final report

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Assessing value chain improvements in processes, practices and technologies using optimised data capture and analytics

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Abstract

Hitachi Consulting (HCC) in partnership with the Australian Country Choice/Australian Cattle and Beef Holdings (ACC/ACBH) developed a digital transformation pilot project to capture data and generate management systems to assess improvements in processes, practices and technologies for a backgrounding property. While initially scoped as a broader value chain project, lack of connectivity across the value chain resulted in the project being rescoped through a rapid assessment process to focus on addressing connectivity issues on remote properties and building up an On Farm Smart Agriculture Control Centre.

Opportunities identified in the rapid assessment were then actioned including the installation of a weather station, soil moisture probes, and water level sensors in troughs and a reservoir. An Unmanned Aerial Vehicle (UAV or drone) was also deployed to image paddocks to measure changes in pasture biomass represented by Brigalow regrowth. A Hitachi Process Intelligence (HPI) Smart Agriculture Control Centre was developed to analyse and display the data relayed via an installed Iridium satellite system. Extended functionality including decision support, was developed to assist with property management practices.

Executive summary

Meat & Livestock Australia is supporting initiatives for the red meat industry that will allow increased digital capacity that aims to:

- Increase production efficiencies on farms and feedlots, and
- Lift processing productivity.

The overarching objective of this project was to deliver productivity gains through the value chain by the adoption of best practice and appropriate technology. In this project, Hitachi Consulting (HCC), Australian Country Choice (ACC) and Australian Cattle and Beef Holdings (ACBH) worked to identify gaps in existing capabilities in data capture and management along the beef value chain by using Hitachi evaluation tools.

This exercise resulted in the development and implementation of a bespoke, on-property, real-time data management platform providing data analytics and predictive decision support capability.

Croydon Station, a backgrounding property north-west of Rockhampton was selected to conduct a trial on the capture and transfer of data along the value chain. The Hitachi Process Intelligence (HPI) Rapid Assessor solution was used to conduct detailed mapping of the property management processes. This work allowed the identification of gaps in data capture and the development of a preliminary platform to capture and interpret on-property data.

ACC has a strategic business imperative to improve the effective transition of data throughout the value chain. This will improve cost control and exert greater management over meat processing and the end products. The process of vertical integration as is the case for the ACC/ACBH operations, quality data is essential to improve efficiencies along the value chain. The provision of quality data is reliant on ease of data movement and the ability to capture data across multiple stages of the value chain. The results of this project highlighted that the ACBH backgrounding property required better-quality individual cattle data and data input to advance the company's vertical integration strategy. As a consequence, ACC has requested improved data measurement and analysis to capture breeding, backgrounding, feedlot and processing operations along the entire value chain.

Hitachi Consulting first evaluated the stations that were chosen by ACBH to be part of this project. The project group utilised a rapid assessor tool to better understand ACC's value chain. Following the deployment of the Hitachi Process Intelligence (HPI) Rapid Assessor and building of a Control Centre for required on-property operations, the foundations for designing and developing a cloud based (open source/open access) system which accommodates diverse data sources and formats was developed.

Preliminary sensor devices were deployed on property across two paddocks. These included the use of drone imagery to identify changes in paddock Brigalow regrowth biomass estimations. Water levels sensors were installed in water troughs in Blackbutt and Bull paddocks and the reservoir feeding these troughs. A weather station was installed in Bull paddock with soil moisture sensors located at a depth of 15 cm (within the root zone) and at 30 cm (just below the main grass root zone). The weather station captured temperature, humidity, rainfall, wind speed and wind direction providing updates to the Control Centre every hour.

The project implemented a connectivity strategy due to a weak Telstra mobile signal near the homestead. Hitachi Consulting deployed a satellite transmission linkage, which allowed for data to be transmitted off the property, collating the data through a 2.4 GHz radio telemetry signal and transferring the data from a satellite hub to the Iridium satellite system. This data was then relayed

to the HPI cloud server and then to HPI Smart Agriculture Control Centre for the ACBH on-property customised data visualisation.

The Control Centre was geared towards data visualisation and decision support, and was developed exclusively for ACBH on-property monitoring of paddock and animal productivity data. This included the transfer of livestock between paddocks and the property herd composition. It was identified that data around the live weight of cattle on the property was limited. Live weight and other animal data can be linked to RFID ear tags, however due to issues with the existing herd recording software, this could not be achieved at Croydon Station during the life of the project.

An unmanned aerial vehicle (UAV) was deployed to monitor a Brigalow regrowth control program. Brigalow with an area of more than 1 m^2 was geotagged prior to a chemical application and a follow up survey six months later indicated a marked decline in the number of live Brigalow plants.

A cost benefit analysis identified that the technology presents potential management benefits, which could positively influence the key profit drivers of a beef business, namely higher kilograms of beef per AE/yr, increased carrying capacity over time, improved labour efficiency and reduced herd expenditure. Whilst the benefits can only be estimated at this time, small changes in each of these drivers using optimised data capture and management can have a significant effect on business performance and cumulative changes will be compounding.

For the management platform to be fully operational and add maximum benefit to value chain operations, all livestock require RFID tags linked to the following information: property of origin, breed, birth date, progressive induction dates/treatments, live weights, dentition, sex, vaccinations and treatments, *Bos indicus* %, transaction dates and carcase attributes. These individual animal attributes are essential for the development of accurate and advanced analytic insights through the HPI Control Centre. Individual cattle data will play an important role in improving the efficiency of vertically integrated supply chains by improving the quality of the end product and the management of all cattle across the value chain.

The project resulted in MLA winning a Hitachi Global Digital Transformation Award for the implementation of this project (Fig i). As part of the nomination process a film crew flew in from the United States to produce a video of the project, this video was played during the awards presentation in Las Vegas and has been widely viewed on a number of social media outlets. A presentation on this project was also delivered at the 2018 GoogleNext conference with a further new video being produced and widely distributed. Extensive promotion of this project was also given at MLA's AGM in Alice Springs in 2017 as well as Beef Week 2018.

Figure i) The MLA- Hitachi Consulting team at NEXT2017 after being presented the Hitachi Global Digital Transformation Award (L-R); Michael Teytaud, Owen Keates, Ben Dwyer, Nigel Tomkins, Phil Townsend, Dean Gutzke, Tyler Young.

Table of contents

1 Background

Value chain mapping is a high-level process that identifies the main activities associated with a business's service or product line and is often used in corporate strategy to identify performance improvement opportunities. Corporates are using value chain mapping to better manage the entire business by improving efficiencies along the entire product chain and to develop a sustainability strategy.

Australian Country Choice (ACC) is a significant vertically integrated supply chain organisation in Australia. The ACC business is dedicated to the best practice supply of high quality meat products with the supply philosophy based on providing a complete chain from 'paddock to plate'.

The company's beef operations encompass:

- Cattle Breeding
- Cattle Growing (backgrounding)
- Cattle Grain Feeding
- Beef Primary Processing
- Beef Further Processing (Value-adding & Retail Packing)
- Product export marketing & sales
- Product primary distribution.

ACC owns, leases and manages 54 Queensland properties totalling 662,500 hectares (1.7 million acres). These properties accommodate around 15,000 breeding beef cows, 54,000 young growing beef cattle and 46,000 young beef cattle in feedlots to provide 240,000 head of cattle each year to the processing facility.

The Cannon Hill processing plant is a fully integrated slaughter / boning / value add / retail-ready / distribution facility located in the eastern suburbs of Brisbane. The primary processing facility has a daily capacity of approximately 1,280 head of beef cattle.

Data measurement and management systems will be critical to a whole of business improvement approach. ACC's vision is to develop and build on current systems and capabilities in data measurement and management to facilitate improvement in real time cost management across the business. ACC is currently evaluating red meat industry data capture, analysis and management systems used across the red meat supply chain including livestock production, feedlots, processing, logistics, wholesaling and retailing. The current project evaluated improvements in beef production processes, practices and technologies via a pilot exercise with ACC-Australian Cattle and Beef Holdings (ACBH) using optimised data capture and analytics.

Engagement with Hitachi was initiated in May 2016 and resulted in a series of meetings with Meat & Livestock Australia (MLA) staff focusing on assessing improvements in red meat production processes, practices and technologies using optimised data capture and analytics. To put the challenges into context, Hitachi and MLA staff visited several beef properties in Central Queensland, an extensive property in Northern Queensland and scoped out a processing supply chain (ACC's Murarrie operations). Data capture and management systems currently and potentially available through Hitachi have been identified as readily applicable to the red meat industry.

The case for a whole of supply chain data management strategy, concentrating on best practice and process efficiencies in the red meat industry is compelling. An increase in measurement technologies capturing more quantitative information along the supply chain creates a significant "data lake", however new processes are required to extract and use this data effectively. Improvements in production efficiencies on and off-property and determining key intervention points for management activities will benefit all participants in the value chain. There is an increasing demand for optimised data capture and management that provides novel and relevant ways for value chain partners to share and mine data to the benefit of their operations. It is important to recognise the red meat industry's regional beef research councils have identified in 2016-2017, the importance of optimising production and the efficient and effective collection of data as priorities.

In partnership with the MLA Donor Company (MDC), an optimised data capture and management system was proposed to assess improvements in processes, practices and technologies to meet the needs of the red meat industry. The current project evaluated a highly integrated value chain within ACC/ACBH with a primary focus on agribusiness operations and the feasibility of transfer more broadly across the whole value chain. The outcomes and learnings have the potential to inform a number of current MLA industry imperatives and strategies currently under development including industry's digital strategy, automation technology and sensing, and building data management systems to support current data.

Due to the versatility of process intelligence, Hitachi Process Intelligence (HPI) could be applied across any industry that could benefit from process improvement or advanced data insights. Specifically, for beef property enterprises, HPI can add value by:

- Higher productivity (kg of beef per Adult Equivalent) (AE)/yr)
- Increased carrying capacity overtime
- Improved labour efficiency
- Helping to reduce herd expenditure.

Hitachi, with the implementation of HPI offered ACBH:

- Data transition & integration – single platform (IoT integration platform)
- Cloud based (access anywhere an internet connection is available, satellite enabled where required)
- Decision support system (DSS) – on-property operations (animal movements and keep, sell, move, feed options)
- Property geographic and infrastructure mapping
- Exit date predictions on a mob and paddock basis
- Alerts when certain set parameters are exceeded
- Weather predictions using historical trends.

2 Project objectives

Collaboration with Hitachi intended to capture the following elements of integration to allow value chain partners to share and mine data.

Specific objectives of the project included:

- Detailed data capture and management mapping exercise of an integrated red meat value chain using existing evaluation tools developed by Hitachi.
- Identify gaps in existing capabilities and capacities in data capture and management by assessment of on-property best practice to document ongoing improvement in livestock production and turnoff potential, animal welfare and husbandry.
- Design and develop a cloud based (open source/open access) system that accommodates diverse data sources and formats.
- Build and implement an on-property pilot evaluating a series of identified new data sensing devices and analytics to fill current data source gaps.
- Evaluation of the outcomes of the on-farm pilot data management system and extrapolation across the value chain.
- Third party independent review of the feasibility, cost benefit and business case associated with adoption of an integrated data management system for adoption on-property and across the entire value chain.

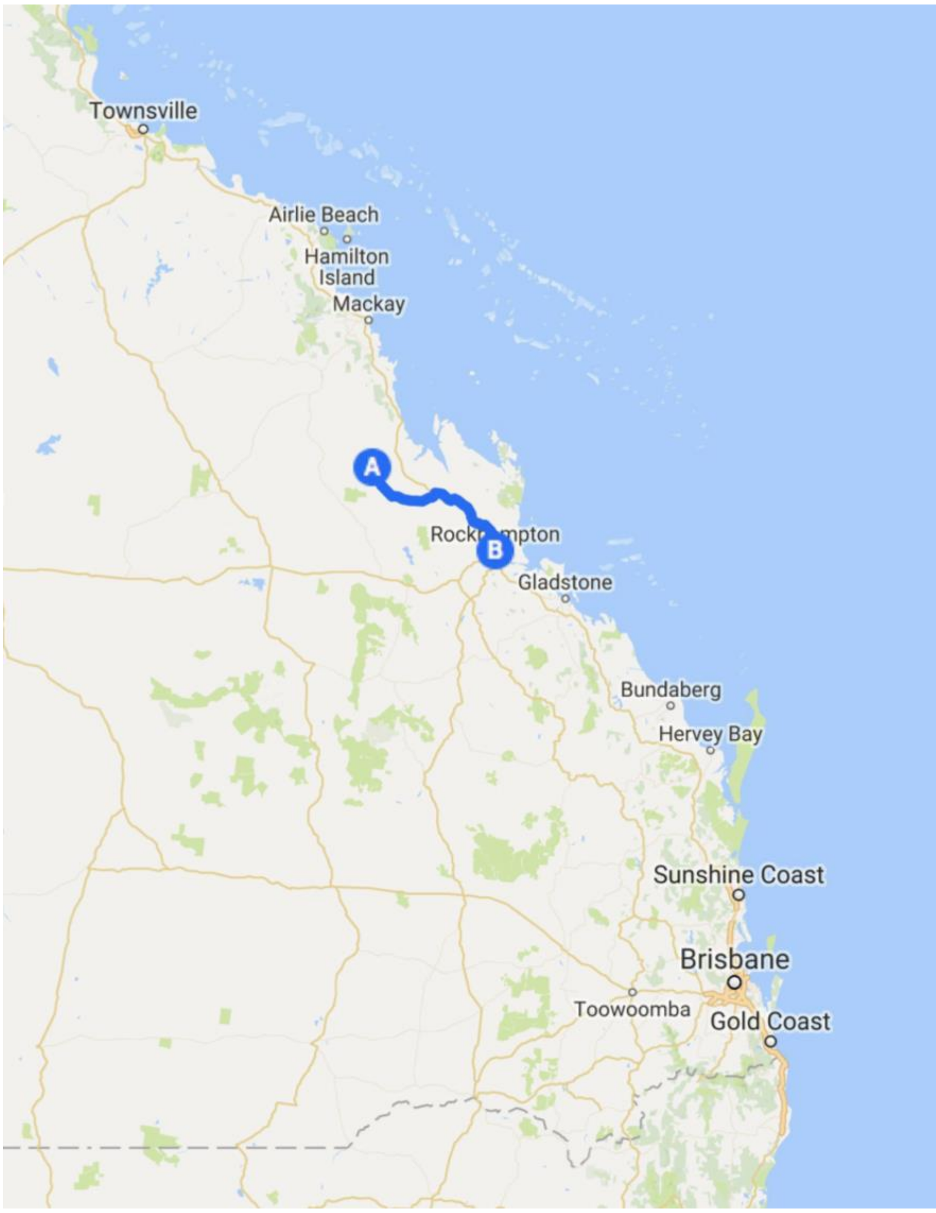
The overall objective of this project was to evaluate the integration of a data capture and management system to assess improvements in processes, practices and technologies for beef productivity.

3 Methodology

3.1 Site details

3.1.1 Location

Hitachi in collaboration with ACBH selected Croydon Station for the project. The location of Croydon Station (22°27'46.69"S, 149° 9'58.94"E) is shown in Fig. 1.



Croydon Station is located approximately 200 km north west of Rockhampton. The property acts as a grow out property taking in young, light cattle and transferring these to a feedlot for finishing. At Croydon Station, two paddocks were chosen to establish sensor devices and monitor Brigalow regrowth, Bull paddock (808 ha), and Blackbutt paddock (620 ha) (Fig. 2).

Fig. 1 Location of Croydon Station relative to Rockhampton

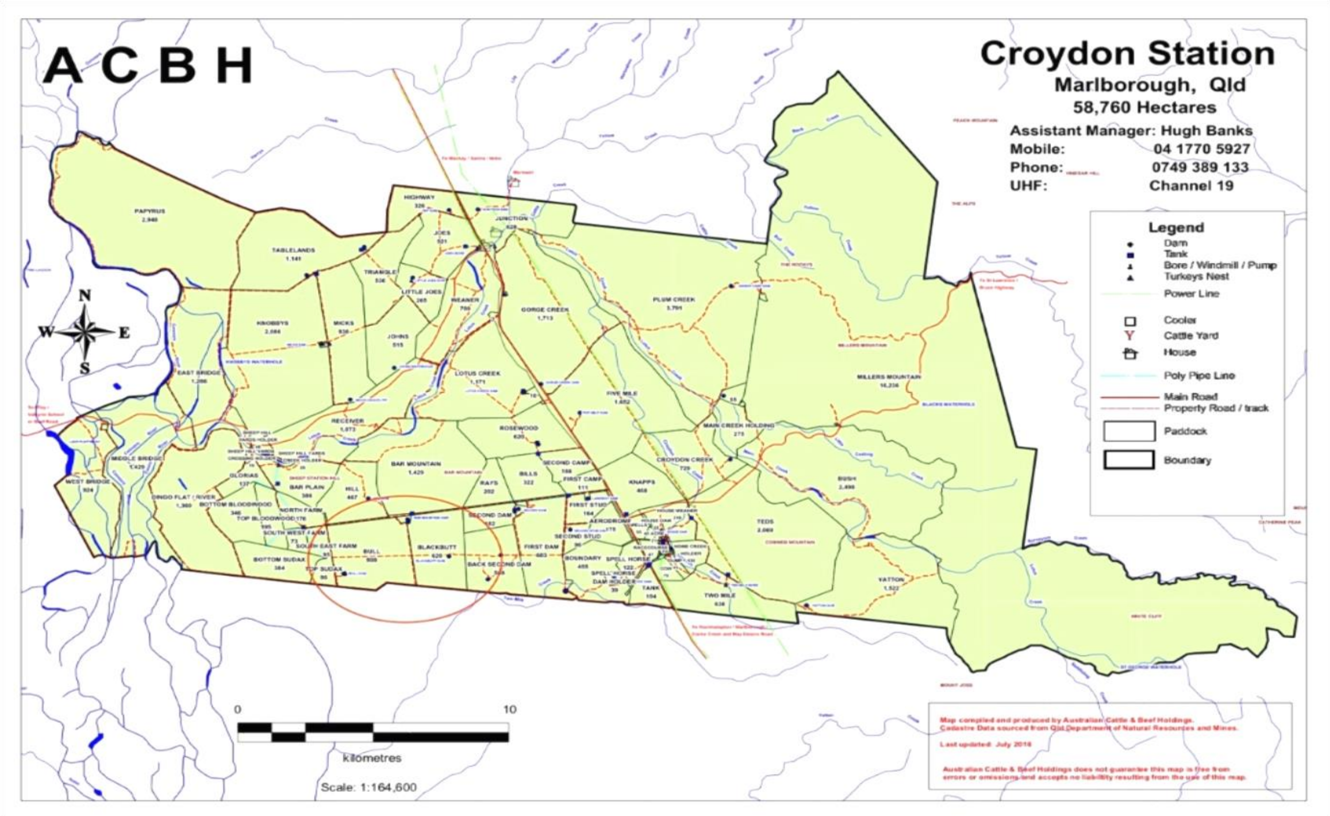


Fig. 2 Location of adjoining Blackbutt and Bull paddocks, Croydon Station (circled in red)

3.1.2 Land type and soils

In both Blackbutt and Bull paddocks the main soil type is Vertosol with some of the area made up of the Sodosol soil type (Fig. 3).

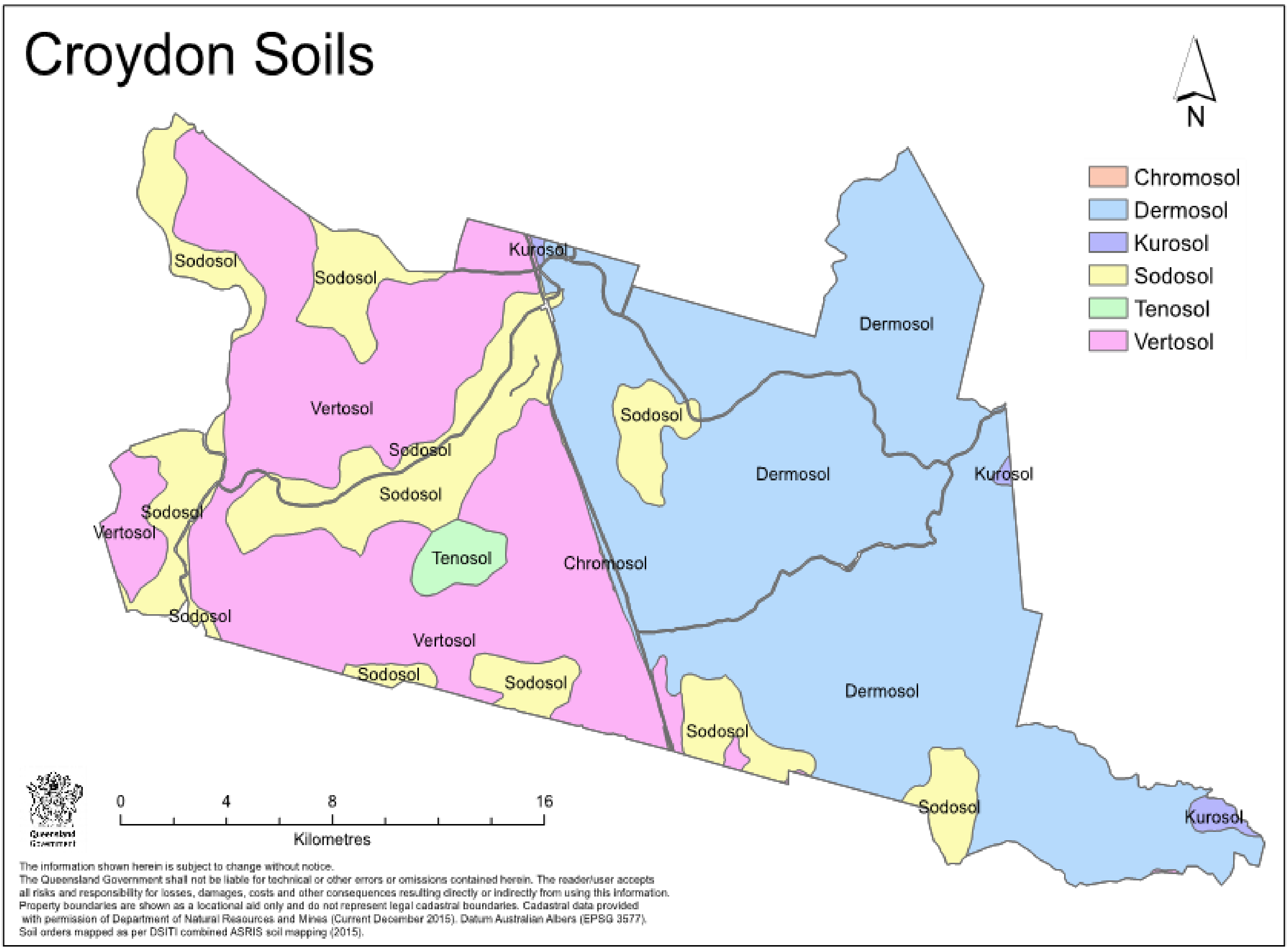


Fig. 3 Soil types on Croydon Station

Vertosols are the most common soil in Queensland. Characteristics include:

- brown, grey or black soils which crack open when dry
- commonly form hummocky relief called gilgai
- very high-soil fertility, and
- large water-holding capacity.

Sodosols are texture-contrast soils with impermeable subsoils due to the concentration of sodium. These soils occupy a large area of inland Queensland. Generally Sodosols have a low-nutrient status and are vulnerable to erosion and dryland salinity when vegetation is removed.

3.1.3 Climate and vegetation

Average rainfall for Croydon Station is approximately 680 mm per annum and is summer dominant. The two predominant land types represented on Croydon Station are Goldfields country – red soils (Land type BD11) making up 21,922 hectares or 37.5 % of property area and Brigalow with melon holes (Land type FT05), making up 8,368 hectares or 14.3 % of the property.

A severe weather event occurred in the period 23-29 March, 2017 when Croydon Station was subjected to extremely high rainfall during Cyclone Debbie. The aftermath of the low-pressure system dumped up to 1,000 mm of rain on certain parts of Croydon Station. This resulted in severe damage to fences and other infrastructure and cattle were displaced from their paddocks and cattle losses were incurred. Due to this event, the execution of the project was delayed by three months until repairs to infrastructure and cattle numbers were accounted for.

3.2 Livestock - cattle

The cattle on Croydon Station are a *Bos indicus* cross and are paddocked in mobs by sex (steers or heifers) and live weight. Mob size is determined by paddock size, watering points, pasture quality and live weight . Croydon Station is a grow-out property with cattle coming from multiple sources including other company properties.

Cattle mobs are paddocked on Croydon Station according to the following live weight groups:

- 180-220 kg (weaners)
- 220-260 kg
- 260-300 kg
- 300-340 kg
- 340-380 kg
- 380 kg+ feeders (ready for feedlot)

3.3 Project stages

The project was completed in five stages:
Stage 1: Detailed value chain mapping exercise using Hitachi agribusiness tools and analytics.
Stage 2a: Design, build and run a value chain pilot exercise for data capture, analyses and management.
Stage 2b Co-create Smart Farm Platform for ACBH Value Chain
Stage 2c Run a value chain pilot exercise for data capture, analyses and management.
Stage 3: Desktop evaluation of pilot data and feasibility of scale-up and transfer across the wider value chain.
Stage 4: Independent cost benefit and business case of developing and implementing an optimised data capture and management system.
Stage 5. Reporting and develop materials on business case and findings to present prospective company(s) seeking ongoing development and testing (Phase 2).

3.4 Value chain mapping exercise

A mapping exercise across the entire value chain of ACC was conducted using Hitachi Process Intelligence (HPI) Rapid Assessor. In particular, a Hitachi Process Intelligence Platform for ACBH was developed for the purposes of:

- Collecting, storing, analysing and displaying the collected data
- Providing a Best Practice Knowledge Repository for ACBH
- Providing a Decision Support System for ACBH
- Providing Big Data Analytic Insights

Fig. 4 illustrates the mapping exercise where linkages between administration, animal management, pasture management, people management and asset management are broadly depicted.

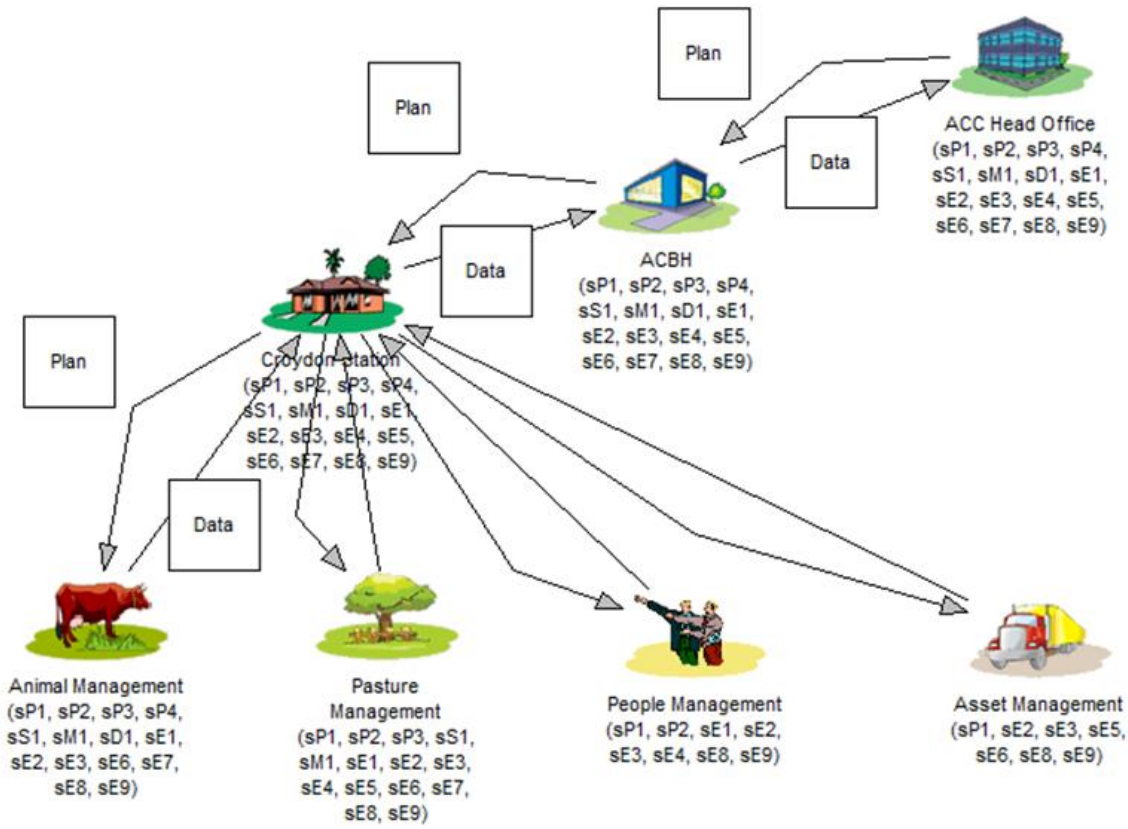


Figure 4. Hitachi Rapid Assessor Value Chain Mapping

3.5 Installation of weather station, soil moisture probes and satellite hub

Assessment and analysis of existing data capture capabilities and management systems currently being utilised on-property, specifically the ACBH agribusiness area was conducted. The project installed IoT sensory and data communications devices (fig 5 and 6) to generate real time on-property data streams for validation of the HPI platform for beef cattle. Devices installed were:

- Weather station measuring barometric pressure, evapotranspiration, humidity, rainfall, rainfall rate, soil moisture, temperature, wind speed and wind direction
- Water level sensors
- Iridium Satellite Gateway Hub.

Figure 5. Weather Station at Blackbutt Paddock

Figure 6. Water level sensors on water troughs

Water level sensors were installed in the water troughs in Bull and Blackbutt paddocks as well as the reservoir feeding the water troughs.(Figure 6)

A solar powered transmitter sends the trough level data to the Iridium Hub, see Figure 7.

Figure 7. Water level sensor transmitter with solar panel

The Iridium Satellite Hub gateway (Figure 8) was installed and successfully commissioned on 1 March 2017. Communications were established with the Iridium satellite and data transferred to the ICT Cloud server and then forwarded to the Hitachi cloud server. The data collected was used to update the Croydon Smart Agriculture Control Centre on an hourly basis. The following data is being collected and displayed:

- Barometric Pressure
- Evapotranspiration
- Humidity
- Rainfall
- Rain Rate
- Soil Moisture
- Temperature
- Wind speed
- Wind direction

Figure 8. Iridium Hub gateway installation and reservoir water monitor.

3.6 Management Smart Agriculture Control Centre

An initial design and layout of a Croydon Station Management Smart Agriculture Control Centre was undertaken by Hitachi Consulting and discussed with MLA on the proposed layout and contents. The design and layout was then forwarded on to the Hitachi Global Development Team to draft a Smart Agriculture Control Centre proposal. The draft Smart Agriculture Control Centre was reviewed with MLA, ACBH management team for inputs, outcomes and recommendations.

Following feedback, Hitachi Global Development Team was given the brief to design a Smart Agriculture Control Centre to comply with the inputs from ACBH.

3.7 Unmanned Aerial Vehicle (Drone) survey

While the Hitachi team was on site assessing requirements, Croydon Farm Management enquired as to whether Hitachi had any ability to conduct drone surveys as they were about to conduct a Brigalow regrowth eradication program and wanted to monitor the effectiveness of the program. Hitachi had run a number of agriculture analysis projects using their drone partner company V-Tol Aerospace https://www.v-tol.com/) and agreed to monitor the regrowth eradication program as part of the project. V-Tol deployed a fixed wing drone (Figure 9).

A drone survey of Bull and Blackbutt paddocks was conducted to establish the effectiveness of the Brigalow regrowth eradication program in those two paddocks. The UAV operated at a maximum of 400 ft above ground level (AGL) when traveling to mission sites and performing missions at the 140 to 180 ft height range. An area of vegetation was observed prior and after the defined treatment. The area surveyed in both paddocks totalled 1,500 ha. The drone footage was shot using a Sony a6000, (Figure 10). The a6000 is a 24 MP camera capable of shooting 11 fps @ 1920x1080/60p. Having the ability to shoot in true 1080 HD gives the camera excellent clarity even at higher altitudes. Individual photos shot with the camera are then joined or stitched in a mosaic platform, (Figure 11), which is the format required for analysis. The development of the algorithm to analyse the Brigalow regrowth was developed and applied. A few days prior to the drone operations a herbicide application was made by aircraft targeting Brigalow regrowth. A herbicide, FMC Allgraze (active ingredient 200 g/kg tebuthiuron) was applied at a rate of 15 kg/ha by helicopter just prior to the drone footage on 15 December 2016.

Figure 9. Fixed wing drone final checks prior to deployment on Croydon Station

Figure 10. Sony a6000 camera used on the drone

Figure 11. Brigalow regrowth across Croydon Station

3.8 Design and build a value chain pilot exercise

Data obtained from on-property sensors and current property records were used to supplement and optimise task allocation and automation. This was visualised data without actual physical labour inputs to check rainfall (checking the rain gauge), register water levels in trough, and identify soil moisture (influence & quantity of rainfall).

The selection of targeted focus areas from ACBH's properties led to a detailed company specific report on the pilot data capture and management system which included:

i) Design and build specifications
ii) Outcomes of pilot trials, results and findings benchmarked against other agribusiness sectors.

New and existing data from the pilot trial was reviewed. This generated the basis for the feasibility study of scale-up and transfer across the wider value chain. The independent business case for developing and implementing an optimised data capture and management system was outlined.

A high-level mapping exercise using Hitachi tools on the ACC/ACBH value chain and business operations was undertaken. This desktop analysis was based on two broad business questions where it was considered better answers would be valuable to the businesses:

i. From the perspective of the processor, how to identify the best sources of animals, and how to provide feedback to producers to enable them to produce animals better matched to the processors' requirements.
ii. From the perspective of the producers, how to best manage weight gain along the supply chain to best meet the requirements at processing and how to predict what an animal will deliver at market.

3.9 Cost benefit of an optimised data capture and management system

An independent cost benefit and business case for application of HPI in the beef value chain was conducted using company commercial in confidence data and industry benchmarks to derive scenario data. A meeting held in November 2017 provided a full briefing on the project data capturing and integration on the Hitachi Process Intelligence (HPI) monitor at the ACBH property Croydon.

A desktop feasibility analyses was conducted to validate the application of developing and implementing an optimised data capture and management system. The long-term performance of businesses with greater than 1,600 head was analysed.

Recommendations from this report formed the basis of the desktop feasibility analysis. The recommendations (for project data and integration) were to include:

- Land Condition (A – D) score on each paddock.
- Adult equivalent (AE) numbers shown on the HPI monitor in addition to the weight group in paddocks.
- Pasture biomass of a paddock accompanied by the nutritional value of the pasture.
- Walk Over Weighing (WoW) data which could assist with changes in paddock biomass due to grazing and to assist with monitoring cattle weight gains or losses.

It was recommended that the key measures used be mostly confined to be the most sensitive to improved management. Many measures are secondary by nature and only serve to clarify primary measure findings. The recommended key measures were Adult Equivalent (AE), the standard livestock measure for northern herds and enterprise performance measures.

Two main measures of enterprise performance were used.

- Earnings before interest and tax per adult equivalent (EBIT/AE).

This is the 'bottom-line' for the herd and takes into account all income and expenses. Analysis stops at this level, because the underlying performance of a herd or business is independent of its financing.

- Cost of production of a live weight kilogram of beef (COP).

It has been shown elsewhere that the lowest cost beef producers (as measured by COP), are generally the most profitable. COP complements the EBIT/AE measure as it is independent of market

fluctuations, which influences EBIT/AE, so can be a better measure of underlying long-term business performance.
The following key measures were used to determine enterprise performance.

- Income per AE.

A function of kg Beef/AE and income per kg.

- Operating Expenses per AE.

Comprised of enterprise expenses and overhead expenses. Enterprise expenses are money spent directly on the herd, better performing producers typically have lower enterprise expenses and better herd productivity, indicating that the money spent on the herd is better targeted and has better results. Overhead expenses per AE are a function of scale and labour efficiency.

- Kilograms of beef (live weight) produced per adult equivalent (kg Beef/AE).

This is the primary measure of herd productivity, which has been shown to explain around 80% of the variation in herd income, at least in northern herds

- Labour Efficiency (AE managed per FTE)

Labour and labour related expenses have been shown to constitute about 70% of overhead expenses and about 50% of total operating expenses in beef businesses. It is about the only area in the expense side of a beef business where, to a point, improved efficiency can drive expenses down.
For analysis of an optimised data capture and management system to provide a meaningful outcome, points of reference were defined. The analysis used comparable industry data to appreciate the performance spectrum, data from *The Australian Beef Report* (www.bushagri.com.au/abr) was used.

From this data, the long-term performance of those businesses with greater than 1,600 hd was extracted and analysed. The businesses that make up this data were considered representative of the commercial scale operations in the north, whereas the average of all northern businesses cannot, due to the number of smaller herds that typify the industry (49% of northern producers have less than 800 hd). The producers with greater than 1,600 hd in the dataset make up 28% of the population and produce 72% of the beef.

3.10 Reporting on the business case and findings

The reporting and development of the business case was performed through assessment of the entire value chain from, breeding, backgrounding, feedlotting and processing to generate and develop best practice management strategies.

The business case included a review of:

- Technology options and funding sources
- A cost benefit analysis including sensitivity analysis, operating costs and revenue
- Results of operational trials
- Recommendations for next development and testing phase.

4 Results

4.1 Developing the Smart Agriculture Control Centre

While individual animal data was not available as mentioned the Hitachi team still developed the Smart Agriculture Control Centre to capture and analyse individual animal data as well as mob level data. Hitachi were aware that ACBH was addressing the technology solution regarding the capture of individual animal level data and agreed that this functionality would be integrated as soon as the animal reading systems had been established. The Smart Agriculture Control Centre was collaboratively developed by Hitachi and ACBH and evolved as follows:

4.1.1 Smart Agriculture Control Centre – main page

A prototype Smart Agriculture Control Centre was demonstrated at workshops at ACC headquarters in Cannon Hill and Croydon Station .

Figure 12 shows ACBH management evaluating the Smart Agriculture Control Centre which was permanenly placed at the Croydon station.

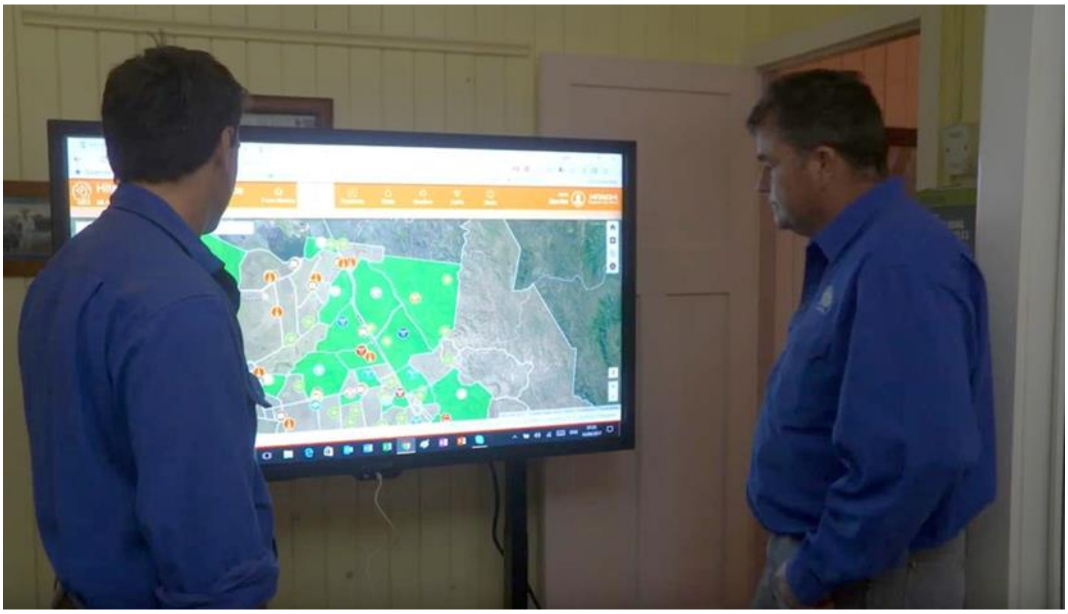


Figure 12. Croydon Farm Manager Hugh Banks and ACBH CEO Ben Dwyer review the Control Centre

Figure 13 shows the main menu of the Smart Agriculture Control Centre summarising cattle numbers, paddocks stocked and spelled, water sources and water availability in bores, dams, tanks and troughs, weather station real time data and the three closest Bureau of Meterology BOM weather stations. Alerts from alarm configurations are set for water levels or paddock pasture biomass levels.

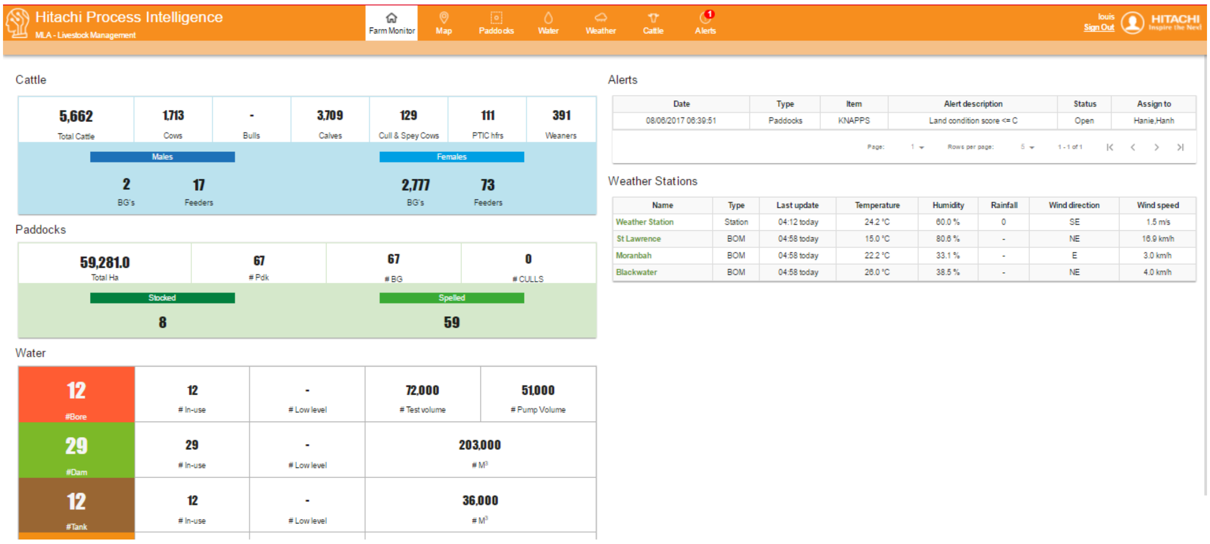


Figure 13 Croydon Station Smart Ag Control Centre – main page

4.1.2 Smart Agriculture Control Centre- paddock page

The paddock page is shown in Figure 14 This page summarises information for each paddock, including area, stock numbers, land condition, available dry matter and water requirements. Stocked paddocks are filled in green and spelled paddocks are filled in brown. When the mouse pointer hovers over a "Stocked" paddock the following information is displayed on the map:

- Paddock Identification
- Paddock size
- Total animals
- Stocking rate
- Number of days' cattle are in the paddock

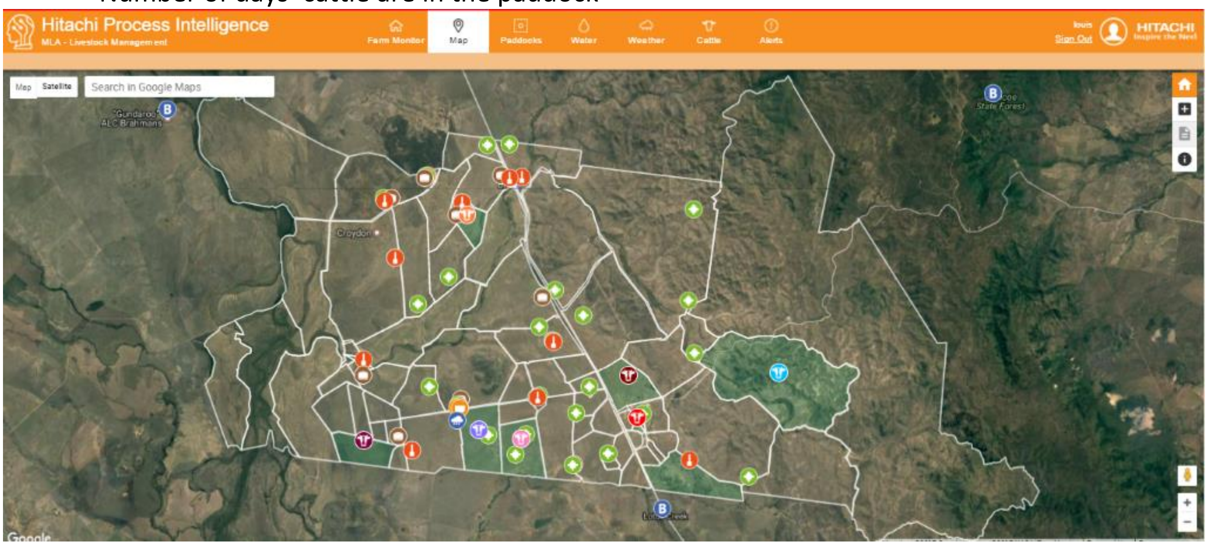


Figure 14. Croydon Station Smart Agriculture Control Centre map showing all paddocks and infrastructure location

When the mouse pointer hovers over a "Spelled" paddock the following information is shown:

- Paddock Identification
- Paddock size
- Number of days without animals

Figure 15 provides an example Paddock page where paddock and animal details are summarised including available pasture biomass and water requirements.

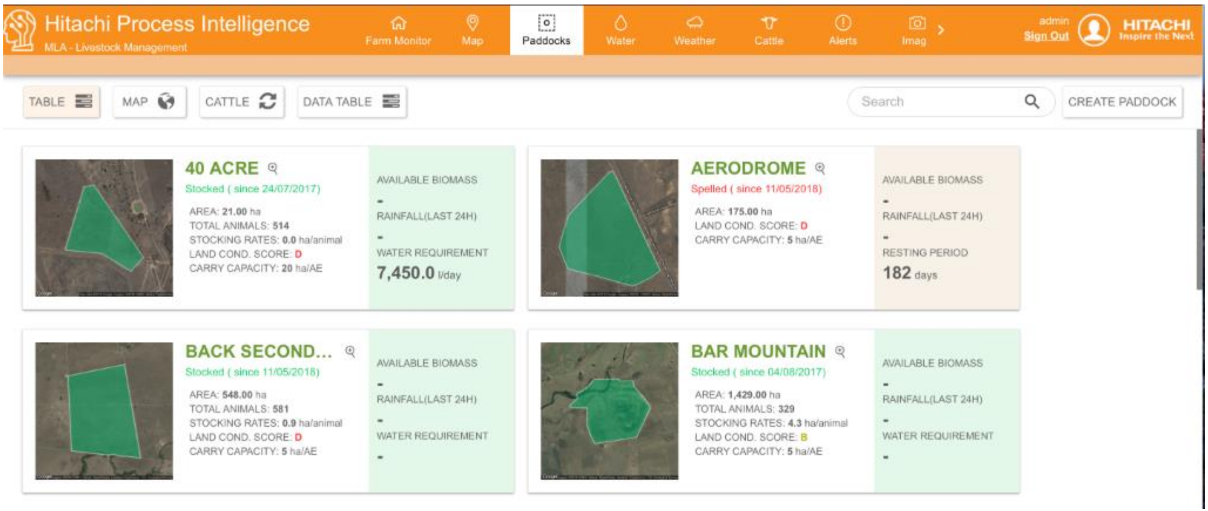


Figure 15. An example of the Paddock page

4.1.3 Smart Agriculture Control Centre - paddock details page

A sample Paddock Details page is shown in Figure 16 This page shows tabs for General, Condition, Animals, Object (infrastructure) and weather (nearest weather station). Importantly this page has an activity history which records the movement of cattle into and out of the paddock. Mapping of the paddocks on Croydon Station was done using Google Earth Mapping. The following general information of a paddocks is displayed when a paddock is clicked on, on the map or at the paddock selection list on the right-hand side of the map.

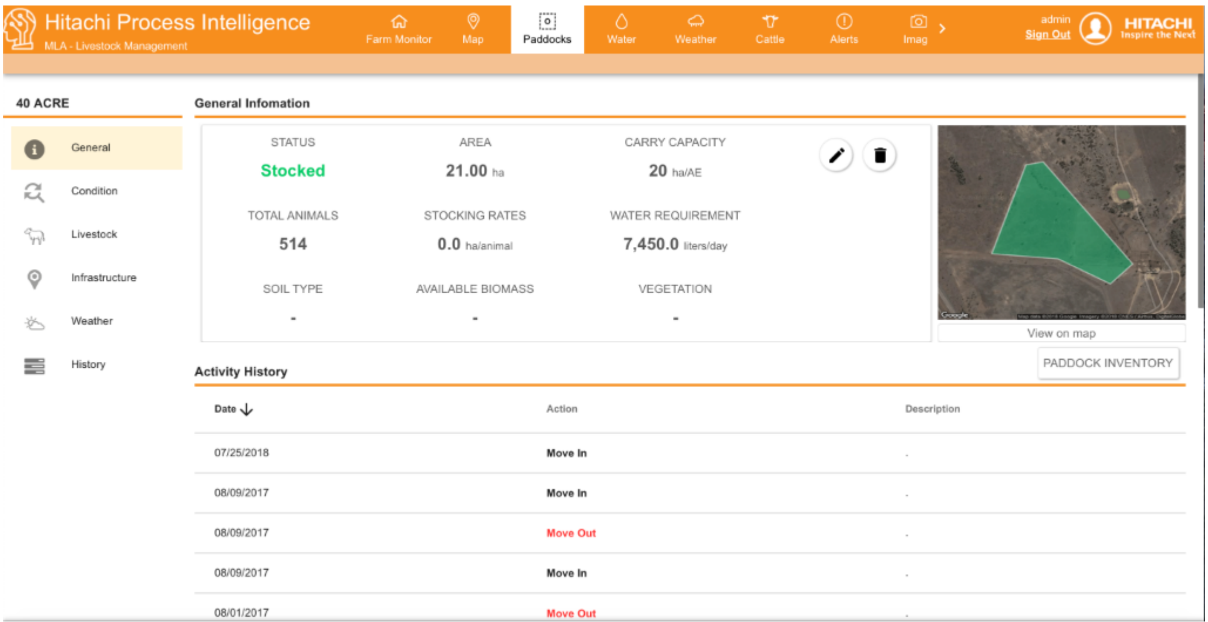


Figure 16 Paddocks detail page

4.1.4 Smart Agriculture Control Centre - water sources page

Figure 17 shows the page labelled Water Sources list. This page provides a summary of the dam, reservoir and bores standing water levels.

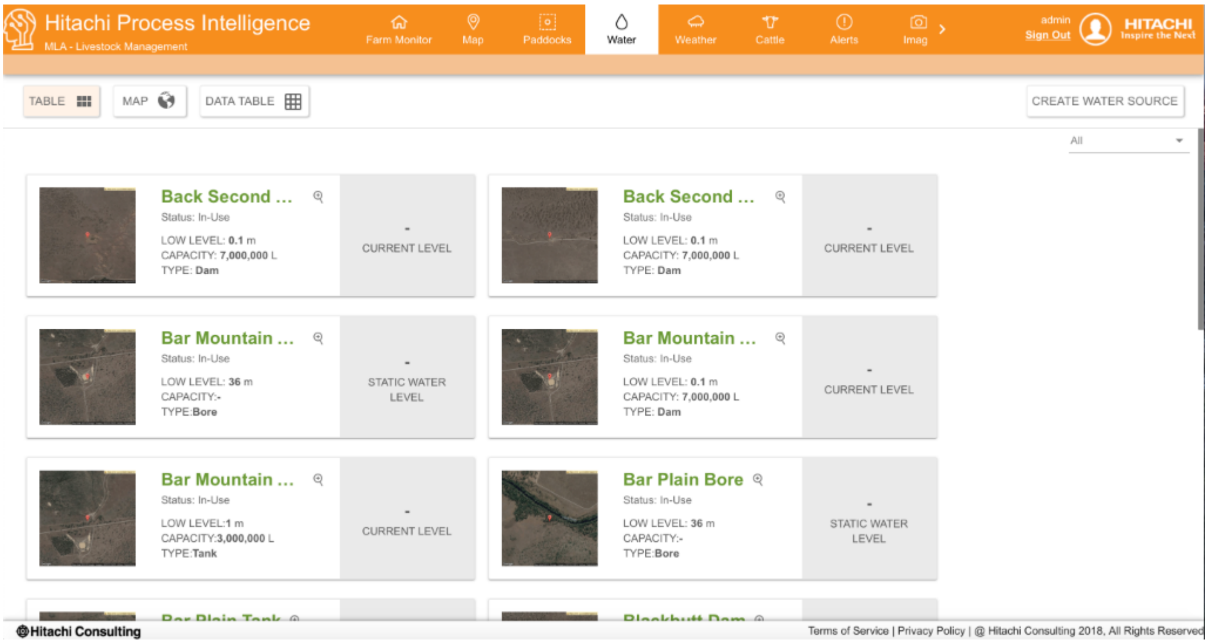


Figure 17 Water Sources list page

4.1.5 Smart Ag Control Centre – Water Sources details page

Figure 18 shows a sample of the water sources details page. On this page can be found the location of the dam or other water source, its current level, water pressure and flow rates.

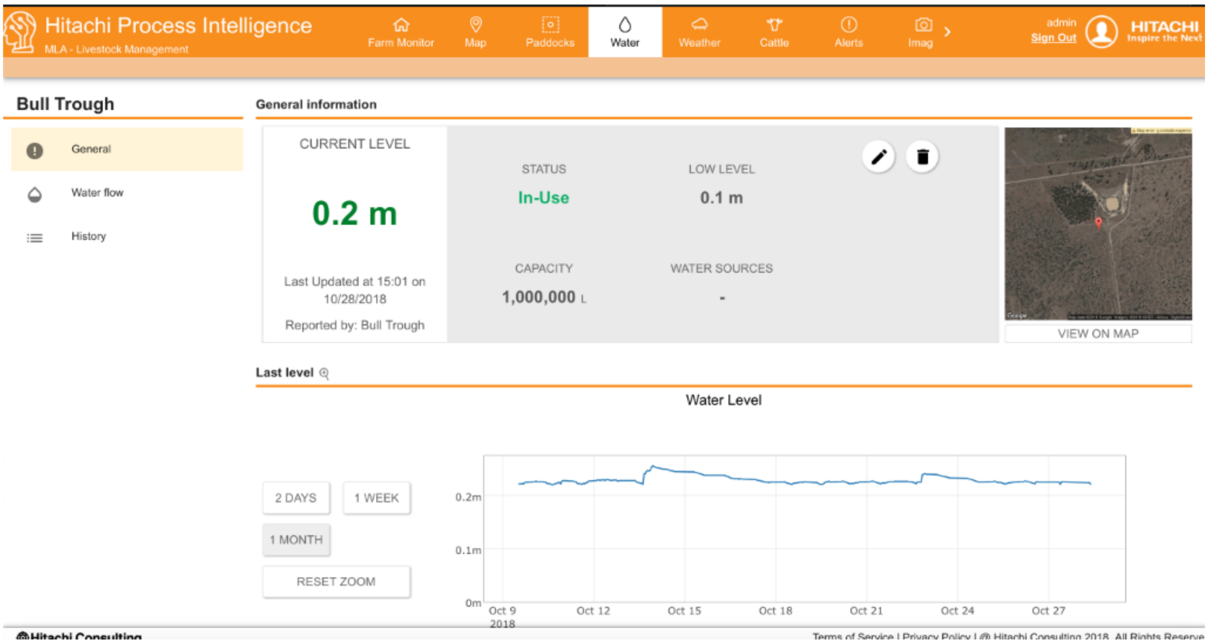


Figure 18. Water Source details page for a dam

4.1.6 Smart Ag Control Centre - Weather station page

Figure 19 shows an example of the weather station page which includes a summary of the weather stations on the property, plus a summary of the climatic data of the nearest Bureau of Meterology (BOM) stations. Weather station data was made available at hourly intervals. BOM weather station data is critical with an application made for free to use BOM weather station data with minimum of three stations required for Croydon Station.

Figure 19. Example of the weather station page

4.1.7 Smart Ag Control Centre - Paddock Details page

Figure 20 shows the Paddock Details page for Dingo Flat paddock. This page shows the temperature, humidity, soil moisture, rain rate and wind speed at the closest on-property weather station or the closest BOM weather station.

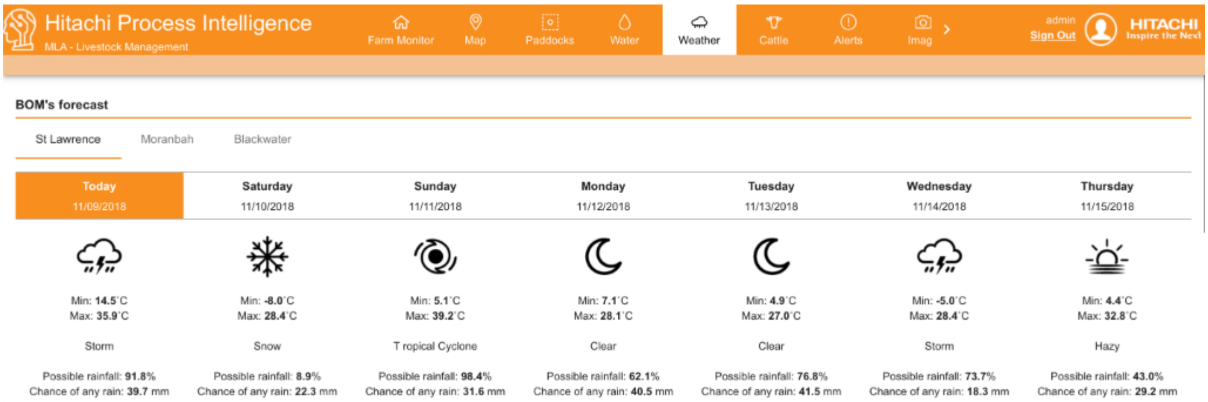


Figure 20. Paddock weather details page for the paddock/area

4.1.8 Smart Ag Control Centre – Animal Groups page

Figure 21 shows the main panel displaying a summary of all cattle across animal class, ear tag number, breed, location, birth date and live weight at a point in time.

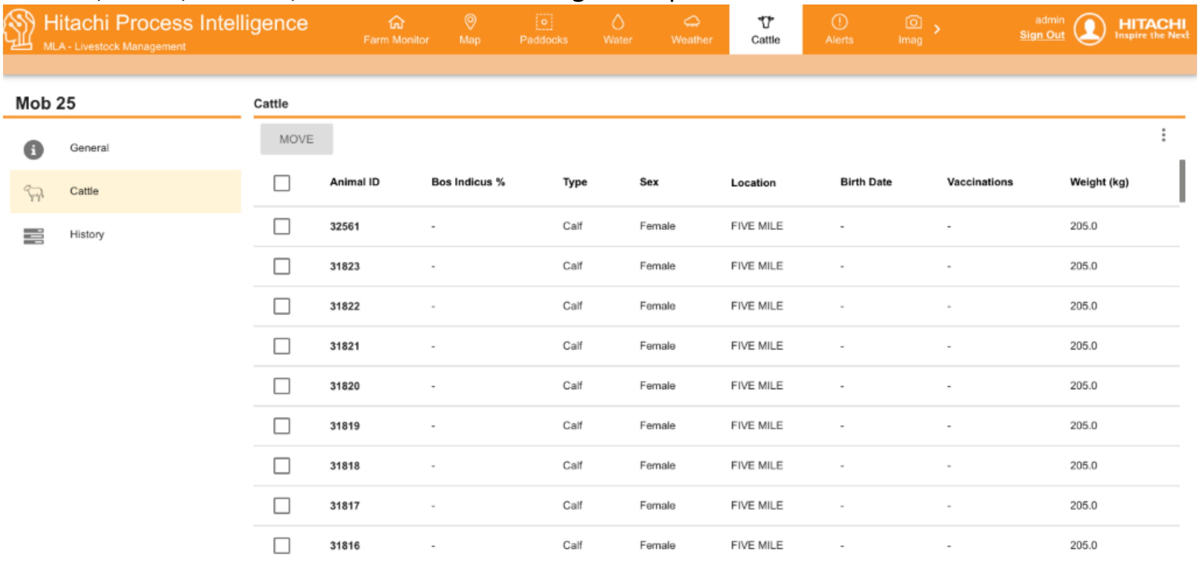


Figure 21. Animal Groups page

4.1.9 Smart Agriculture Control Centre - alarms page

Figure 22 shows an example of the alarms page. Alarms could be raised and a task scheduled when critical set points are triggered by an event. The event may be when a paddock land condition drops to score D or a dam level drops below 4 metres. The responsible person will be notified by text message and email and if this person does not respond within one hour, alternative persons, scheduled on the notification system, will be contacted.

Figure 22. Example alarms page.

4.2 Hitachi Smart Agriculture Control Centre – Advanced Functionality

The general animal dataset obtained to test the HPI algorithms, due to non-availability of individual animal data from Croydon was inconsistent. After attempting to match the data between 40,223 on-property animals and 78,580 processed animals, only 9,887 animals were able to be matched using RFID. The RFID tags linked to each animal lacked any description regarding animal history including details such as birth date, year brand, date of first animal live weight recording, processing date and carcase weight. More detailed information linked to each animal's RFID tag and an improvement in sharing this animal information between properties is needed.

The Smart Agriculture Control Centre is designed to provide information in a highly visual manner for touch screen access. Key farm information is available on the Farm Map screen as illustrated in Figure 23. When the mouse pointer hovers over a paddock, a summary of the paddock can be seen, providing the paddock name, paddock area, total animals, stocking rate and the date the paddock was stocked.

When the mouse pointer hovers over an infrastructure icon, it will show the type of infrastructure, location and water level in the case of bores, dams, tanks and water troughs. Clicking on a mob icon will show the mob name, total animals, average weight, water requirement and paddock in which the cattle are located.

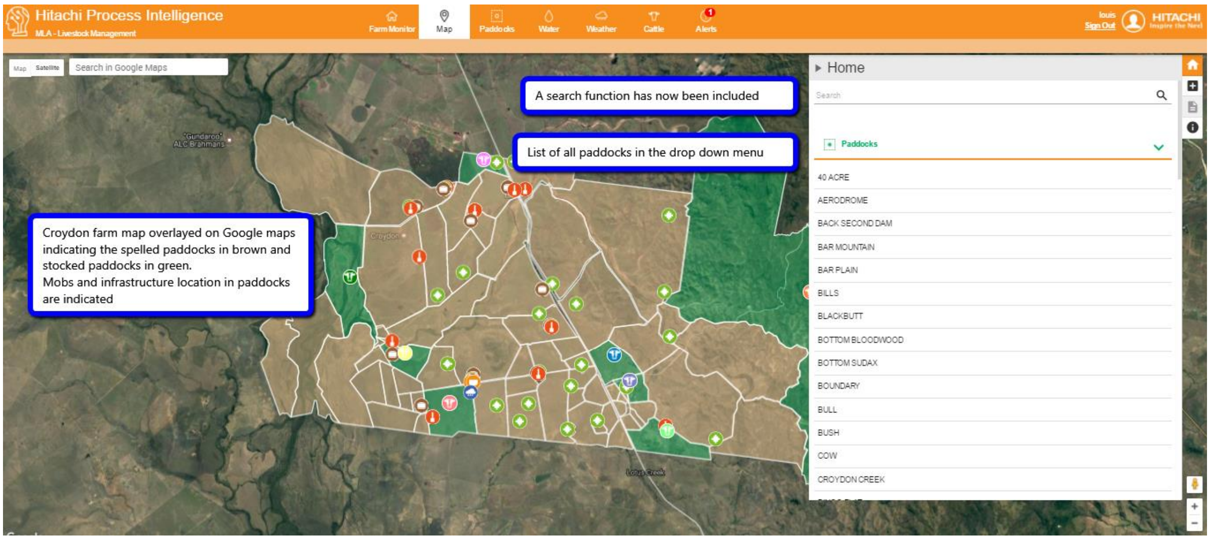


Fig 23. Map of Croydon Station allowing access to data on paddocks, waters, cattle and weather

Similarly, Figure 24 shows individual paddock information. The paddock main menu shows all paddocks, their location and a summary of the characteristics pertaining to the paddock. If the right-hand table is coloured green it will show the paddock is stocked as in the case of Bar Plain paddock or brown when the paddocks are spelled, as in the case of 40-acre paddock.

Mapping water infra-structure provides data on water availability in individual paddocks at 12 hour and 24 hour intervals. Refining coverage depends on the level of senses installed across the property. Water maps are live and the option is available to edit, drag and drop additional watering points which are automatically uploaded onto the property map.

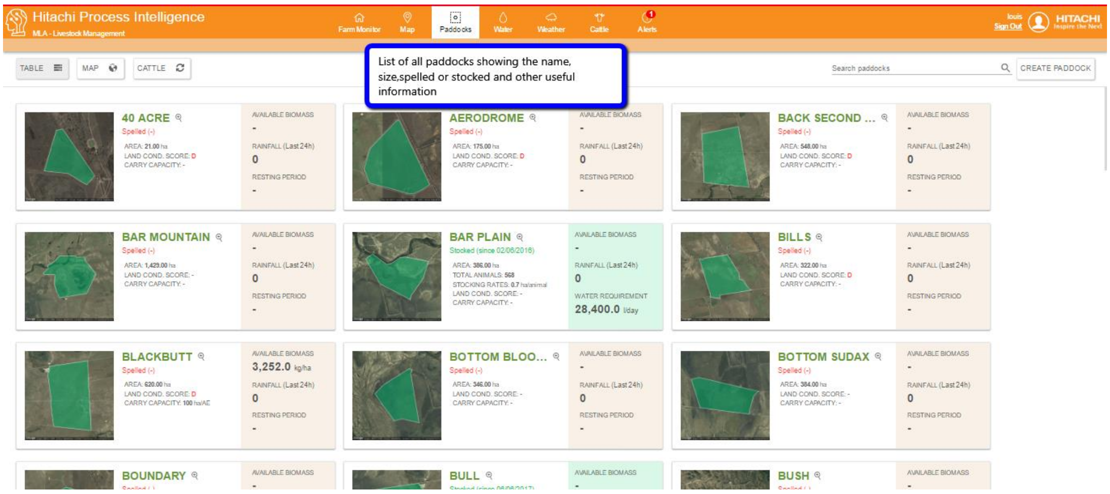


Figure 24. Paddock main menu showing all paddocks, their location and a summary of paddock features

Figure 25 shows where individual paddock carrying capacities expressed as adult equivalents (AEs) can be compared to actual cattle numbers and their relative AE.

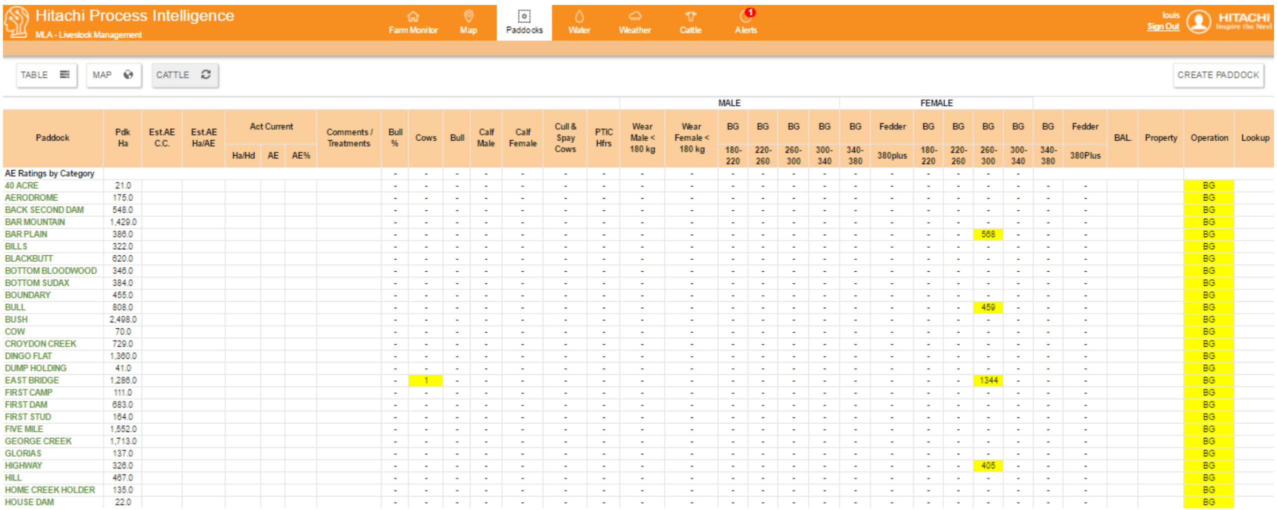


Figure 25 AE ratings mapped by paddock compared to actual cattle numbers

The paddock mapping module provides stocking rates together with rainfall, current stocking rate, pasture biomass and other input parameters.

Figure 26 illustrates more detail on paddock information and historical stock flows. More detailed information can be accessed via a side menu.

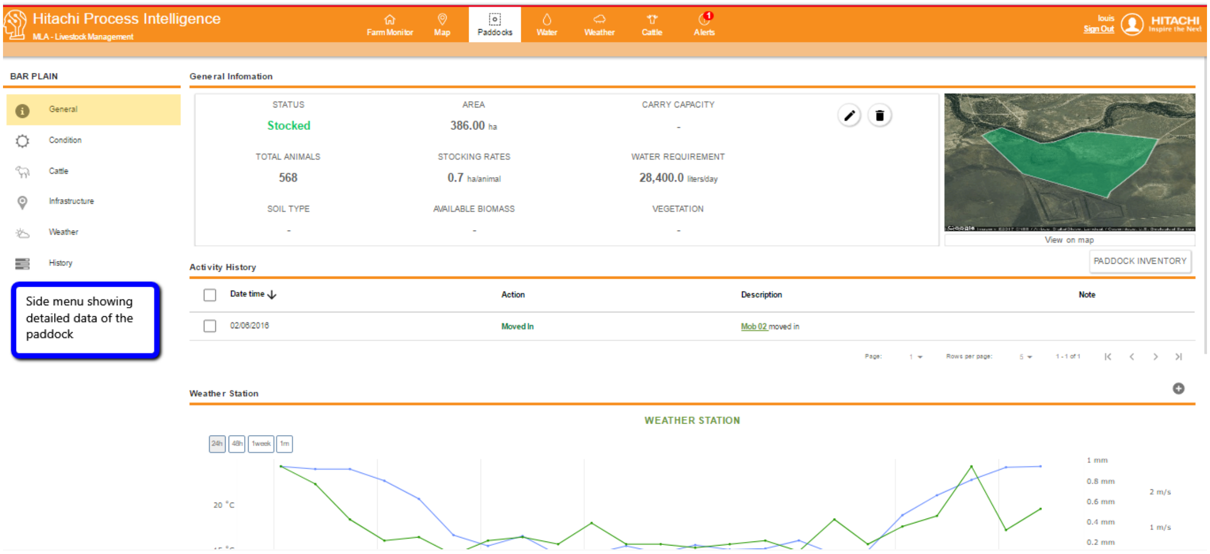


Figure 26 Illustration of mapping of individual paddock areas and cattle movements

Figure 27 shows the cattle page with cattle grouped in mobs. Every mob is indicated, showing its paddock location, live weight, water requirements and if the mob could be moved.

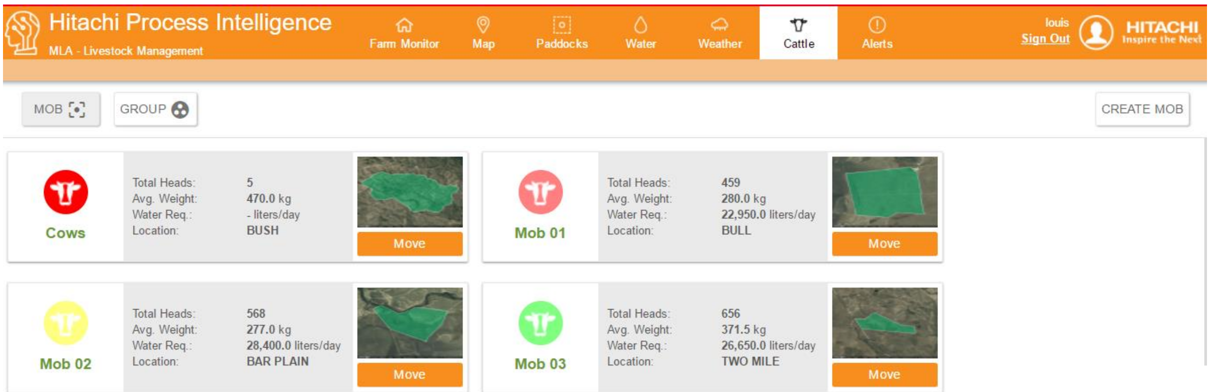


Figure 27 Cattle page showing mob information

Figure 28 shows individual animal information including animal ID number, *Bos indicus* content, class, sex, location, birth date, vaccinations and live weight.

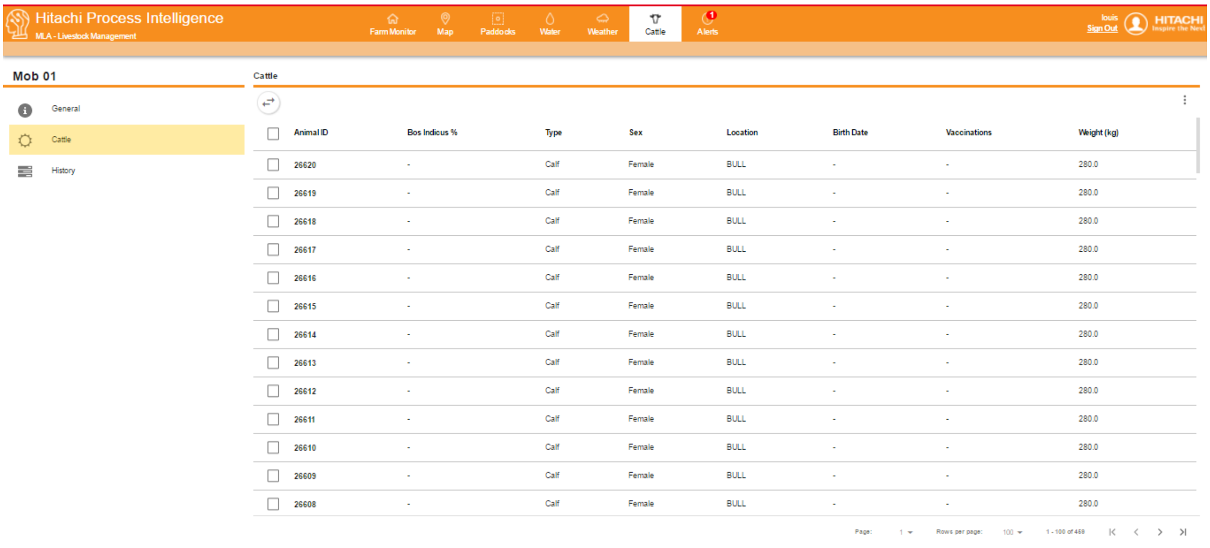


Figure 28 Individual animal information

4.3 Decision Modelling and Decision Support

Algorithms to assist decision support were developed in the HPI Process Intelligence system. This allowed decision making at various levels of the operational and marketing management at Croydon such as:

- Internally - the date a mob of cattle needs to be removed from a paddock, taking into consideration, paddock size and pasture biomass, rain received on the paddock, mob size, mob average live weight.
- Externally - the decision on when to sell, buy, move or keep cattle, taking into consideration, property size, total available pasture biomass, current mob sizes and weight groups, sale yard prices and weather conditions.

Figure 29 shows the Decision Centre page where support is provided to make decisions on when to buy/sell/move/keep cattle. In this instance, drone survey data could be used to provide information on pasture biomass. Although not used in this project, Walk over Weighing (WOW) technology can be used to provide animal live weight and weight gain trends over time. Weather stations provide weather information and the beef market report provides market signals. Decisions are based on the collective use of pasture biomass, animal live weights, weather and market prices.

A new process was developed for building Decision Support Models.

1) In consultation with ACBH Team members appropriate areas of Decision Support were identified.
2) A Decision Model was developed by the Hitachi Team and manually tested
3) A Decision Algorithm was developed and tested by the Hitachi Global Development Network
4) The Decision Algorithm was integrated into the Smart Agriculture Control Centre

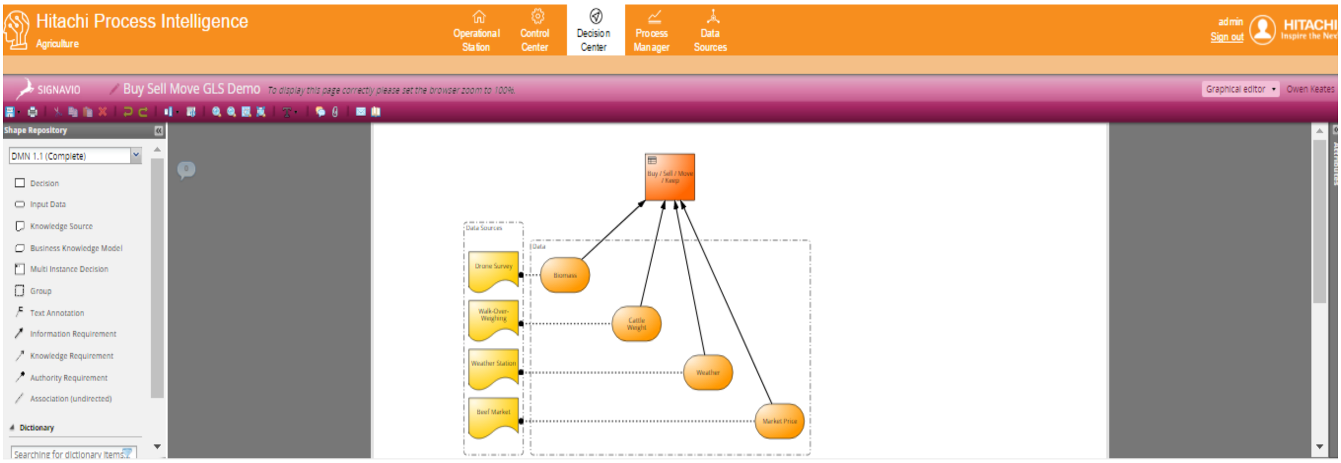


Figure 29 Decision Centre page

4.4 Best Practice Repository

In order to support the Decision Support models a cattle management best practice repository was developed in the Smart Agriculture Control Centre. This repository was based on the framework of the APICS-Supply Chain Council SCOR model and adapted for the meat and livestock industry. A literature research was conducted to extract the latest cattle management best practices including a review of papers published by MLA. The best practice repository is intended to be a starting point for ACC/ACBH to build on, capturing their own business and farm specific practices on top of the industry best practices. Figures 30 and 31 show an extract of the best practice repository.

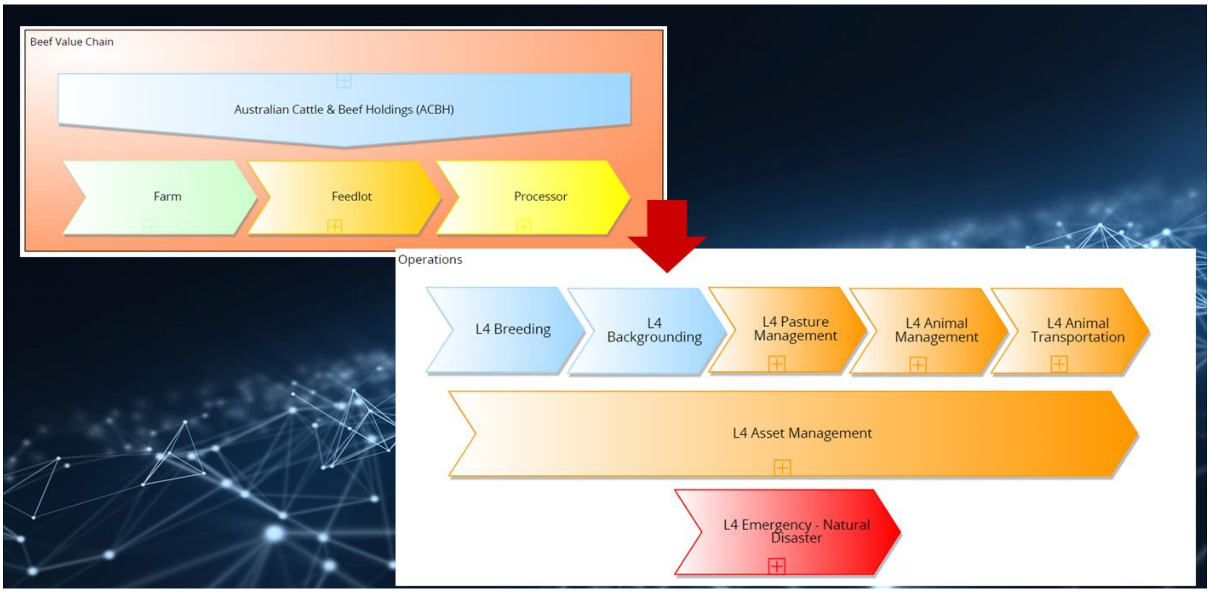


Figure 30 Best Practice Repository Level 3 and 4

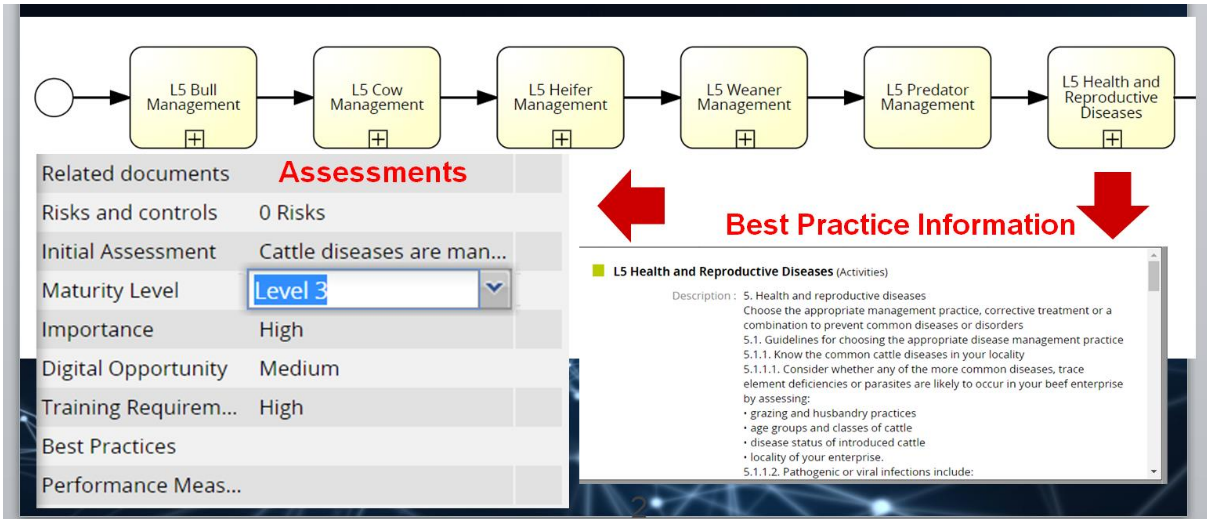


Figure 31 Best Practice Repository Level 5 with Assessment

As illustrated in Figure 31 an Assessment was also built into the Best Practice Repository allowing for practices to be evaluated on the various farms.

4.5 Brigalow regrowth results using drone imagery

Drone imagery of the Brigalow regrowth in Bull paddock was analysed with regrowth larger than 1m² in area pinpointed and counted. The average coverage of the Brigalow regrowth was 5.47% of the Bull paddock area.

The effect of the herbicide application was measured by another drone session on 25 May 2017 to monitor the effect of the herbicide. A visual on-ground survey showed that smaller plants were dying off, but there was evidence of regrowth taking place in the more mature Brigalow regrowth.

The drone surveys measured Brigalow regrowth coverage in Bull Paddock (Figure 32) to be 5.47 % on 14 December, 2016 and 5.39 % on 25 May 2017. This is a change of 0.08 % less coverage after six months. It is difficult to say if the dry spell after application at the beginning of December 2016 and/or the very wet period in March 2017 had an effect on absorption of the chemical by the Brigalow roots.

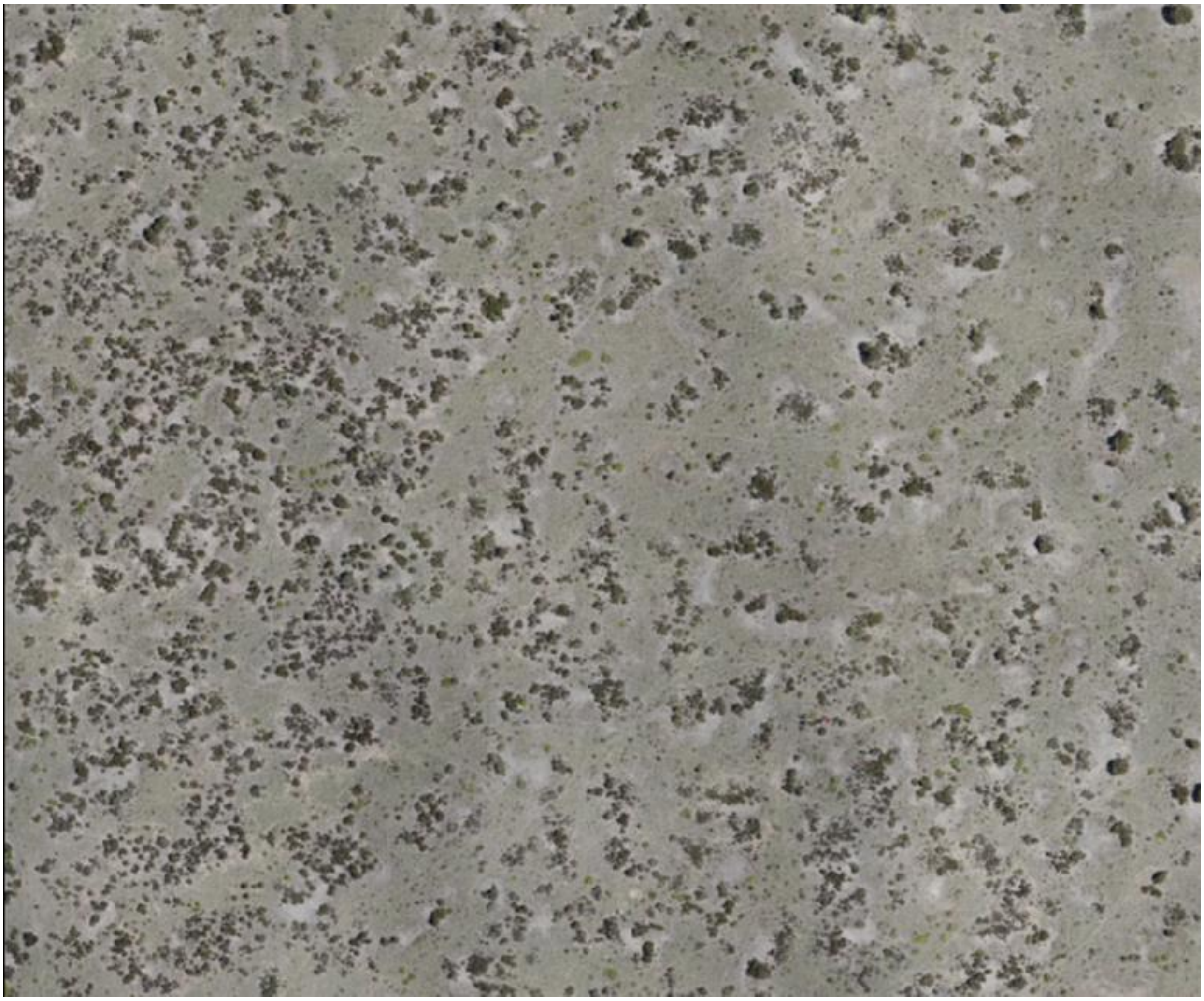


Figure 32 Drone footage showing actual Brigalow regrowth in Bull Paddock

An algorithm was developed to count the number of Brigalow trees as well as the size of the canopy. Each Brigalow tree with a canopy area greater than $1m^2$ was geotagged in order to allow for specific analysis and treatment in the future(Figure 33).

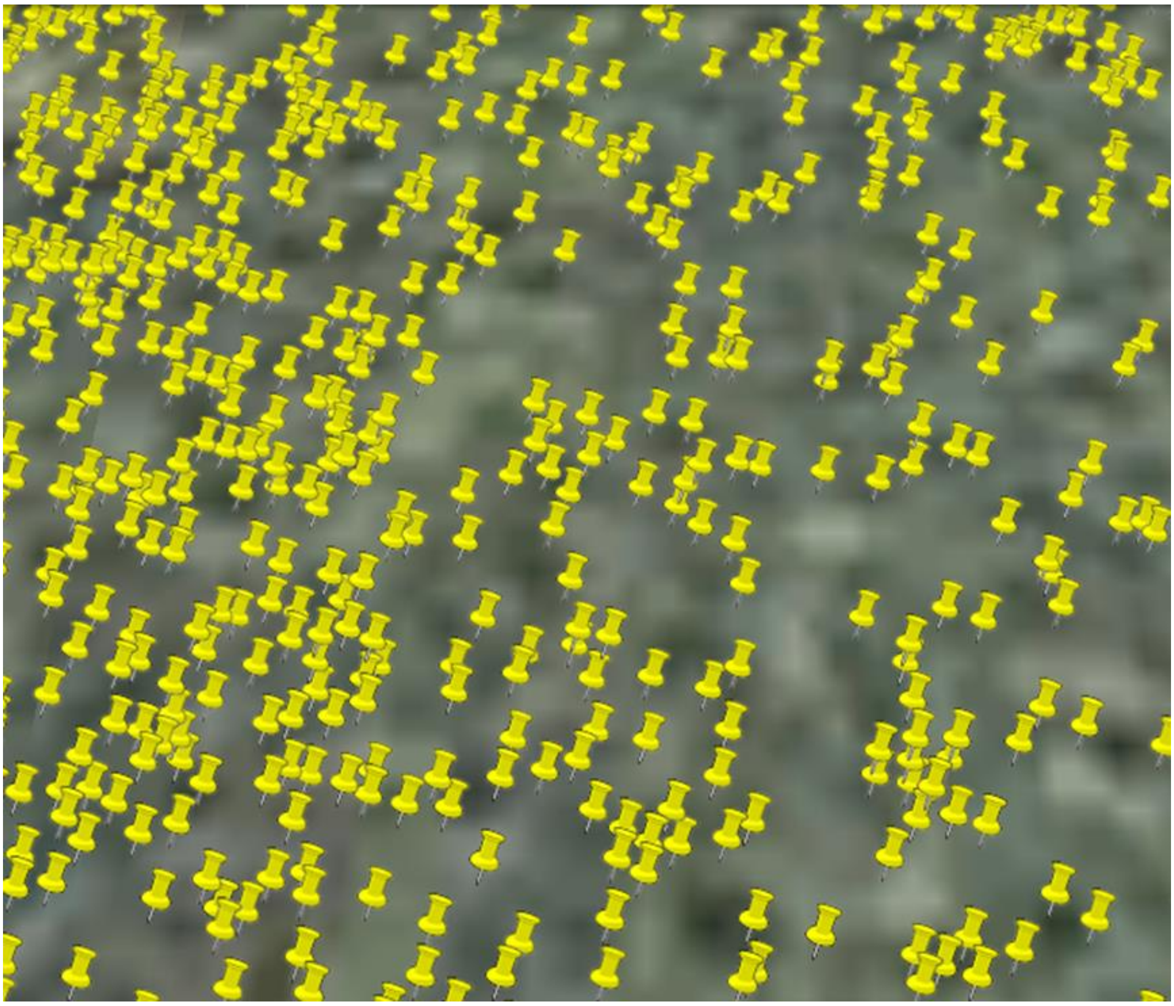


Figure 33 Keyhole Markup Language (KML) footage of pin pointed Brigalow and other trees greater than 1m² in Bull Paddock

In Figure 34, the effects of aerial spraying are starting to show with leaves turning yellow.

Figure 34 The effect of herbicide application on Brigalow regrowth in Bull paddock on 27 February 2017

Figure 35 shows the impact of rain in the aftermath of Cyclone Debbie which left the ground soaked and the multitude of “melon holes” filled with water.

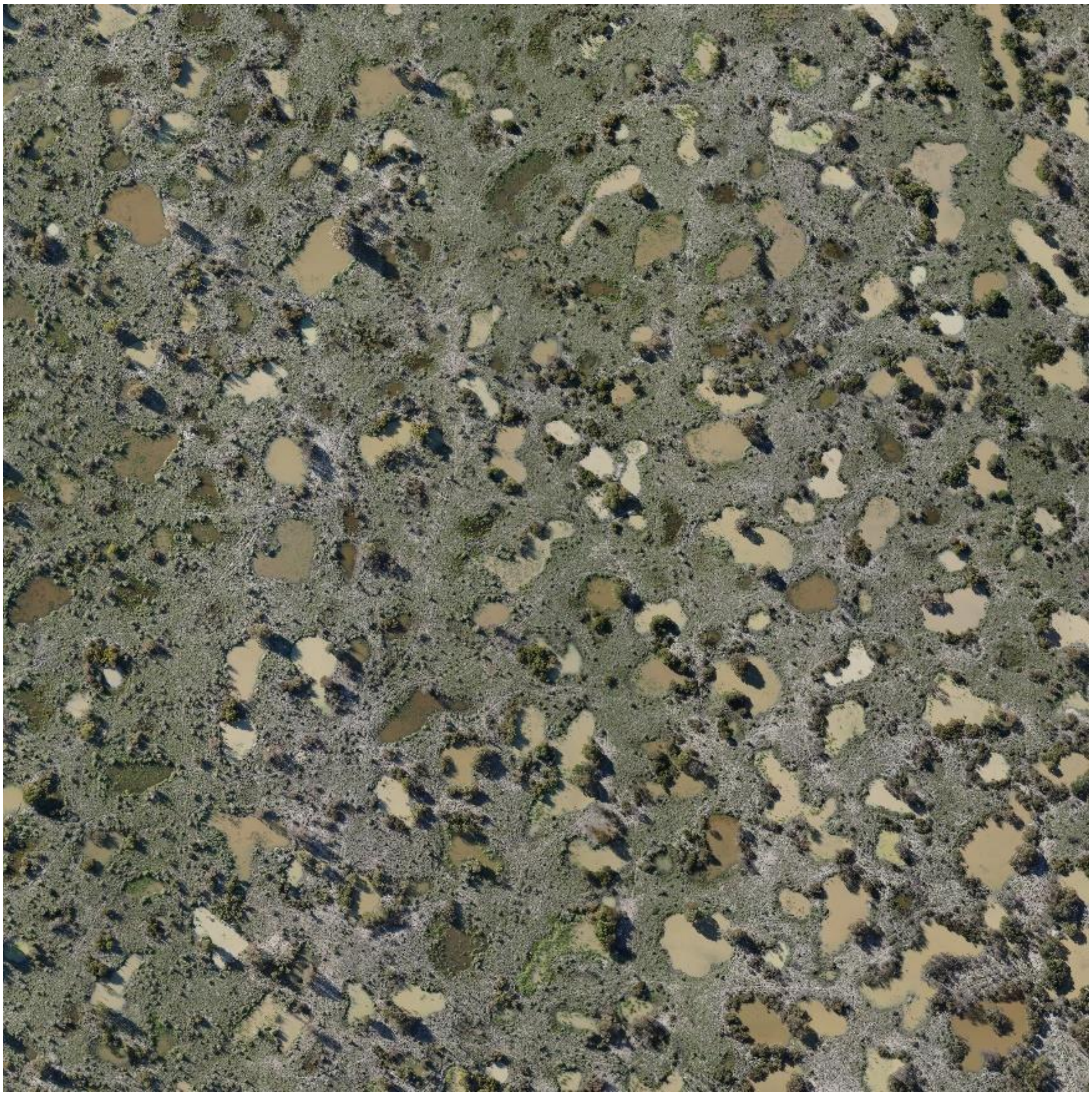


Figure 35 Aerial view of Bull paddock following Cyclone Debbie rain showing extent of water in melon holes

4.6 Cost benefit of an integrated data management system and technology platform

The technology platform presents management benefits, which have the potential to positively influence the key profit drivers of a beef business, namely higher kilograms of beef per AE/yr, increased carrying capacity over time, improved labour efficiency and reduced herd expenditure. Whilst the benefits can only be estimated at this time, small changes in each of these drivers using optimised data capture and management can have a significant effect on business performance and cumulative changes will be compounding.

The management benefits from the optimised data capture and management system for commercial beef cattle and their associated outcome on the business are detailed in Table 1.

Table 1 Management benefits and associated potential outcomes

Management benefits	Potential outcome	Application for ACBH Croydon
Better matching of feed supply and demand (within & across years).	– Higher kg Beef/AE – Increased carrying capacity over time – More stable grazing pressure over time	✓ ✓ ✓
Better selection and management of breeding females	– Improved herd reproductive rate – Reduced herd mortality rate – Higher sale weight (through less older and poorer females being sold) – Reduced herd expenditure (less supplement & fodder necessary)	✕ ✕ ✕ ✕
Better management and timing of sale for growing cattle	– Higher sale weight – Improved weight for age – Higher kg Beef/AE – Reduced herd expenditure (less supplement & fodder necessary)	✓ ✓ ✓ ✓
More timely management interventions for all cattle (e.g. weaning, sale, paddock movements, starting and stopping supplementation etc.)	– Reduced herd expenditure – Improved labour efficiency – Higher kg Beef/AE	✓ ✓ ✓
Better meeting of market specifications	– Improved average sale price	✓

The identified potential outcomes for Croydon Station were:

- Higher kilograms of Beef/AE (function of increased reproductive rate, reduced mortality rate, improved sale weight)
- Increased carrying capacity over time
- More stable grazing pressure over time
- Reduced herd expenditure
- Improved labour efficiency
- Improved average sale price (through improved market compliance)

The impact of improvements in each of these outcomes is discussed. Each outcome is analysed independently of the others.

1. Higher kilograms of Beef per AE/yr

The top 25% of northern producers are reported to be achieving 18% better productivity than the average (100.6 vs 85 kg Beef/AE) which indicates significant improvement is possible. There is also room for improvement for the top 25%, but only the average is modelled. Table 2 shows the impact on EBIT/AE and COP from increases of 5-20% in the herd productivity of the average, *ceteris paribus.*

Table 2 Modelled benefit from improved kg Beef/AE

Change in herd productivity	0%	5%	10%	15%	20%
Kg Beef/AE	85.0	89.3	93.5	97.8	102.0
EBIT/AE*	$40	$48	$57	$66	$74
Cost of Production	$1.55	$1.47	$1.41	$1.35	$1.29

* For reference, every $10 in additional EBIT/AE represents over $50,000 additional profit per year for the data used.

2. **Increased Carrying Capacity over time.**

Through better matching of stocking rate to carrying capacity in the short and long term there are likely improvements in carrying capacity through less overgrazing and improved land condition. The improvements will be dependent on current land condition and grazing management but will be modest at best in most circumstances. Improvements of 2.5% and 5% are modelled Table 3. It is assumed that kg beef/AE and enterprise expenses remain unchanged for the additional AE and that overheads will increase by $50/AE.

Table 3 Modelled benefit from improved carrying capacity

Change in Carrying Capacity	0%	2.5%	5%
Number of AE	5,364	5,498	5,632
EBIT/AE*	$40	$41	$42
Cost of Production	$1.55	$1.54	$1.53

* For reference, every $10 in additional EBIT/AE represents over $50,000 additional profit per year for the data used.

The improvements are minimal, however there will be greater improvement in Return On Asset (ROA) due to increased returns over the overall asset base. However, the analysis consistently demonstrates that the returns from improving per animal unit performance will be greater than increasing number of animal units.

3. **More stable grazing pressure over time**

A more significant benefit for a beef business is likely to come from improved herd stability than from an increase in carrying capacity. Herd stability will result from better matching of stocking rate to carrying capacity, resulting in less selling and replacing of stock during seasonal variations. Previous analysis for the northern beef industry indicates that there is a strong relationship between herd inventory volatility and poor performing businesses; the better performing businesses have more stable inventory over time. However, this could not be validated from the data available for this project.

4. **Reduced herd expenditure**

A reduction in herd expenditure can be associated with management benefits as indicated in Tables 1 - 4. Lower herd expenditure, along with higher herd productivity, is a characteristic of better performing beef businesses.

Table 4 shows the changes to the performance measures resulting from reductions in herd expenditure.

Table 4 Modelled benefit from reduced Herd Expenditure

Change in herd expenditure	0%	-2.5%	-5%	-7.5%	-10%
Enterprise Expenditure/AE	$40.31	$39.31	$38.30	$37.29	$36.28
EBIT/AE*	$40	$41	$42	$43	$44
Cost of Production	$1.55	$1.54	$1.52	$1.51	$1.50

* For reference, every $10 in additional EBIT/AE represents over $50,000 additional profit per year for the data used.

5. Improved labour efficiency

Improving labour efficiency reduces the overhead cost structure of a beef business. The relationship between labour efficiency and overhead expenses from the Australian Beef Report by Holmes and McLean (2017) and the labour efficiency of the Top 25% (Table 1) were used to model the effect of improvements in labour efficiency on overheads per AE. The results of this modelling are shown in Table 5.

Table 5 Modelled benefit from improved labour efficiency

Change in labour efficiency	0%	10%	20%	30%
Labour Efficiency	1,520	1,672	1,824	1,926
EBIT/AE*	$40	$46	$52	$58
Cost of Production	$1.55	$1.48	$1.41	$1.33

* For reference, every $10 in additional EBIT/AE represents over $50,000 additional profit per year for the data used.

6. Improved average sale price

An improved average sale through better meeting market specifications is a likely benefit. However, the average price received will still be predominately determined by the overall market, and increased sales price benefits will be minimal.

Table 6 models the change in performance based on changes in income/kg (note income/kg produced is slightly different from average price received as kilograms produced and kilograms sold are not the same each year, however income/kg is a good proxy for price received).

Table 6 Modelled benefit from changes in income from $2.02/kg - $2.12/kg

Change in sale price	0%	1%	2%	3%	4%	5%
Income/kg	$2.02	$2.04	$2.06	$2.08	$2.10	$2.12
EBIT/AE*	$40	$42	$43	$45	$47	$48
Cost of Production	$1.55	$1.55	$1.55	$1.55	$1.55	$1.55

* For reference, every $10 in additional EBIT/AE represents over $50,000 additional profit per year for the data used.

Caveat

The critical factor in business performance is the capability and attitude of those in charge of the business. A capable manager, focussed on the fundamentals, with an efficient production system could further enhance and fine tune their management system with the powerful information this platform could generate. An inefficient manager that is not focused on the fundamentals, has the most to gain but is unlikely to realise the full benefit of the platform. The likely benefits of an optimised data capture and management system for whole of industry use are yet to be realised.

5 Discussion

5.1 Insights & Implications

Increased productivity can be derived along a beef value chain if data was better captured, tracked, and managed across the entire supply chain. The potential increase in associated revenue will only be fully realised if individual cattle data is utilised effectively and best use is made of remote sensing and IoT device usage. The importance of this data is twofold. Firstly to help property managers make better decisions on behalf of their on-property operations, and secondly at a larger scale, to use analytics to improve decision making across the value chain from the property of origin to the point of processing.

5.2 Value chain improvements

The development of the smart agriculture control centre has shown the benefits of making data more visible at a single node in the value chain. The control centre is built on a robust extensible technology stack on Google LLC cloud platform and can be easily extended to the broader value chain. For example, similar data can be collected from breeding properties, backgrounding properties, feedlots and processing plants. This data can then be analysed via HPI's Smart Agriculture Decision Support algorithms to provide advice on how to get the right animal to the right place at the right quality and price.

5.3 Unmanned Aerial Vehicle or Drone technology

Although limited to the monitoring of Brigalow regrowth biomass in this project, the results demonstrate the benefits of drones and imaging to rapidly and at low cost assess changes in paddock biomass over time. Objectively measuring and assessing vegetative biomass and ground cover in extensive paddocks on a regular and cost-effective way will improve management efficiencies.

Accurate assessments of pasture biomass and land condition will improve feed budgeting (matching animal demand with dry matter supply) and help to manage land more sustainably. Land condition and its short and long term productivity are fundamental components of the beef value chain. The results of this project will encourage further related research using drone technology to monitor property infrastructure including fencing, water points, buildings, roads and stock yards to improve on-property decision making in relation to repairs and maintenance and capital expenditure.

5.4 Cost benefit analysis

Small changes in some of the key measures modelled in this exercise can have a significant effect on business performance. Each of the scenarios were modelled in isolation, howerver the benefits from multiples benefits would be compounding. This is demonstrated in the difference between the average and top 25% of producers, where small differences in each of the key measures leads to a considerable difference in business performance.

The performance of the average and Top 25% herds as reported in *The Australian Beef Report* (running more than 1,600 hd) are shown in Table 7.

Table 7 Northern Herd Comparisons/AE (1600 + head cohort)

	Average	Top 25%
Income/AE	$171	$200
Enterprise Expenses/AE	$40	$36
Gross Margin/AE	$131	$164
Overheads/AE	$91	$77
EBIT/AE	$40	$87
Cost of Production	$1.55	$1.13
Kg Beef/AE	85.0	100.6
Labour Efficiency	1,520	1,761
Reproductive Rate	61%	67%
Mortality rate	2.5%	2.1%
Sale Weight	423	443
Herd Size (AE)	5,364	6,211

It is apparent from Table 7 that the gap in herd performance between the top 25% and the average is substantial. The top 25% are achieving more than double the EBIT from every AE, when compared with the average. The difference is coming from a mixture of additional income and lower operating expenses. The additional income is attributable to better herd productivity (kg Beef/AE) which itself is attributable to small, but significantly better performance in reproductive rate, mortality rate and sale weight. The lower operating expenses comprising enterprise and overhead expenses ($113/AE vs. $131/AE) are attributable to better targeted herd expenditure and better labour efficiency.

There is likely to be value in making more informed and timely decisions that will have a positive influence on the primary measures listed. Small changes in each can have a significant impact on overall business performance.

Technology platforms can have multiple management benefits realising improved earnings and a lower cost of production. Possible outcomes include higher annual animal productivity, increase in safe carrying capacity, more stable grazing pressure, reduced herd expenditure, improved labour efficiency and higher sale prices. Improving productivity per animal and increased sale price are likely to have the largest impact on business performance.

5.5 Project constraints

The key obstacles encountered with this project included:

i. availability of data,
ii. data integrity,
iii. on-property data transmission and cost,
iv. data transmission to satellite,
v. cost and availability of IoT devices,
vi. on-property cattle data availability, and
vii. transition of data from property to property (RFID open data ecosystem).

An important constraint to achieving a proof of concept with this project was the limitation in accessing data from the pilot property (Croydon Station). Croydon Station did not capture any IoT data prior to this project commencing with the first IoT devices installed being a weather station, soil moisture probes and water level sensors. In the second half of 2017, Croydon Station started capturing RFID tag numbers plus cattle live weights inducted onto Croydon. A weaner spends 15 – 17 months on Croydon Station, thus any meaningful cattle data will only be available towards the middle of 2019.

For the HPI platform to be most effective, data along the entire value chain from the breeding properties to background properties to feedlot and eventually the processing plant is needed.

To improve the quality of animal data and the ability to meet grade and compliance measurements, better data sources are required. Within this project, IoT connectivity and data could not be utilised efficiently at the on-property level. With the advent of improved animal monitoring and more reliable data linked to RFID tags, the ability to track animal weight over time at critical stages in the beef production cycle (calving, weaning, 200 day post weaning, 300 day post weaning, critical mating weight, feedlot entry/exit, at slaughter) will translate to increased production efficiencies and cost savings.

To improve functionality, more information on the available pasture, i.e. species composition, biomass and perhaps pasture growth rate is needed and linked into weather data and associated platforms like VegMachine®. VegMachine® is an online tool developed by CSIRO that uses satellite imagery to summarise decades of change in Australia's grazing lands. It allows the selection of an area of interest, and to generate simple reports and analyses of how those areas are changing over time [https://vegmachine.net/].

Best practice requires more information linking the supply of pasture biomass with feed demand from cattle. This could provide dates on when a mob needs to be removed from a paddock, taking into consideration paddock size and biomass, rain received on the paddock, mob size and mob average live weight. Ultimately decision pathways on when to sell, buy, move or keep cattle, taking into consideration total available pasture biomass, mob sizes and live weights, cattle prices and weather conditions/forecasts could also be provided.

6 Conclusions/Recommendations

6.1 Conclusions

While the project navigated missing links in data, it was unable to derive maximum value from the available analytics. Data availability needs to be improved to engage in a digitally-transformative strategy for value chain enhancement. To achieve this, a broader view beyond the property backgrounding stage is required.

The improved availability of data and associated analytics across the entire value chain will allow the implementation of a livestock decision support system. Such a decision support system will not only ensure cattle production is optimised at the property level but will also improve efficiencies down the value chain at the feedlot and processing plant. This likely would be executed on a property by property basis with customised features per business.

The optimised data capture and management system proposed by Hitachi Consulting and currently being applied on Croydon Station presents many management benefits, which have the potential to positively influence the key profit drivers of a beef business. Whilst the benefits can only be estimated at this time by modelling current data, small changes in each of the drivers can have a significant effect on business performance and cumulative changes will be compounding. A significant benefit for a beef business will come about more from improved herd stability than from an increase in carrying capacity.

The importance of accurate data capture and its integrity will help lead to a significant improvement in whole of business performance if managed through a Smart Agriculture Control Centre. The most important outcomes will be improving live weight gains through improved management of available pasture, water and infrastructure.

6.2 Recommendations

Croydon Station did capture IoT data but only started using devices late in the project. It is recommended the property continue to capture data and develop the optimised data capture and management system for ACBH. The findings from this process will help to identify applications and benefits for the wider beef industry.

It is recognised that there is significant additional relevant data already available for individual animals at various points in the supply chain. A livestock agent's and assessor's reports for animals which have been through sale yards could also be used.

The accuracy of this information is also likely to be problematic as reports tend to be at the mob level, and while these reports might recognise differences between animals in a mob, they don't seem to identify any animals in the mob (i.e. by RFID tag). To be able to describe animal history and treatments accurately, information at the individual, animal level is required.

It is recommended additional sources of information, such as sale yard reports, be investigated as to how they can be correlated to the NLIS RFID tag identifiers.

On-property data from RFID sensors which is only captured during the last few weeks the animal remains on that property has limited utility. It is important for detailed analytics to have at least the following data sets:

- Origin of animal and NLIS and or RFID code

- RFID code supplied if it does not already have one
- Induction date on property
- Induction weight
- Dentition on induction
- Sex
- Vaccinations and treatments
- *Bos indicus* %
- Exit date
- Exit weight
- Dentition on exit
- Destination on exit

Along the value chain it is important to capture the following data and be linked to the RFID code.

Feedlot:

- Induction date at feedlot
- Induction weight
- Vaccinations and treatments captured to RFID codes
- Exit date
- Exit weight
- Sex

Processor:

- RFID code
- PIC
- Sex
- Dentition
- Induction Weight
- Shrink %
- Kill Date
- Total HSCW
- P8Fat and marble score/s
- Ossification
- Hump height
- pH
- MSA Index
- Yield% (HSCW/Induction live weight)

As additional information can be associated with NLIS RFID tags, including information from breeders and conditions on the properties , it should be possible to train machine learning (ML) models to identify and correct inaccurate information, and secondly to train ML models to predict, while animals are still being backgrounded, the likely attributes of animals when they are processed. Provided suitable software is in place to manage the the data and the linkages to RFID, then these models could be applied in a simulator to predict future attributes of animals arriving for processing under different assumptions such as time spent in backgrounding and feedlot.

It is recommended that further work be conducted on the different categories of animal required for processing, and for each of the desired attributes as measured in grading and processing, as a basis for further analysis of how the history of each animal impacts these characteristics.

Previous analysis for the northern beef industry indicates that there is a strong relationship between herd inventory volatility and poor performing businesses. This aspect is yet to be fully assessed by the proposed data capture and management system and requires attention. It is recommended that the project continue to capture data and develop the optimised data capture and management system for Croydon Station so as to continue to identify the application and benefit for the wider beef industry.

An observation from this project has been the potential to better monitor land and pasture conditions (feed budgeting) and property fixtures and improvements such as fencing, roads, tanks, and stockyards. using drone technology. This information can be linked to animal, weather and water data to improve the value chain map. As a consequence of this observation, a separate and new project Eagles Nest P.PSH.0859 was conceptualised and launched.

7 Future R&D and Industry Adoption

For future research in this area, several recommendations can be made:

- The data capture strategy should be based initially on the data collection gaps along the value chain
- The development of the visualisation platform and control centre should focus on using the available data
- The IoT implementation on-property requires more research and development to be practical and cost effective

Through the course of this project, several research and development opportunities were noted:

- Pasture Management: with a focus on assessing paddock carrying capacity, utilisation rates and associated decision support to better match pasture supply with pasture demand.
- Cattle Management: better cattle information from within livestock management systems detailing major life events captured across the value chain including detailed individual animal trait and treatment data capture (vaccinations, movements). This should encompass the property of origin and all inter-property transfers.
- Animal performance/pasture growth modelling: insufficient analytics and informatics for livestock on pastures to estimate ultimate/optimum growth models.

Small changes in the key measures modelled in benefit cost analysis can have a significant effect on business performance and requires further investigation. The potential alignment between process innovation (the doing) and the financial management of the beef business requires further attention.

8 Key Messages

8.1 Key Messages for Producers and Processors

The capture and analysis of relevant data using a decision support platform has the potential to improve efficiencies along the beef value chain. At the property level, these efficiencies will likely lead to improved utilisation of pasture, water and other natural resources as well as improved animal health, welfare and performance. The average producer will be rewarded by increased earnings and an improved return on assets managed.

9 Bibliography

HOLMES, P., MCLEAN, I. & BANKS, R. 2017. The Australian Beef Report, Bush AgriBusiness Pty Ltd.

10 Glossary of Terms

1. HPI – Hitachi Process Intelligence
2. HCP - Hitachi Consulting's platform
3. ACC – Australian Country Choice
4. MDC - MLA Donor Company
5. IoT – Internet of Things
6. RFID – Radio Frequency Identification
7. NBN – National Broadband Network
8. NLIS – National Livestock Identification System
9. AE – Adult Equivalent (nominally 450 kg (LW) steer at maintenance)
10. RDI – Research, Development and Innovation
11. SAMRC – Southern Australian Meat Research Council
12. NABRC – North Australia Beef Research Council
13. PIC – Property Identification Code
14. MSA – Meat Standards Australia
15. HSCW – Hot Standard Carcass Weight
16. PoC – Proof of Concept
17. BOM – Bureau of Meteorology
18. R&D – Research and Development
19. CBA – Cost Benefit Analysis
20. B1 & C1– Cattle Grade Score (A-E, heavy to light muscle score. 1-6, depth, light to heavy mm)
21. GF – Grain Fed
22. LW – Live weight (kg)