Final Report

Romani Pastoral Bull Tracking 2021

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1. Abstract

This report provides analysis and summary of the work done by AGTech360 during the Romani Pastoral Bull Tracking 2021 project. This colaborative project with MLA was conducted across two locations; Romani Pastoral cattle stations (Windy and Warrah) near Quirindi NSW and the Four Post farm in Taroom QLD.

AGTech360 has provided an animal management, monitoring and sensor integration solution to help farms more efficiently track and manage their animals from a single digital interface.

Small, easy to assemble base station towers are spread over the property to create a LoRa communication web network with a 3G/4G base station, putting all the information online. Romani Pastoral and Four Posts property animals were tagged with the AGTech360 Trackers to monitor movement during the project and understand animal behaviour towards the devices and in general.

All data was displayed on the AGView360 software along with any external sensors that have been integrated. The system generated reports on various aspects of an individual animal and has a built-in alarm system that alerts the farmer if the animal is not moving or is outside of the desired paddock/farm boundary.

The final product is an all-inclusive easy to use farm and animal management system that can be accessed from the internet.

This system helped the producers to manage their farms more efficiently and easily observe individual animal data and history. Animal behavioural patterns were found from observing the historical data recorded leading to better paddock optimisation. The tracking technology allowed the farmer to muster his animals much more efficiently. The alarm systems quickly alerted the farmer if the animal was in danger, was in the incorrect paddock and reduced the threat of theft. This system allowed the farmer to manage his farm from a remote location. The system allowed for individual animal monitoring (weight gain, medication, fertility) and more efficient data entry.

All these aspects of the AGTech360 system led to better, more efficient practises and decision making, requiring less manpower and overall cost savings.

2. Executive summary

Background

The purpose of this research was to observe the impact of the AGTech360 system (hardware and software) on producers and farming practices.

The AGTECH360 system was created to tackle the problem of the inefficiency involved with monitoring and management (location, weight, medication, etc…), mustering animals and integrating other farm sensors to reduce the number of interfaces a producer needed to work with.

The AGTech360 system was formed to increase the efficiency and productivity of farming practices by reducing the number of lost or injured animals, reducing the time taken to individually manage animals' data (tracking of animals over the lifecycle for genetic improvement, record keeping of medication, EBV's, etc…).

Benchmarked production data is not readily available and historical data recording is mostly in the hands of the farmer, in the form of paper or based on their personal experience. The AGTech360 system also aimed to assist in this problem.

The results of this study will be used to raise awareness for the AGTech360 System, to determine the viability of the AGTech360 system and to see what improvements or further developments may be beneficial.

Objectives

The AGTECH360 system creates an all-inclusive web-based interface that combines with animal/vehicle tracking, water, automatic weighing and medication application sensors that allows the farmers to quickly and easily monitor their animals and other farm-based sensors from a single web-based interface. It will significantly increase animal farming efficiency and understanding across the agricultural industry.

The aim of the project was to establish a digitally data managed farm demonstrating the benefits to Romani Pastoral Company (RPC) and the Four Posts property using modern technologies to better utilise farm resources such as paddocks and labour.

The main objectives of this project were:

- Tracking bull performance and movement
    - More data was required to properly measure bull performance
    - Animal movements were successfully tracked
- Record keeping of treatment and animal traits e.g. weight gain
    - Medication, animal traits, weight and fertility data were successfully tracked and recorded
- Improvement of genetics through decision making based on quality data recordings
    - Producer trust and experience with the system along with more historical data records will lead to decision making based on the system, however during this trial it was not utilized
- Having a single platform for farm information

    - The AGView360 software platform successfully displayed most livestock farming information including the integration of other developers' sensors
- Paddock utilisation and management
    - The AGTech360 system has successfully introduced aspects of paddock utilisation and management however additional studies are required to take this further

To achieve this, the project was broken down into three phases. The objectives of each phase were successfully completed and can be seen below.

- Phase 1
    - Ensuring all hardware and software is set up and functioning as expected
    - Provide training to all staff members involved
- Phase 2
    - Verifying that hardware and software is functioning as expected
    - Observing any animal interactions
- Phase 3
    - Looking at the real-world use cases to assess the productivity gains/cost savings
    - Discussing the next steps for R&D activities

Methodology

- Raw data from devices was analysed and compared to data seen on the AGView360 web interface
- Calculations were made to see how far animals moved
- Historical data from the AGView360 system was observed and any trends identified
- Producers were consulted to verify the accuracy of alerts and data being displayed on the AGView360 system

Results/key findings

- All hardware and software were successfully set up and training was given
- All devices worked as expected however some went into sleep mode under extreme weather events
- Device failure rate was greater on bulls than cows
- Animal behavioural tendencies were observed (hiding under tree cover, gathering around water bodies, clustering in small groups, etc…)
- Alarms triggered were by animals escaping the property, entering incorrect paddocks, etc…
- Comprehensive reports on weight gains were seen

Benefits to industry

- Reduced cost of manpower required in mustering
- Reduced the loss of product from real time early warning of theft or sickness
- Better decision making due to historical data records for paddock optimisation, weight gains and fertility

Future research and recommendations

- Improve the intelligent alert system based on the movement characteristics of the animal to more clearly identify sick animals, bulls joining detection, pregnancy detection and calving detection.
- Integrate pasture data and other inputs overlayed with the GPS tracking data to develop a better understanding of feed available and optimise livestock growth.
- Improve medicine stock and compliancy management with full traceability of the exact medicine batch and dose used on individual animals.

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3. Background

3.1 Aim

3.1.1 Problem

The AGTech360 system was created to tackle the problem of the inefficiency involved with monitoring (location, weight, medication, etc…), mustering animals and integrating other farm sensors to reduce the number of interfaces a farmer needs to work with.

3.1.2 Solution

The AGTech360 system creates an all-inclusive web-based interface that combines with animal/vehicle tracking, water, automatic weighing and medication application sensors that allows the farmers to quickly and easily monitor their animals and other farm-based sensors from a single web-based interface. It will significantly increase animal farming efficiency and understanding across the agricultural industry.

3.2 Key Benefits the AGView360 System can Bring to the Producer

3.2.1 Behaviours/Practices

- Manage the farm from a remote location
- Save time mustering
- Helps keep track and monitor individual animals (location, weight, medication, fertility, breeding, etc…, all in real-time and historically)
- Allows for quick response time if an animal has broken out of a paddock, being stolen or is injured
- Create a more in-depth knowledge of animal behaviour (e.g. It was found that opening a fence with rich feed on one side was not enough to get the animals to start grazing on that side of the fence. After investigating though the AGView360 it was found that the animals would not leave a certain distance from water and thus more water needed to be added to the rich feed area so the cattle would graze there.)

3.2.2 Economic

The AGView360 system can be used to run a farm more efficiently and save money.

- Less people required to muster and run the farm
- Efficiently moving animals to paddocks with more feed
- Reduce the loss of animals due to theft, running away or sickness (farmer is alerted if the animal stops moving)

3.2.3 Social

- Operate farms from a remote location outside the property
- Requires less people to run the farm

- More in-depth understanding of animal behaviour

3.2.4 Sustainability/Environmental

- Moving animals to richer pastures before the current pasture is over grazed
- Save water by optimising water point locations
- Protecting riparian zones (quick alerts when animals are entering restricted areas)

4. Objectives

The main objectives of this project were to assess the benefits the AGTech360 system brings to a producer by observing the effects on the following sections;

- Tracking Bull performance and movement
- Treatment and animal traits record keeping e.g weight gain
- Improvement of genetics through decision making based on quality data recordings
- Having a single platform for farm information
- Paddock utilisation and management.

To do this the project was broken down into three phases. The objectives of these phases can be seen below.

4.1 Phase 1

The objective of this phase was to install and setup the AGTech360 hardware, ensure the system was working as expected and to provide training to the producers on the AGView360 software. For a successful phase one the following was achieved.

4.1.1 Equipment

The hardware that was supplied can be seen in Table 1.

Table 1: Hardware supplied for this project

Technologies Provided	Function	Communication Network	Supporting Infrastructure
Repeater	Relay data through network to mobile gateway	LoRa	Self-sufficient solar powered, small easily deployable tower
Mobile Gateway	Uploads all data on the network	LoRa and 3G/4G	Self-sufficient solar powered, small easily deployable tower
Animal Tracking Tags	Sends GPS and other sensor data	LoRa	Self-sufficient solar powered
Data Sim	Uploads Data	3G/4G	Used inside the Modem Gateway

Software subscription	Interface for AGVIEW360 system	Internet	Computer/Smart Devices

4.1.2 Tag Tracking and Data

Each animal tag needed to be able to send at least one set of locations and other sensor data every hour. There was a possibility of tags going into sleep mode during low sunlight weather and during night-time hours to conserve power.

All this data needed to be viewable from the AGView360 interface map section.

4.1.3 AGView360 Alarms

Alarms needed to be triggered when:

- An animal was outside of the assigned paddock
- An animal was outside of the farm boundaries
- An animal was no longer moving
- A device was not healthy

4.1.4 AGView360 Reporting

The AGView360 system needed to be able to export data to an excel spreadsheet and display data in chart format.

The system needed to be able to report on current and historical data of individual animals and sensors such as:

- Age
- Weight
- Medication
- Joining history
- Animal orientation
- Alarm data
- Fencing data
- Pastoral data (Total Standing Dry Matter(TSDM), Food On Offer(FOO),Dry Sheep Equivalent(DSE), etc…
- Weather
- Water levels
- Other external sensor data history

4.1.5 Other Sensors Integrated External Sensors

The system needed to be able to integrate data for other external sensors such as:

- Camera sensors
- Rain gauges

- Water level sensors
- Weather sensors
- TSDM, FOO, DSE, etc…
- Gate and fence sensors

4.2 Phase 2

Phase two was the largest component of the project, its main objective was to assess the AGTech360 system by analysing animal behaviours and recorded data such as:

- Animal locations
- IMU
- Animal movement ranges
- Interactions between animals
- Animal breeding behaviours
- Confirm captured data accuracy

4.3 Phase 3

Phase three was the last component and its primary objective was to assess the benefits of the AGTech360 system by looking at the following:

- Real-world use cases seen throughout the project
- Productivity gains/cost savings
- Producer feedback on how their business has evolved
- Next steps for R&D activities

5. Methodology

5.1 Phase 1

5.1.1 Software

Farms can be created on the AGView360 software in three ways or as a combination of these three ways.

- The producer can create his own property from scratch
- Farms can automatically be created from the lot plan number data
- Data can be imported from a kml i.e.(google maps)

For this project AGTech360 built the farms based on imported kml boundary data and provided paddock data csv files along with manual modification to refine and update the new paddocks.

5.1.2 Hardware

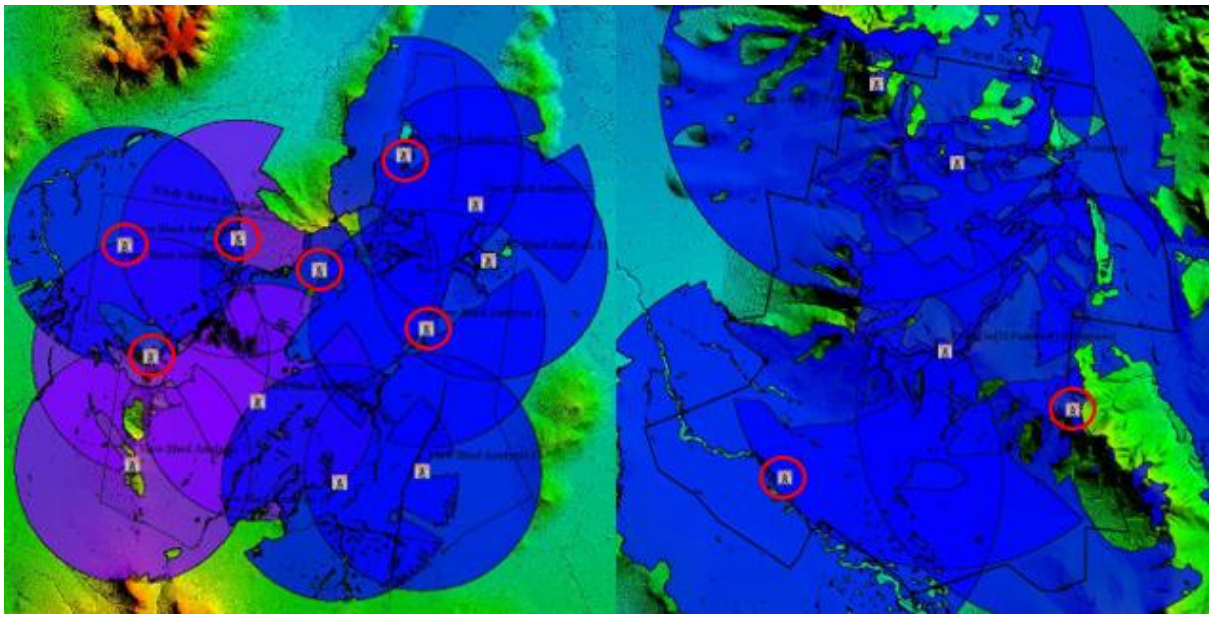
5.1.2.1 Site Survey

An initial site survey of the property was conducted, to determine the best locations to set up the AGTech360's LoRa mesh network. This was done by:

- Downloading elevation data for the target area from relevant websites
- Importing boundary kml and elevation data GIS Software
- Analysing the best positions for the gateways and repeater stations
- Calculating the required number of devices for the desired coverage
- Going to the site to check that positions selected are suitable

The site survey and the points selected can be seen in Figure 1 circled in red.

Figure 1: Site survey coverage view of Winday and Warrah Stations



5.1.2.2 Base Station and Sensor Installation

Base stations towers can be created with 1-2 people. AGTech360 took a team of three people and found the best possible locations, close to what was seen in the site survey. The steps taken were:

- Travelled to the base station assembly sight
- Fastened the tower base plate to the ground
- Mounted the device to the pole
- Mounted the pole into the tower base plate

5.1.2.3 Animal Tagging

Cattel tagging is best to be done with 2-3 people. This includes pushing cattle through the crush. On average 100 tags can be applied in 2 hours with 3 people. AGTech360 took two people and worked with the producers. The steps taken included:

- Downloading the AGTech360 Tag installation app a smart device

- Connecting the NLIS wand to the smart device
- Mustering the animals into the crush one at a time
- Locking the head of animal
- Using the AGTech360 two-pronged applicator
- Inserting a prong into the applicator
- Inserting a tag into the applicator
- Disinfecting the prongs and prong holes
- Using the wand to scan the current animal NLIS tag into the AGTech360 Installation app
- Using the app to assign the AGTech360 tag number and producers visual ID number to the Animal NLIS number
- Tagging the animals ear with the new AGTech360 Tracker Tag
- Once in reception of the internet all field data was uploaded to the AGView360 system using the app

5.2 Phase 2

5.2.1 Location

GPS Coordinates were sent online and AGView360 positioned these points on the web interface.

5.2.2 Tracking

All data uploaded from the tags was stored on the AGView360 data base and could be called back at any time using the web interface. One of the functions of AGView360 was to display all the GPS coordinates between specific dates. The system will then connect the recorded points and distinct tracks can be seen.

5.2.1 IMU Data

Raw IMU data was compared to the web interface alert data to ensure it was working as expected.

5.2.2 Movement Ranges

The tracking data from the section above was observed to see if any trend could be found. Animal behaviour in relation to distance from water, vegetation, time of day, etc were examined to gain insights. Pockets that had not seen cattle movement at all were assessed as possible reception blank spots.

5.2.3 Animal Interactions

The tracking data was observed to develop animal interactions i.e., do animals tend to stay in herds.

5.2.4 Bull Breeding Behaviour

The breeding behavioural patterns was observed using the tracked history data.

5.2.5 Confirm Data Accuracy

Confirmation with the farmers was done to ensure the accuracy of the data. The following questions were checked between farmers.

- Are the current marked cattle displayed in the paddock what is expected to be in the paddock?
- What has happened to the tags that are displaying alerts or missing, have these animals been deliberately removed from the expected animals?
- Do missing animals still have tags on their ears?

Raw data was also analysed to determine if any messages were being lost and the overall health of the tags.

5.3 Phase 3

5.3.1 Use Cases

The producer was contacted to determine the use cases they experienced whilst using the system.

5.3.2 Assessment of Productivity and Cost Savings

From the use cases an assessment of productivity and cost savings was created.

5.3.3 Producer Feedback on How Their Business Has Evolved

Final feedback from the producer was obtained in relation to their business and how it has or could evolve using the AGView360 system. A comparison between the new and old farming methods was done.

5.3.4 Next Steps

Several future developments were discussed based on the wants and needs of the producer.

6. Results

6.1 Phase 1

6.1.1 Romani Pastoral Corporation

On 16/7/2021 the site was successfully set up with all functions noted in 4.1.1 behaving as expected. Training on the AGView360 software was also given. 70 bulls were tagged with the intention of expanding the network and tagging additional animals later in the year. However due to the COVID-19 travel restrictions and excessive flooding it was decided to move the extra equipment to a more easily accessible site in QLD (Four Posts property).

6.1.2 Taroom Four Posts Property

The initial installation on Four Posts property was conducted in June 2019. On 8/7/2022 the Four Posts property was added to the project, the network was expanded, and additional tags were added to animals. On this property cows, heifers, steers and a small number of bulls were tagged.

6.1.3 Hardware Installation

6.1.3.1 Base Station

An example of the base stations installed can be seen in Figure 2.

Figure 2: Base Station Installation

6.1.3.2 Cattle Tagging

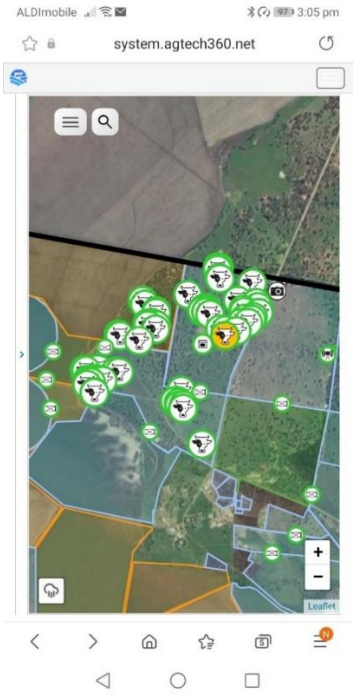
Examples of cattle being tagged can be seen in Figure 3.

Figure 3: Animal Tracker Installation

6.1.4 AGView360 Tracking

All bull tags started responding immediately. Screen shots of the AGView360 interface can be seen below. The cattle icon indicated the current location of the animal.

Figure 4: AGView360 Screen Shot from Mobile Device



6.1.5 AGView360 Alarms

There are several alarms the farmer can set up to receive alerts via email. However, for this project the alarms activated can be seen in the key below.

Figure 5: AGView360 Map Key

6.1.6 AGView360 Reporting

Figure 6 shows a summary report of several animals and their plotted weights.

Figure 6: Individual animal management and weight report

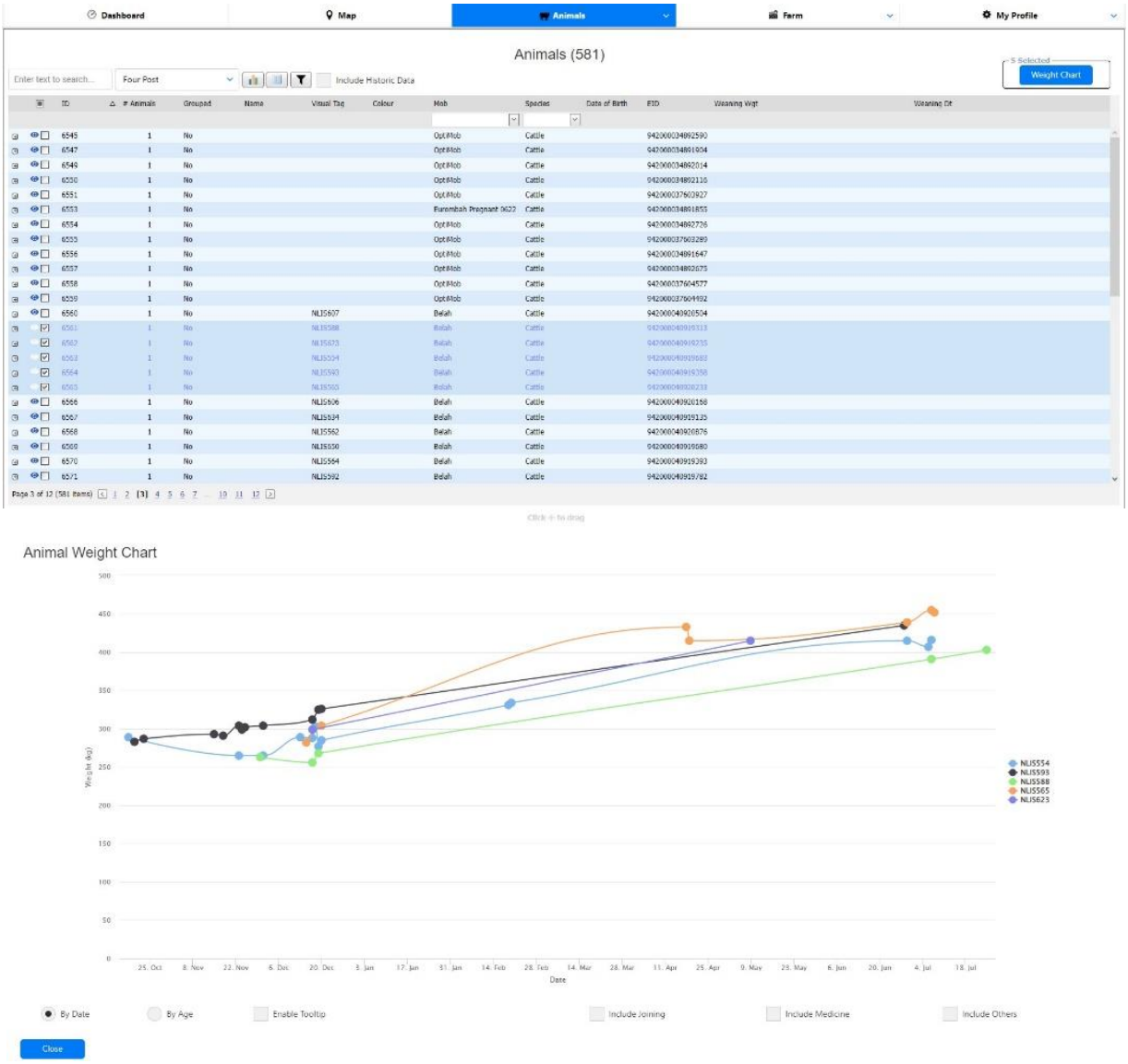
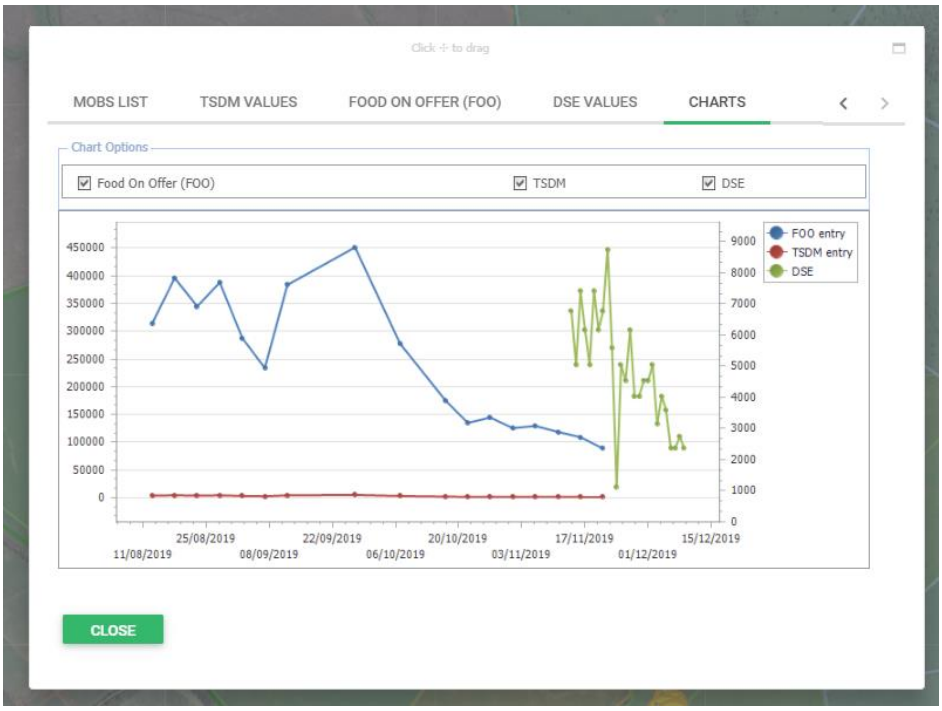


Figure 7 shows a graph of how much and the history of feed that was available in the paddock.

Figure 7: AGView360 Paddock Reporting Tab

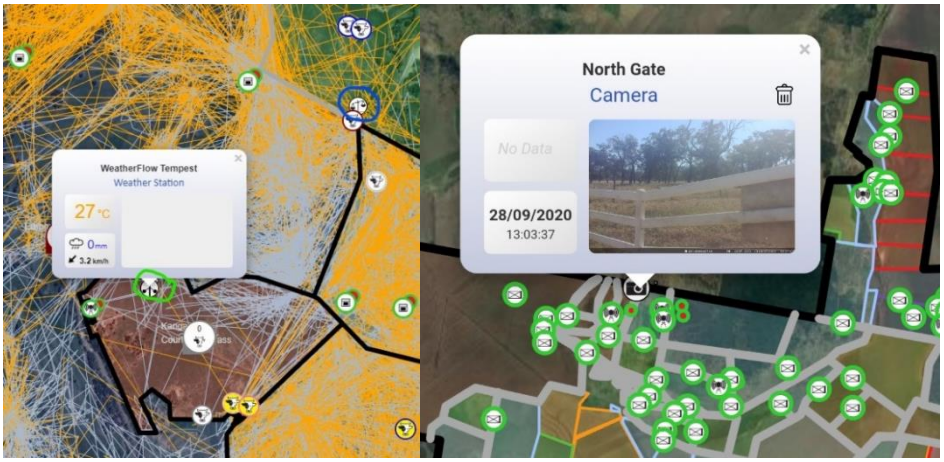


6.1.7 AGView360 External Integrated Sensors and Data

Figure 8 is a screenshot for the AGView360 web interface showing the data generated from Cibolabs satellite imagery of feed in each paddock. On the Four Post property there were Weatherflow (green circle) weather station and the OptiWeigh (blue circle) in field weighing system (Figure 9). The Windy and Warrah stations also included camera systems (Figure 9).

Figure 8: AGView360 Satellite Feed Data Colour Map

Figure 9:Four Post External Sensors and Windy Station Cameras



6.2 Phase 2

6.2.1 Location

Figure 10 depicts the animals GPS coordinate location on the AGView360 web interface with the picture of a bull's head. Selecting the icon (Figure 11) will give detailed information of the exact animal as seen in the picture below.

6.2.2 Tracking

Figure 10 below shows the AGView360 web interface with all the tracked data being displayed. The lines trailing the individual animal show the hourly track of the movement of the animal. The track can more clearly be seen in Figure 11 where only a single animal is being monitored.

Figure 10: Screen Capture from AGView360 of the Windy Farm

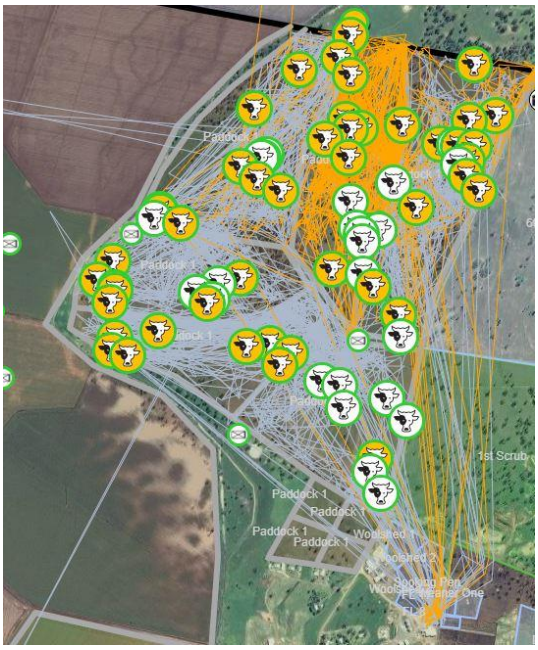
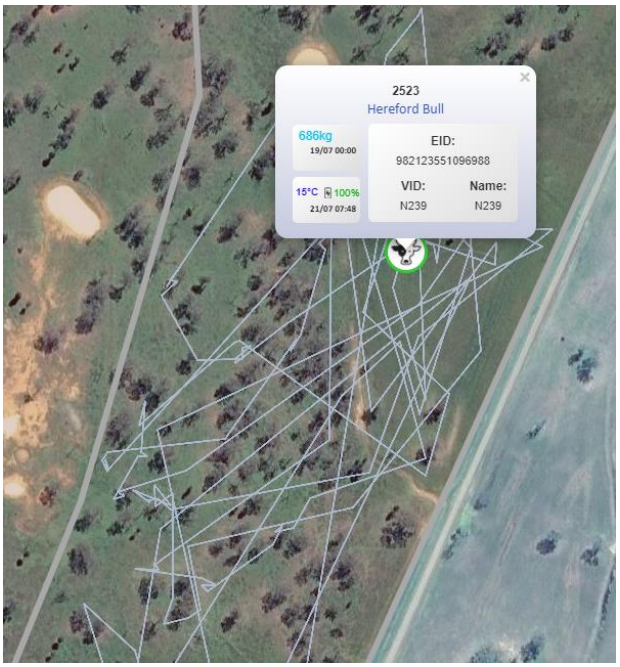


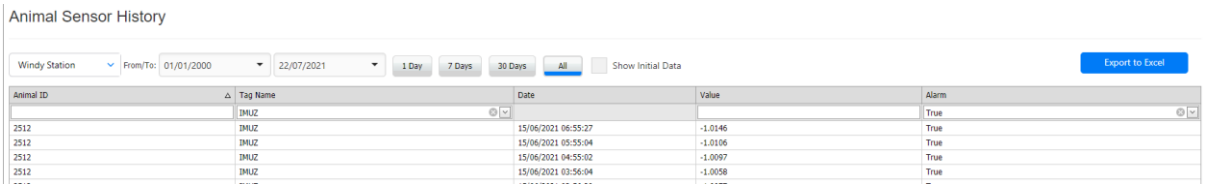
Figure 11: Screen Capture of AGView360 Interface (Selecting Individual Animal)



6.2.3 IMU Data

Raw IMU data was compared to the web interface alert data to ensure it was working as expected.

Figure 12: AGView360 Web Interface Sensor Report of Alarms (All Time)



The Figure 12 shows a report of all IMU alarms. Here we could see the system correctly identifying and flagging the tags as stationary during the time they were stationary waiting for the install.

Figure 13: AGView360 Web Interface Sensor Report of Alarms (Past 30 Days)

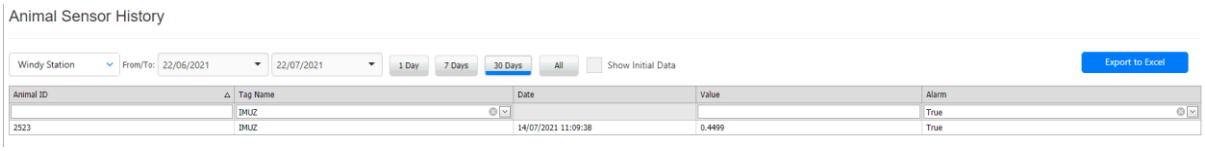


Figure 13 illustrates the IMU report data of alarms. Here we could see that in the past 30 days only one tag had given an alert for the tag being stationary. This only occurred on a single hour and this discrepancy was corrected on the next hour.

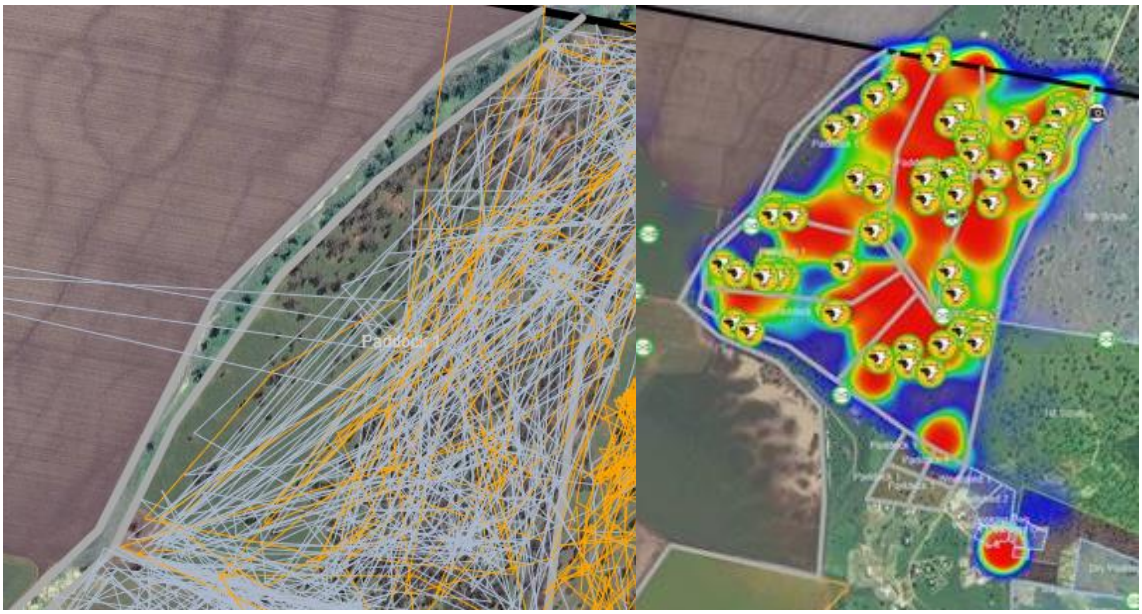
6.2.4 Movement Ranges

6.2.4.1 Romani Pastoral Corporation

As the area of paddocks that the cattle can roam was quite small, it was difficult to make observations of movement ranges and trends in relation to the environment. However, these trends became more obvious on the Four Post location.

Figure 14 illustrates an area that has very little cattle movement in comparison to the other sections of the paddock. The data has also been displayed on a heat map to illustrate further.

Figure 14: Screen Capture Illustrating Possible Coverage Blank Spot (tracks and heat map)



6.2.4.1 Four Pour Property

In Figure 15 the current displayed animal tag locations are not representative of heat map display.

Animals were swapped from the southeast paddock to the northeast paddock between these two heat maps.

Figure 15 shows darker patches around the southeast base station.

During May 2022 animals moved out of low-lying areas to higher ground.

Figure 15: December 2021

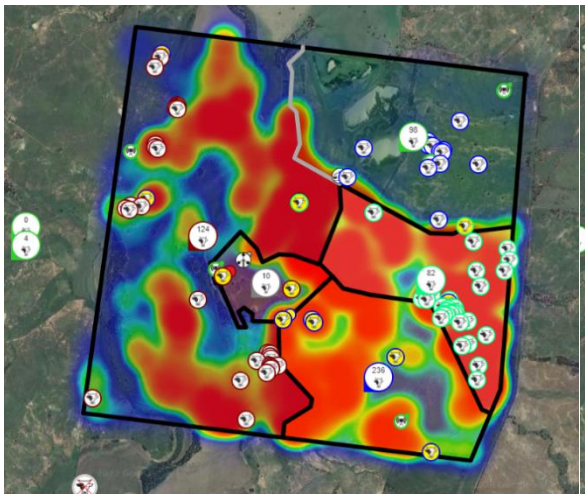
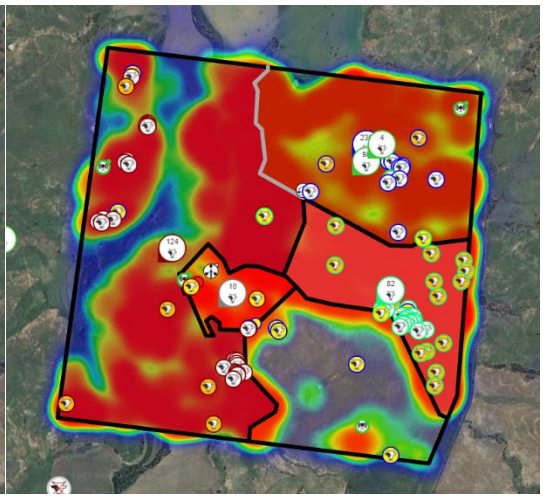


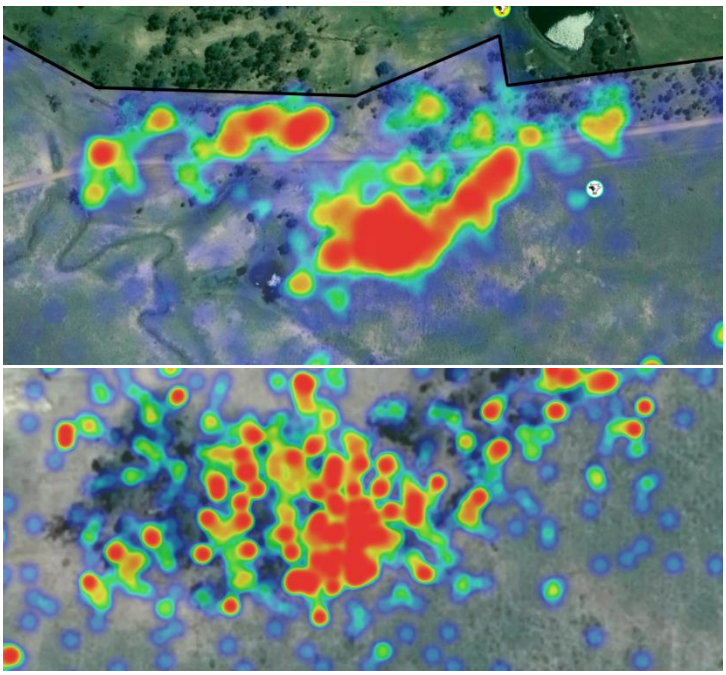
Figure 16: May 2022



When taking a closer look at the heat map in Figure 17 a higher density of activity under tree cover was seen. This was particularly evident during hotter days and colder nights. Colder days indicated a tendency for the animals to stay in open sunny areas.

The same trends were also seen when observing the relative charging capacity and voltage levels of the tags.

Figure 17: Heatmap of Animal Positions Under Tree Cover.



From Figure 18 an outer boundary fence break can be seen.

Figure 18: Animal Position Heatmap Illustrating Outer Boundary Fence Break

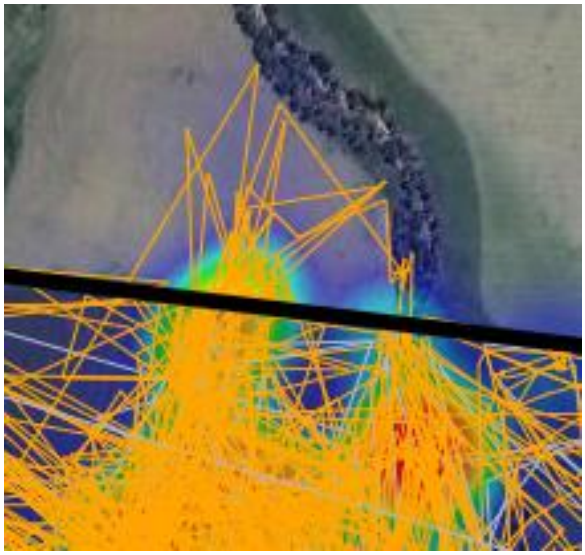


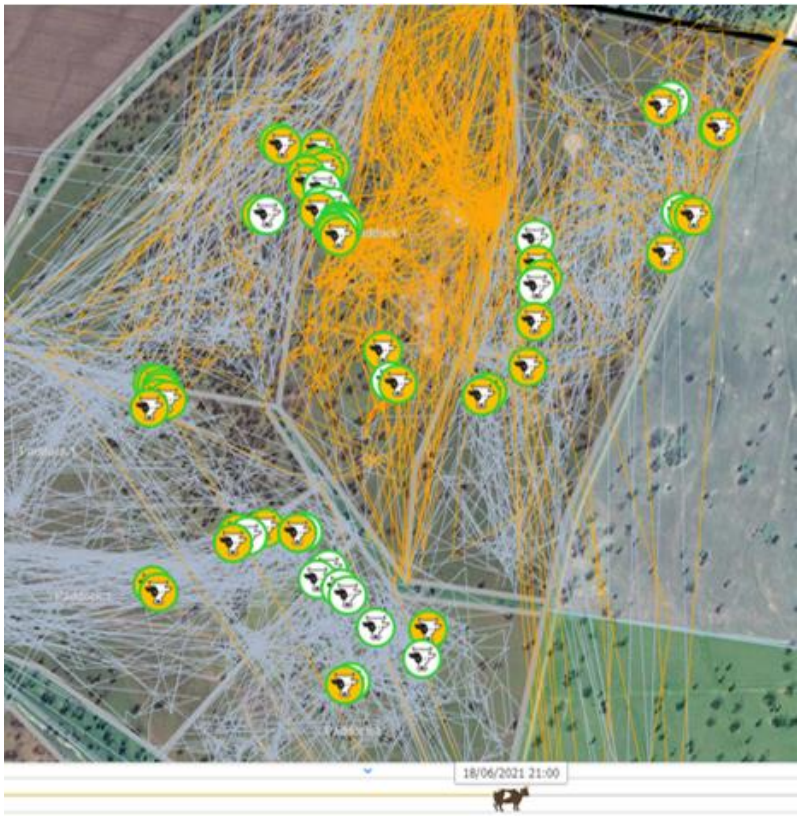
Figure 20 illustrates the tendency of the animals to cluster in large groups around certain points. Figure 20 also shows smaller groups forming where as in Figure 10 there is a tendency for animals to spread out evenly throughout the paddock.

6.2.5 Animal Interactions

6.2.5.1 Romani Pastoral Corporation

It could be seen from the tracking data that bulls clustered in groups at night-time Figure 19.

Figure 19: Screen Capture Taken at 9PM



In Figure 20 of the Four Posts property showed: clusters of animals with red icons spread thought the paddocks; blue icon animals stayed in larger groups; blue icon animals would often join up with the red icons; up until mid-October blue and red or blue and green icon animals would often congregate along the fence line.

Figure 20: Screen Capture of AGVIEW360 Four Post Farm Image from October 2021

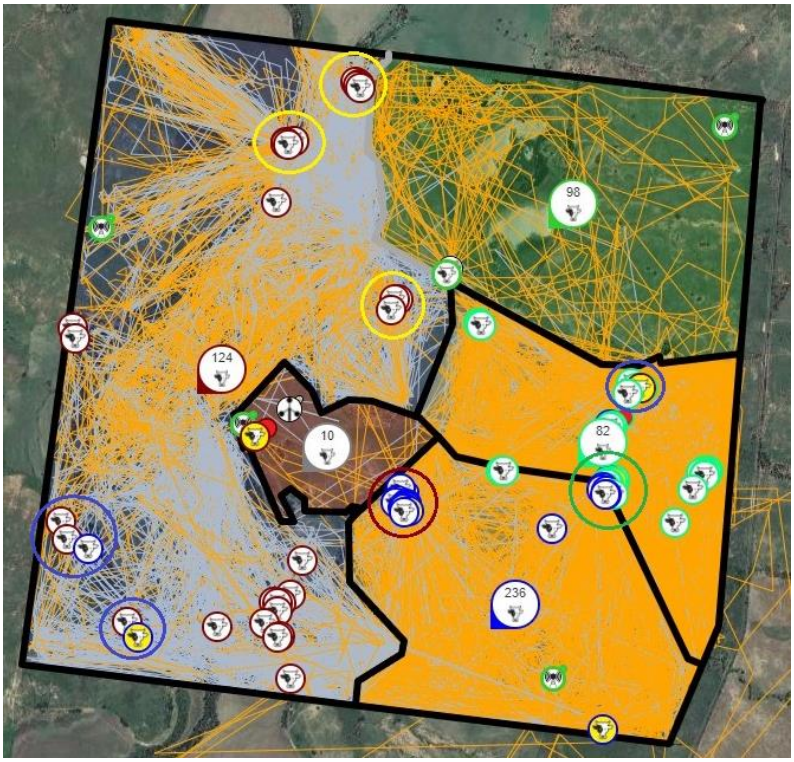


Table 2: Key for Figure 20.

Animals Grouping at Water/Lick Blocks	O
Animals Forming Smaller Groups	O
Animals Breaking Paddock Fences	O
Weaners Trying to Reach Their Mothers	O
Tracked Paths	- or -
Boundary Fences	-

6.2.6 Breeding Behaviour

Due to the inability to access the Romani Pastoral sites it was difficult to observe the bull breeding behaviour. Cow pregnancies were closely monitored and logged to the system on the Four Posts property.

6.2.7 Confirm Data Accuracy

On both these sites there was a total of 3 cases where the GPS location was largely incorrect, this error was corrected over a four-hour period automatically. IMU Data was correct 99% of the time.

Tags began to shut down and go into sleep mode during the February – May period of 2022 on the Four Posts Property.

6.3 Phase 3

The results of phase three have been discussed in the conclusion.

7. Key findings

7.1 Phase 1

7.1.1 Romani Pastoral Corporation

- Installation and training went as planned.
- The initial solar panels used for the sites base stations were inadequate for the initial rainy weather at the time and required resetting.
- A return visit was required to restart, inspect, and possibly update the equipment however due to COVID-19 travel restrictions and excessive flooding in the area, a return visit was not possible.
- Replacement units were prepared with extra solar panels and mailed to the property but were not set up properly. The producer was very busy with floods and other challenges and difficult to collaborate on testing and configuration of the new equipment.
- Due to these challenges data could not be captured for the intended period of joining.

7.1.2 Taroom Four Posts Property

- The addition of this site allowed for more diverse observations of animal behaviours with larger paddocks and diverse terrain.
- Additional sensors could be tested with the AGView360 system.
- More insights could be seen from tagging a variety of animals such as cow, bull, steer and heifer.

7.2 Phase 2

7.2.1 Location

- Location data was correctly obtained and displayed on the AGView360 web interface.

7.2.2 Tracking

- The tracks and historical data were successfully obtained and displayed on the AGView360 web interface.

7.2.3 IMU Data

- IMU Data was obtained and performed as expected.

7.2.4 Movement Ranges

- Due to the number of animals in the Romani paddock it was difficult to see trends in movements. Figure 14 showed a blank section on the northeast side of the paddock, this could have been an area of low signal coverage.
- From Figure 15 it could be seen that the Four Post property had good signal coverage. Three base stations were set up in a triangular grid pattern on the surrounding high points.

- Figure 15 showed darker patches around the southeast base station. This was due to the gradient of the slope the base station was on. When the animals were on the face of the slope they were blocked from the base station.
- The difference between the movements seen in Figure 15 and Figure 15 was primarily due to the flooding that occurred. In May 2022 the animals were forced to go to higher ground and stay out of the low-lying flood plains.
- Figure 17 indicated a higher density of activity under tree cover at certain times. This was because animals try to shelter from the heat during hotter days and shelter from the wind during colder nights. During colder days the animals try to get warm by staying in the direct sunlight.
- In Figure **20** the animals circled in red indicates a point of interest such as a water point/lick block. Here the animals would cluster.
- The yellow circles in Figure **20** also showed smaller groups forming and being more spread out on the Four Posts property compared to the paddock in Figure 10 of the Romani property. This could be due to the larger paddocks on the Four Posts property and/or it could also be due to the difference between cows and bull behaviour.
- Animals breaking through an external fence to graze on the neighbouring pastures can be seen in Figure 18.

7.2.5 Animal Interactions

- When comparing the animal interactions between the two properties, Figure 10 and Figure 20 it could be seen that the animals found on the Four Post property often formed smaller tighter groups. This could be due to the territorial nature of bulls in comparison to cows, heifers and steers.
- Animals grouped together more tightly at during the evening for safety (Figure 19)
- In Figure 20 it could also be seen that younger animals will stay in larger more compact groups.
- Figure 20 also illustrates the strong desire for mothers and weaners to remain together after separation, this can be seen by them huddling along the fence line and many pairing back with their mothers after breaking through the fence. From mid-October 2021 there seemed to be much less drive for the animal families to reach each other and less time was spent on the fence line.
- It could be seen from Figure 19 that during the evenings animals would often cluster closer together. This was most probably due to the increase to safety when being in numbers.

7.2.6 Breeding Behaviour

- After running several weighing and pregnancy test sessions, trends could start to be seen between the average weight gains and whether the animal was pregnant. More research is required to generate a more accurate relationship.

7.2.7 Confirm Data Accuracy

- Both tag GPS and IMU functionality worked as specified.

- Due to the significant flooding and lack of sunlight during the February – May period of 2022 some of the tags on the Four Posts property went into low power mode with reduced messaging. These tags all recovered.
- From the data at the 2 properties, It could be seen that there was a higher retention rate on cows compared to the bulls. From observation it seems that the bulls are more aggressive in their attempts to scratch and remove the tags until they get used to it. The bulls were also in an enclosed areas including transport in trucks which contributed to the physical damage of the tags.

8. Conclusion and recommendations

8.1 Use Cases

Initial use cases were more focussed on tracking of bulls during joining. These use cases were adapted to another property. The following use cases were being investigated during this trial:

- Theft prevention
- Animals escaping through fences to incorrect paddock
- Animals breaking external fences
- Animals isolated from herd during flooding
- Paddock utilisation and water point planning
- Mustering assistance
- Early warning of sick animals
- Integrated animal management
- Remote monitoring

8.1.1 Assessment of Productivity and Cost Savings

Real time monitoring and peace of mind that animals and infrastructure (fences) are in a good state, enabled the farmer to focus his energy and resources on other productive activities.

8.1.2 Theft prevention

Real time alerts allowed the producer to know if theft was occurring, giving them the ability to react and prevent the loss of product.

8.1.3 Animals escaping through fences to incorrect paddocks

This improved productivity and cost by allowing the farmer to quickly find the animals and restore broken fences. This can assist with preventing unplanned joining and calving out of the planned schedules. The GPS Tags also assisted with spotting weaners escaping back to their mothers as shown in Figure 20.

8.1.4 Animals breaking through external fences

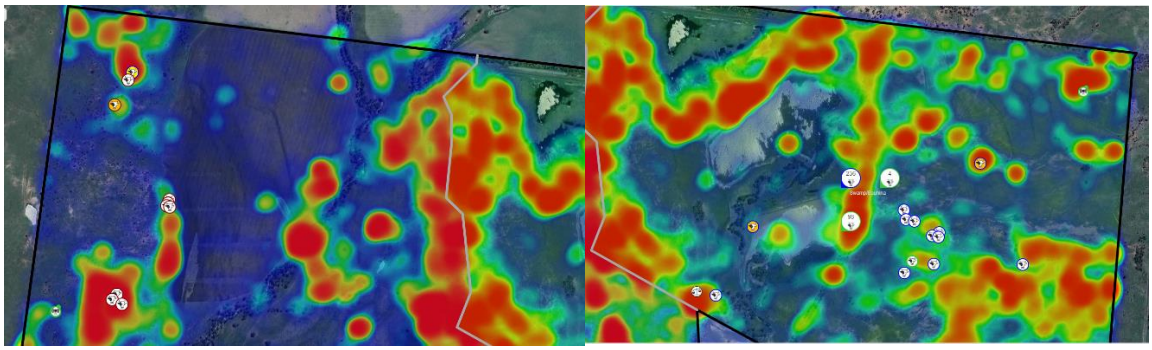
This improved productivity and cost by allowing the farmer to find the animals and broken fences effectively. The farmer received alarms when animal(s) were out of the property, and by viewing the

historical tracks of the animal the location of the break could be determined. Retrieval of the animals was easier because of the quicker response (Figure 18).

8.1.5 Paddock utilisation and water point planning

Using the historical movements of the animals the areas of the paddocks not utilised by the animals were identified. This assisted in planning new water points and placement of lick blocks. The GPS trackers delivered immediate feedback on these changes in the paddocks (Figure 21).

Figure 21: Animal Position Heat Map for March, April, May 2022



8.1.6 Mustering assistance

Musters could be planned better with the locations of the animals known. Animals missed in the muster could be viewed in real time (Figure 22). This saved animals from being missed in yard sessions where they received health assessments and medicine as part of the farms' health plan.

Figure 22: Mustering Information Prior and After Muster (8/6/2022)

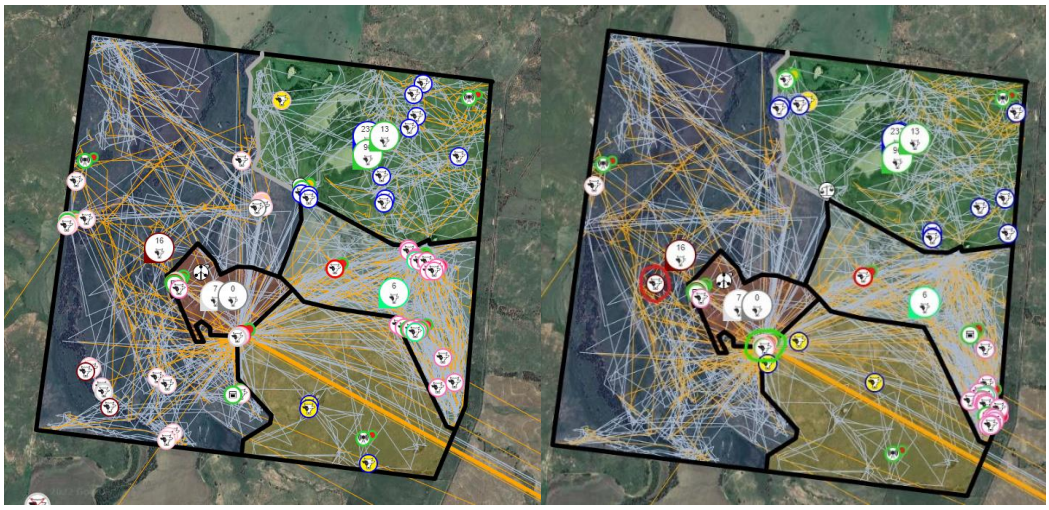


Table 3: Key for *Figure 22.*	
Missed Animal While Mustering	O
Animals in the yard/crush	O
Tracked Paths	- or -
Boundary Fences	-

8.1.7 Early warning of sick animals

In the past, the AGView360 system has been used by the producer to identify three animals that separated from the herd and stopped moving. When the farmer went to check on these animals, it was found they had 3-day sickness. The farmer was able to treat these animals, saving two out of the three.

8.1.8 Integrated animal management

The AGView360 software system integrates all the tracking data with the individual animals' data. This includes weight data gathered from other sensors on the property e.g., OptiWeigh and data entered at the yard. Weight, medicine, animal condition and pregnancy status were recorded during this trial, this enabled comprehensive reporting for a greater understanding and planning of the producers' business (Figure 6).

Other sensors were integrated into the AGView360 system, this was combined with AGTech360 sensor data and displayed on the single platform. Examples of sensors on the Four Post property were weather stations and the OptiWeigh in field weighing system. The Windy and Warrah stations also included camera systems (Figure 9).

8.1.9 Remote monitoring

Using the AGView360 web system and the GPS tracking tags information could be viewed and managed from remote locations. All hardware including Gateways and Repeaters could be monitored and any issues were addressed.

8.2 Producer Feedback of how Their Business Has Evolved

Table 4 illustrate the differences in business operation before and after introducing the AGView360 system.

Table 4: Differences in operation of before and after using the AGView360 system.

Scenario	After	Before
Theft prevention.	Can be observed in real time and alerts given for specific events.	
Animals escaping through fences to incorrect paddock.	Immediate alert of animals in the wrong paddock. The location of the break in the fence could be determined by the historical track data.	The producer had to physically patrol paddocks and fences. Issues were only found when animals were brought to a yard session.
Animals breaking through external fences.	Immediate alert of animals outside of the property. The location of the break in the fence could be determined by the historical track data.	The producer had to physically patrol paddocks and fences. Issues were only found when animals were brought to a yard session.
Paddock utilisation and water point planning.	With the historical position data, the producer could now make more informed decisions e.g., planning of paddocks, fences, and water points.	The producer would manually need to observe the behaviour of the animals over a period.
Mustering	The producer can plan mustering with the real time position of the animals. Animals missed in the muster can be seen in real time.	The producer needed to travel over the whole paddock to gather animals. Animals missed would only be determined in the yard session.
Early warning of sick animals.	Immediate alerts are given when an animal stops moving, allowing the producer to quickly identify and reach the animal before the potential problem escalates.	Producer periodically needed to inspect animals. If a carcass was found it was often too late to determine the cause of death.
Integrated animal management.	The producer saves time with all the sensor data recorded and displayed in the integrated animal management system.	The producer had to manually capture data on paper and or spreadsheets and use multiple interfaces for different sensors.
Remote monitoring.	The producer can remotely view the state and location of the animals. Animal data can also be viewed and managed remotely.	

8.3 Next Steps

Based on the experiences of this trial and discussions with the producer, the following extensions and further projects were scoped.

- Improve the outer casing material strength.
- Improve out of farm detection using updated firmware on GPS trackers.

- Meshing of GPS trackers to form a complete redundant network across the property without extra radio infrastructure.
- Full handsfree integration of scales and scanners at the yard interfacing to the AGView360 animal management system.
- Improve the intelligent alert system based on the movement characteristics of the animal to more clearly identify sick animals, bulls joining detection, pregnancy detection and calving detection.
- Improve the integration of pasture data and other inputs overlayed with the GPS tracking data to develop a better understanding of feed available and optimise livestock growth.
- Improve medicine stock and compliancy management with full traceability of the exact medicine batch and dose used on individual animals.
- Add automatic dose calculation based on the medicine rules and animal history in a yard session.
- Add full integration with the NLIS system for movement of animals on and off the property.

9. References

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10. Appendix

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