unknown, and the value which can be extracted from the separation of the scores, particularly 7,8 and 9 requires a business case analysis across the industry and for individual processors to calculate the additional value which could be extracted. From a value-based marketing perspective a consumer may not be able to differentiate between a marble score 4 and 5 therefore differentiation isn't necessary from a marble score perspective, however for a fine dining experience the marbling score may also be used to indicate prestige which offers a different value proposition.

It is recommended producers focus on the KPI's of **kg beef sold/ha and weaning % –**a KPI often quoted is kg/beef produced/ha/year which measures the animals body weight at a point in time however this doesn't reflect outputs and profit drivers of a pastoral business as an animal's body weight varies with growth, body condition and pregnancy. Focusing on weaning % supports females having a body condition score above 2.5 to fall pregnant. The herd will be mustered, managed and weaned appropriately to increase weaning % and a focus on weaning % will encourage advanced management techniques like seasonal mating, spike feeding, strategic use of lick blocks, targeted feeding and growth for heifers.

7. References

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