DigiFarm Final Report Summary

Smart Farming Partnerships – Round 1

August 2023

Application ID: SFP1-167

Grantee Name: Guy Roth

Project Title: DigiFarm. A digitally enable durable agroecosystem

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1 Project Description

The DigiFarm project aimed to develop a digitally enabled network to simultaneously monitor crop and animal production (including native flora and fauna), and soil and ecosystem health. This network aimed to enable the triple bottom line framework of social, environmental and financial accounting to optimally manage a production ecosystem.

The project aimed to transform Llara Farm into a sentinel digital agile, production and environmentally resilient 'digi-ecofarm' of the future which is a beacon for the north-west NSW region. It has done this through the building of a physical and virtual DigiFarm hub at Llara in addition to a network of ten satellite farms across north-west NSW which provide digital dashboards of health, production and social metrics. This aimed to create an education platform for farmers, agribusiness, schools and other stakeholders to experience the latest ag-innovation thinking. The purpose of this was to provide easily accessible information and training that would permit stakeholders and farmers to adapt to changes in climate and markets, improve capacity to demonstrate sustainability of products, and to demonstrate improved environmental stewardship and social awareness by providing the data to develop triple-bottom-line accounting.

The project involved 20 collaborators and has demonstrated a range of digital technologies to farmers across the north-west NSW region. It has delivered outcomes from a multidisciplinary perspective relating to cropping, livestock, ecology, the environment, and agricultural technology. The project has highlighted the benefits of integrated sensing and is an excellent showcase for digital agriculture for the agricultural and environmental sectors, the government and community.

2 Executive Summary

The DigiFarm project involved partnerships with over 20 collaborators and demonstrated a range of digital technologies to farmers particularly across the North West NSW region. The project outcomes were delivered from a multidisciplinary perspective related to cropping, livestock, ecology, the environment, climate change and agricultural technology. The key success is a digitally enabled network which simultaneously monitors crop and animal production, native flora and fauna, and soil condition and ecosystem health. Because of this broad perspective, the project is an excellent showcase for how digital agriculture can shape the future of sustainable food production and, in so doing, highlighted the benefits of integrated sensing approaches to the joint agricultural and environmental sectors, as well as the government and community.

We have delivered 4 networks on Llara Farm which support the 24/7 sensor network of equipment including digital soil moisture and temperature monitoring capacitance probes, weather stations, trough sensors, tank sensors and tipping bucket automated rain gauges. The project has also used technology to produce digital soil maps of plant available water and soil biodiversity (including soil molecular microbial ecology) which will enable better informed management decisions to be made. Extensive work was carried out using unmanned aerial vehicles (UAVs), demonstrating their benefits to agriculture for assessing crop emergence, facilitating precision weed control and for canopy sensing to simulate crop condition and production. A further outcome of the project is the development of an autonomous spot sprayer and associated 'Open Weed Locator' (OWL) platform. Livestock and pasture technologies were also used and tested including remote weighing systems and sensors to measure diet quality, animal performance and methane emissions.

Extensive biodiversity monitoring has been a feature of the project with a substantial dataset of ground-dwelling invertebrates generated. Extensive data has also been generated for terrestrial mammals, microbats and birds, all of which will be vital for examining whether natural systems around crops influence the ability of communities to recover from drought. In addition to floral, faunal and soil biodiversity, sustainability has also been a focus with an emissions analysis of the farm carried out as well as a Llara Farm sustainability report. The use of soundscape sensors was a particularly novel development. This forms part of the broader commitment of the farm and University to climate action and supports our vision to create a more sustainable future for the farm and the associated industry.

This project has demonstrated the use of these technologies and practices in a way which will give growers the confidence to implement them. It has allowed Llara to now be part of a digitally enabled network to simultaneously monitor different components of the production system. The output and outcomes can be used for productivity, animal welfare, profitability, and environmental and financial accounting to optimally manage a production ecosystem. These outputs are of significance and will help shape the future of Australian agriculture for both growers and policy makers alike.

By giving farmers the confidence to adopt these technologies, the outcomes and findings from this project are significant for the Australian agriculture industry by bringing greater resilience to Australian agricultural production and the agricultural sector into the future. However, a question which remains unanswered relates to the current skills shortage in the sector for digital, networking and technological skills which are required to install, maintain and upkeep such equipment. Without an increase in training which is focussed on these skills, the wide-scale adoption, utilisation and potential of these technologies will be limited.

3 Project Summary

Project title – DigiFarm. A digitally enabled durable agroecosystem

3.1 Partner organisations

Lead Organisation: The University of Sydney

Partner Organisations:

1. Local Land Services - Facilitated 13 extension satellite farm sites, developed communications, delivered feral pig activity and co-delivered livestock activity
2. Vantage NSW – Provided professional technical experts as well as loan equipment (GPS, Yield Monitoring)
3. Penagcon – Engaged their grower clients in activities and hosted a demonstration site
4. Goanna Telemetry Systems – Provided a Wi-Fi network, automatic weather stations and soil and nutrient probes
5. ICT International – Provided soil moisture sensors
6. Precision Cropping Technologies – Provided an EM38 soil monitoring instrument for data collection to build continuous soil and soil moisture maps.
7. Australian Grain Technologies – Provided staff time contribution and access to novel germplasm and supervised undergraduate students
8. CSIRO – Delivered the Integrated Pest Management (IPM) activity to demonstrate its benefits in dryland cropping systems and remnant native vegetation
9. Dryland Cotton Farmers Research Association – Involved their extensive network of growers in project activities and hosted satellite demonstration sites
10. NSW Wheat Research Foundation – Trustees provided strategy advice on grower priorities in relation to Research, Development & Extension (RD & E).

3.2 Summary

The DigiFarm project has transformed Llara Farm into a digital ecofarm of the future which is agile and production and environmentally resilient. The numerous project activities have turned Llara into a beacon for the north-west NSW region which is an educational platorm for farmers, agribusinesses and other stakeholders to experience the latest ag-innovation developments. The work carried out has developed a digitally enabled network to simultaneously monitor crop and animal production as well as soil and ecosystem health.

3.3 Objectives

1. To develop a digitally enabled network which will simultaneously monitor crop and animal production (including native flora and fauna), and soil and ecosystem health. The network will enable the triple bottom line framework of social, environmental and financial accounting to optimally manage a production ecosystem.
2. To provide new knowledge and capacity of cropping, pasture and farm natural resources strategies which are more efficient, productive and sustainable.
3. To increase the number and diversity of partnerships operating at Narrabri site and ensuring legacy activity beyond this project

3.4 Key Activities

The project involved partnerships with over 20 collaborators in order to deliver 11 sub projects to test, investigate and demonstrate a range of digital technologies for farmers. In addition to the 11 project activities which have been based at Llara Farm, there have also been an additional 13 satellite farm activities across North West NSW which have been incorporated. A large range of partners have also been included including LALCs, community groups, Local Government, LLS and other commercial enterprises.

The project concluded in March 2023 and over its 3 ½ year period, clearly demonstrated the concept of DigiFarm, a digitally agile production and environmentally resilient farm which simultaneously brings benefits to cropping, livestock, environmental management and sustainability monitoring. The achievements span at least three diverse areas: 1. It has provided easily accessible information and training which will permit farmers and stakeholders to adapt to changes in climate and markets, 2. The project further secure operational aspects of the farm through improved capacity to demonstrate sustainability, quality and traceability of products, and 3. The financial and social dimensions of the farm business are also enhanced through the DigiFarm approach to monitoring and improved environmental stewardship and social awareness and by providing the data to develop triple-bottom-line accounting.

The 'Farm, Soil and Soil Water Sensor Network 24/7' activity has delivered 4 networks on Llara Farm which were used to test different digital remote and automated farm sensing equipment including: digital soil moisture monitoring capacitance probes, weather stations, trough sensors, tank sensors and tipping bucket automated rain gauges. This delivered social and community outcomes by demonstrating such technology, increasing the knowledge and capacity of local growers regarding the options available for 24/7 farm monitoring.

Digital soil maps of depth to constraint for pH, salinity and sodicity have been produced as part of the 'Digital Soil Water Mapping' activity. This also estimated plant available water capacity and modelled plant available water using a spatial water balance to allow for better and more effective management leading to enhanced productivity and natural resource management (NRM) outcomes.

The 'Remote and Automated Farm Sensing of Crop Status' activity showed that crop condition and production simulation in the Agricultural Production SIMulator (APSIM) model can be improved by assimilating remote and proximal sensing observations. This activity used the APSIM crop model to accurately predict yield, thereby contributing the program objectives of applying unmanned aerial vehicles (UAVs) for crop monitoring and precision farming.

The ‘Data Management’ activity of the DigiFarm project has been instrumental in establishing the use of AgWorld and AgriWebb which are now being used across the farm. These commercial platforms are fully integrated with precision agriculture software such as PCT Agcloud and Cibo Labs. These platforms provide a farm-wide system for data collection, curation, daily operational use, periodic reporting and archiving. In addition to this, the project also developed the Pairtree platform as a holistic farm dashboard where data such as mapping is entered, stored and managed. The dashboard stores and displays all data from all platforms including AgWorld and AgriWebb as well as allowing data from soil probes and other digital equipment to be viewed on a single dashboard

The ’Cropping and Farm Management Systems’ activity of the project demonstrated the application of numerous technologies into cropping systems including: Digital remote soil moisture sensors cover cropping, use of drones for emergence and plant density and canopy sensing equipment. It has also demonstrated alternative crops such as industrial hemp. This project activity contributes to the program objectives by demonstrating a range of alternative crops to growers as well as acting as an education and showcasing platform for farmers and other stakeholders to experience the latest ag-innovation thinking. It has demonstrated the use of technologies and practices in a way to give growers the confidence to implement them. The project also established a Dryland Cotton Research Hub in partnership with the Dryland Cotton Growers Association.

In addition to cropping, ‘Livestock and Pasture’ related technology has also been used and tested including remote weighing systems (Walk over Weigh and OptiWeigh) and the development of a smart NIRS sensor method and equations to measure diet quality, animal performance and methane emissions. This contributes to objective one of being part of a digitally enabled network to simultaneously monitor different components of the production system. The output and outcomes can be used for productivity, animal welfare, profitability, environmental and financial accounting to optimally manage a production ecosystem.

‘Drone Based’, ‘Robotic Based’ and ‘Spot Spraying’ precision weed management technologies have also been used and tested. The activity delivered a Digital Farmhand (DFH) robot which became capable of autonomous spot spraying weed control in fallows and along fence lines following the mounting of a digital camera based weed detection and spot spraying system. By demonstrating this to growers along with developing the Open Weed Locator (OWL) platform, this contributes to the program objectives of increasing knowledge, capacity and digital competence with regards to the application of robotics for weed control and precision farming.

The ’Soil Health Systems’ activity of the project established a large reference baseline soil health monitoring dataset to understand the variations and conditions of the soils on the farm. The activity also explored the impact of substituting traditional fallows with short duration, non harvested crops, on several soil condition and health indicators, moisture balance, and cash crop yields. This delivered enhanced soil security and a greater capacity and awareness of soil health and its management. Soil carbon monitoring was also carried out.

GPS data has been gathered on the movements of collared feral pigs as part of the ‘Feral Pig Monitoring’ activity. This provides valuable insights into how the local population of feral pigs spatially use the Mulgate Creek region throughout the year, allowing for better informed management decisions to be made. This contributes to the program objectives by providing an education platform for farmers and other stakeholders to experience the latest ag-innovation thinking, particularly with regards to feral pest management.

‘Natural Capital and Integrated Pest Management’ activities generated a substantial dataset of ground-dwelling invertebrates which will be vital for examining whether natural systems around crops influence the ability of communities to recover from drought. Feral pig monitoring was carried out as well as extensive biodiversity monitoring relating to ‘Terrestrial Mammals’, ‘Microbats’, ‘Birds’ and the ‘DroughtNet’ Protocol. Detailed bird surveys were also carried out over four years at quarterly intervals. The use of soundscape sensors was a particularly novel development from the project.

Various ‘Managed Native Grasslands and Food’ activities were also carried out resulting in the establishment of 13 ha of native grain areas on Llara as well as the building of extensive connections between growers and the indigenous community.

In addition to floral, faunal and soil biodiversity, ‘Sustainability and Provenance’ were also part of the project with the primary outputs being a carbon emissions analysis of the farm and a Llara Farm Sustainability Report which forms part of the broader commitment of the farm and University to climate action and supports our vision to create a more sustainable future for the farm and the associated industry. This contributes to the objectives to develop environmental and social metrics to demonstrate more sustainable farm management.

13 Satellite demonstration sites were also established in order to showcase and demonstrate the technologies and practices implemented in the project across a wide area of North-west NSW.

This project resulted in an increased number and diversity of partnerships from the public and private sectors operating at the Narrabri Llara Farm. These partnerships are continuing beyond the life of the DigiFarm project, demonstrating its ongoing legacy.

3.5 Outcomes

The project outcomes were delivered from a multidisciplinary perspective related to cropping, livestock, ecology, the environment, climate change and agricultural technology. The key success is a digitally enabled network which simultaneously monitors crop and animal production, native flora and fauna, and soil condition and ecosystem health. Because of this broad perspective, the project is an excellent showcase for how digital agriculture can shape the future of sustainable food production and, in so doing, highlighted the benefits of integrated sensing approaches to the joint agricultural and environmental sectors, as well as the government and community

The concept of DigiFarm, a digitally agile production and environmentally resilient farm, has been well demonstrated by this project with it bringing benefits to cropping, livestock, environmental management, and sustainability monitoring, making Llara farm a showcase and great resource for future work on digital agriculture.

3.6 Implications

The findings of this project are significant for farmers and the wider Australian agriculture industry with this project demonstrating technologies and networks to develop a digitally enabled network which simultaneously monitors crop and animal production, native flora and fauna, and soil and ecosystem health. By rigorously testing and demonstrating the benefits of novel unproven technologies, it has given farmers the confidence to apply these to their own enterprises. By allowing the monitoring of numerous on-farm parameters relating to productivity as well as soil and ecosystem health, the application of technologies demonstrated through this project will bring greater resilience to Australian agriculture into the future.

Whilst the DigiFarm project has been able to provide an eye to the future for the potential of digital agriculture, it has also identified pitfalls for growers and producers. There are potentially a number of private and public organisations pitching a product or service that over-promises and will under-deliver and so growers must be aware of such challenges. Without an increase in digital capability to keep technology working and to generate the products and services for end users to interpret across the agricultural sector, the wide-scale adoption, utilisation and potential of these technologies will be limited. Most digital technologies are being developed by the private sector meaning it is crucial for that sector to be supported into the future.

3.7 Project Summary Facts

- 13 Satellite Demonstration Sites across North-West NSW
- 26 Events engaging over 2,000 people on-site
- 80 Social media posts reaching 34,500 people and engaging 4,500
- Changed the way in which spatial, farm management and sensor data are managed by pioneering the use of AgWorld & AgriWebb
- 20 collaborative partnerships from public and private sectors
- 90 active participants delivering the project
- Established new partnerships with 5 organisations
- 200 Soil Tests Performed and Analysed
- 4 networks installed to allow for 24/7 remote and automated farm sensing and monitoring
- 56 Digital Soil Probes Installed
- 20 Mammal Biodiversity Cameras
- 20 Bird Eco-acoustic Monitoring Devices
- 20 Bat Audio Monitoring Devices
- 3 Digital Weather Stations
- 5 Digital Water Tank Sensors
- 81 Plant Species Identified
- 55 Terrestrial Animal Species Identified and Monitored over 3 years
- 140 Unique Bird Species identified and Monitored over 3 years
- 14 Bat Species Identified from 440,000 bat call recordings and Monitored over 3 years including 5 threatened species.
- 100,000 invertebrate individuals counted and 107 species groups identified
- 3,000 digital images of weeds generated

4 Project Photographs

4.1 Activity 1 – Farm, Soil & Soil Water Sensor Network 24/7

Figure 1: LoRaWAN Tower being installed on Llara Farm which provides coverage in a 10km radius. It is a long range low power wireless network – March 2018

4.2 Activity 2 – Remote & Automated Sensing of Crop Status

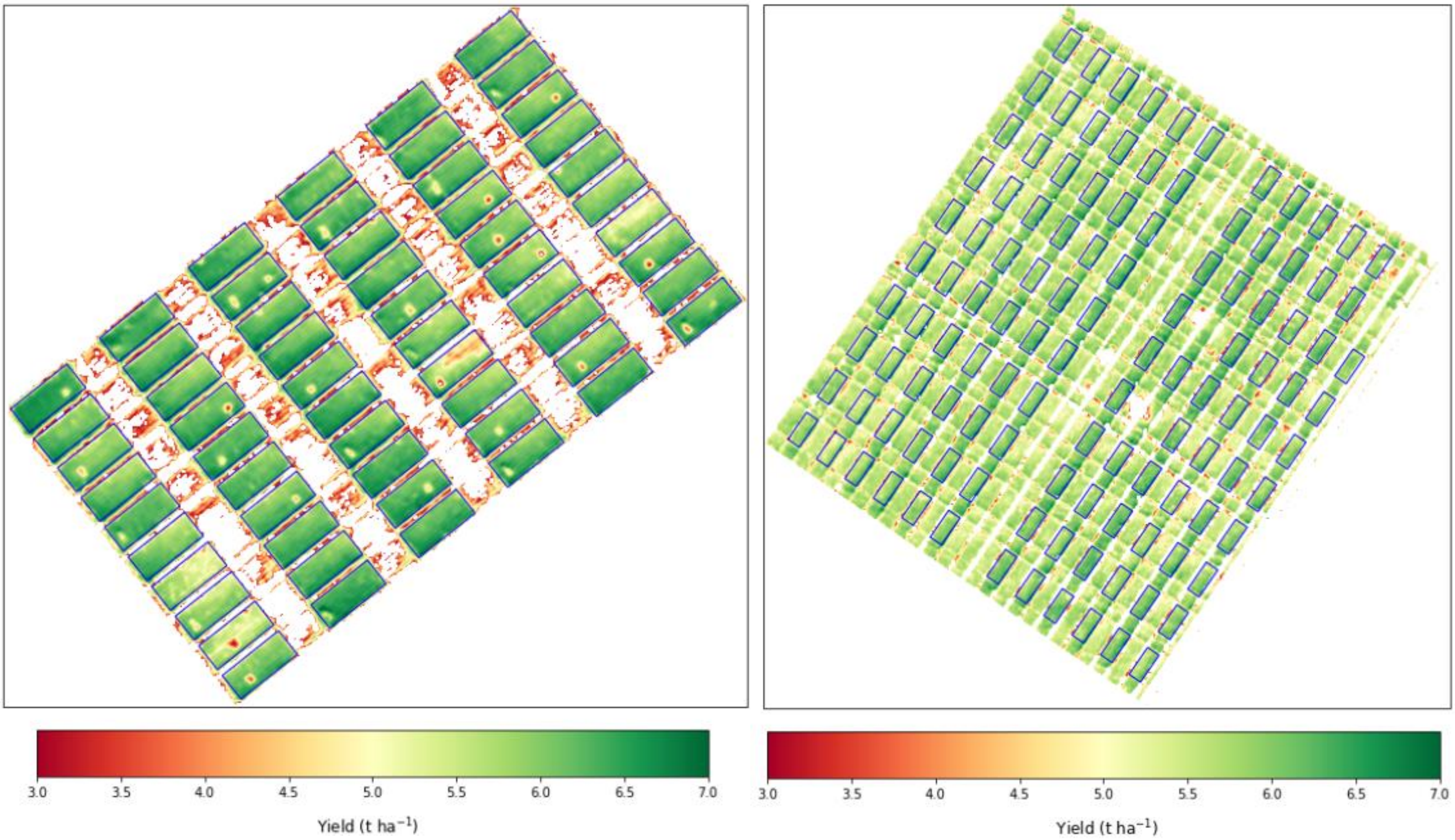

Figure 2: Yield prediction using sum of thermal imagery over the 2019 and 2020 seasons. The single red/yellow dots inside plots correspond to biomass cuts.

4.3 Activity 3 – DigiFarm Data Management

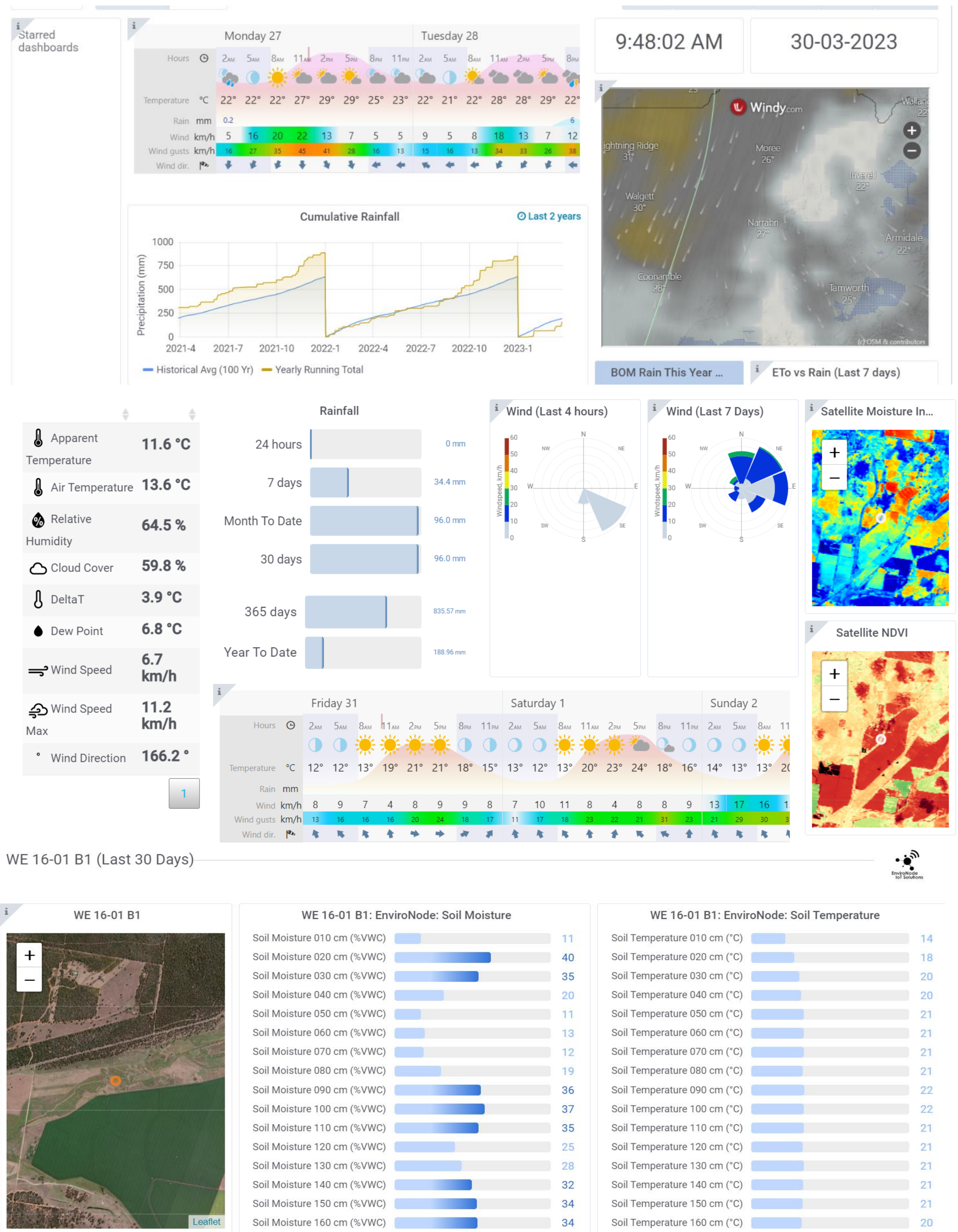

Figure 3: Pairtree Dashboard integrating data from all platforms and technologies such as weather station data (upper) and soil capacitance probe data for temperature and moisture (lower) shown here – https://pairtree.co

4.4 Activity 4 – Cropping & Farm Management Systems

Figure 4: Inspection of the Cotton Crop by the Cotton Research and Development Corporation Board - Deputy Chair CRDC Board R Richards, Guy Roth DigiFarm, Ian Taylor Executive Director CRDC, Geoff Oniel Dryland Cotton Growers Association – 6th April 2022

Figure 5: Dryland Cotton Research Association Field Day attended by 45 participants – 31st March 2021

Figure 6: John Deere Cotton Trial crop at different growth stages - December 2022 (Top Row & Bottom Left) and January 2023 (Bottom Right)

Figure 7: Drone image of the 2022/23 John Deere Cotton Trial with plants indicated by red dots to determine emergence and plant density – December 2022

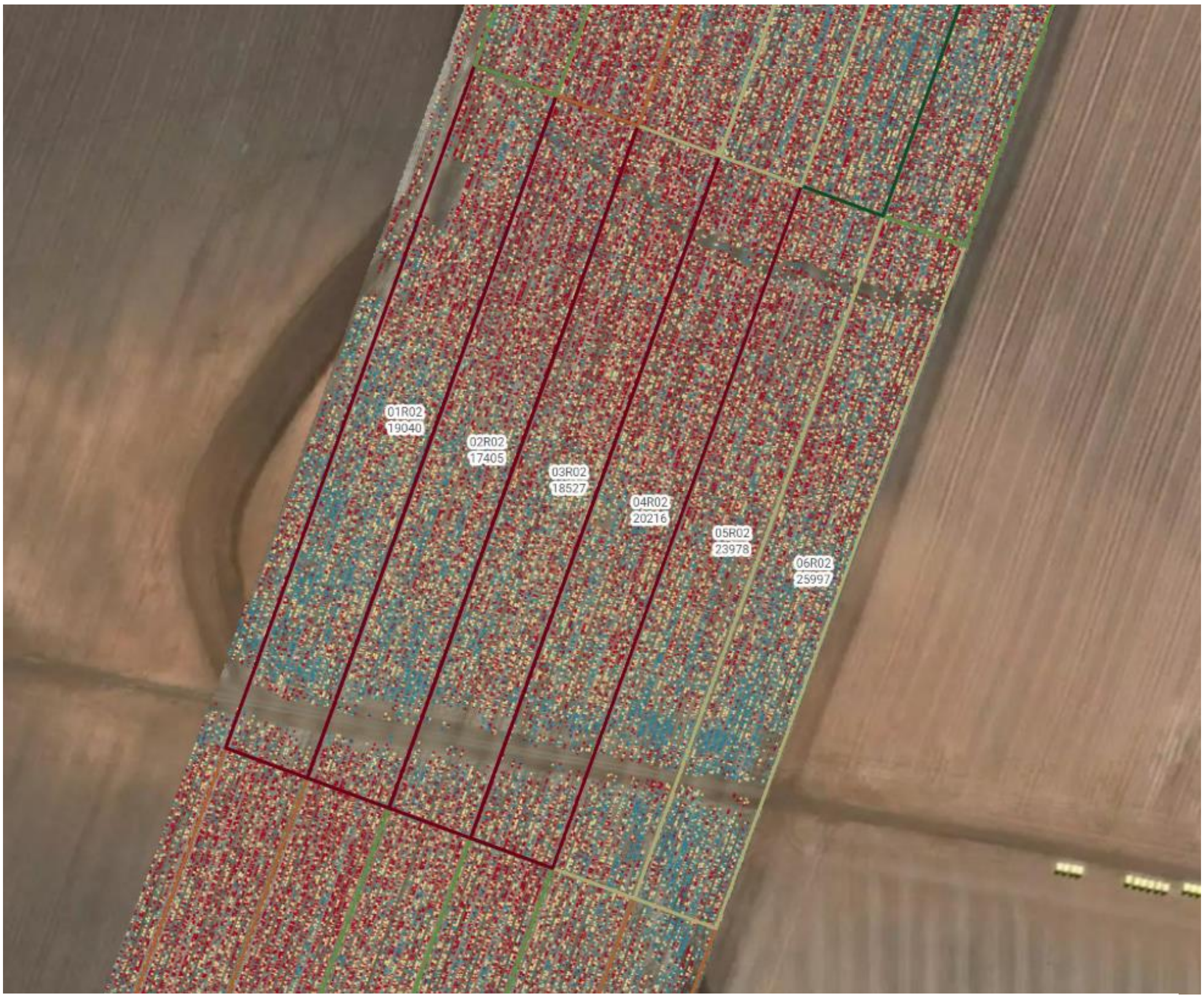

Figure 8: Drone image of the 2022/23 John Deere Cotton trial showing emergence counts with plants indicated by red dots – December 2022

Figure 9: Low THC Hemp trial in January 2023 showing soil probes used to record soil moisture and temperature

Figure 10: Guy Roth, Ed Chaplin & John Batemen inspecting the Industrial Hemp trial in February 2023

4.5 Activity 5 – Livestock & Pastures

Figure 11: Trailer Walk over weighing station (left) and walk over weighing station installed at Manilla (right).

Figure 12: Optiweigh station on Llara Farm, Narrabri

4.6 Activity 6 – Precision Weed Management:

Figure 13: Landcare Conference Visit to site. Guy Coleman pictured talking about weeds, robots and machine learning – 12th June 2019

Figure 14: Demonstrating the digital farm hand autonomous spot sprayer at the AgTech Expo in Tamworth – March 2022

Figure 15: Autonomous Spot Sprayer
Top: Autonomous spot sprayer on the Digital Farm Hand robot at Narrabri.
Bottom left: Demonstration of ute mounted spot sprayer in Junee, NSW in March 2021.
Bottom right: OWL hardware in 3D printed enclosure

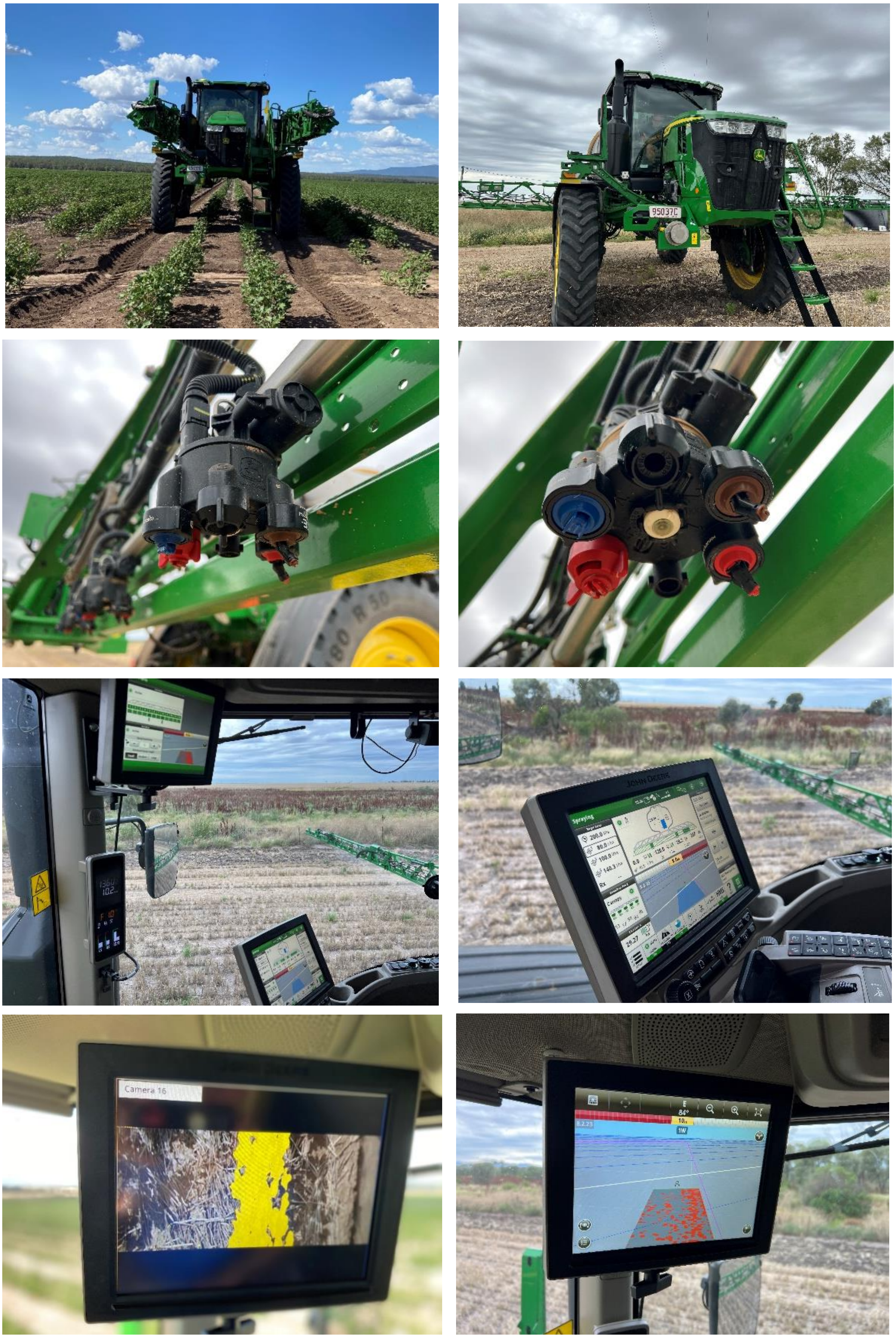

Figure 16: John Deere See & Spray Technology for Precision Weed Management being used for the weed assessment trial – February 2023

4.7 Activity 7 – Soil Health Systems – Monitoring & Cover Cropping

Figure 17: Trial 1 cover crop termination by roller crimper - March 2020 (left), Trial 2 cover crop - September 2020

Figure 18: PhD Student Tom O'Donoghue completing his last measurements using an EM to measure soil moisture in January 2022. A soil moisture capacitance probe can also be seen in the background.

4.8 Activity 8 – Digital Feral Pig Monitoring:

Figure 19: Tracking collar attached to pig - August 2021

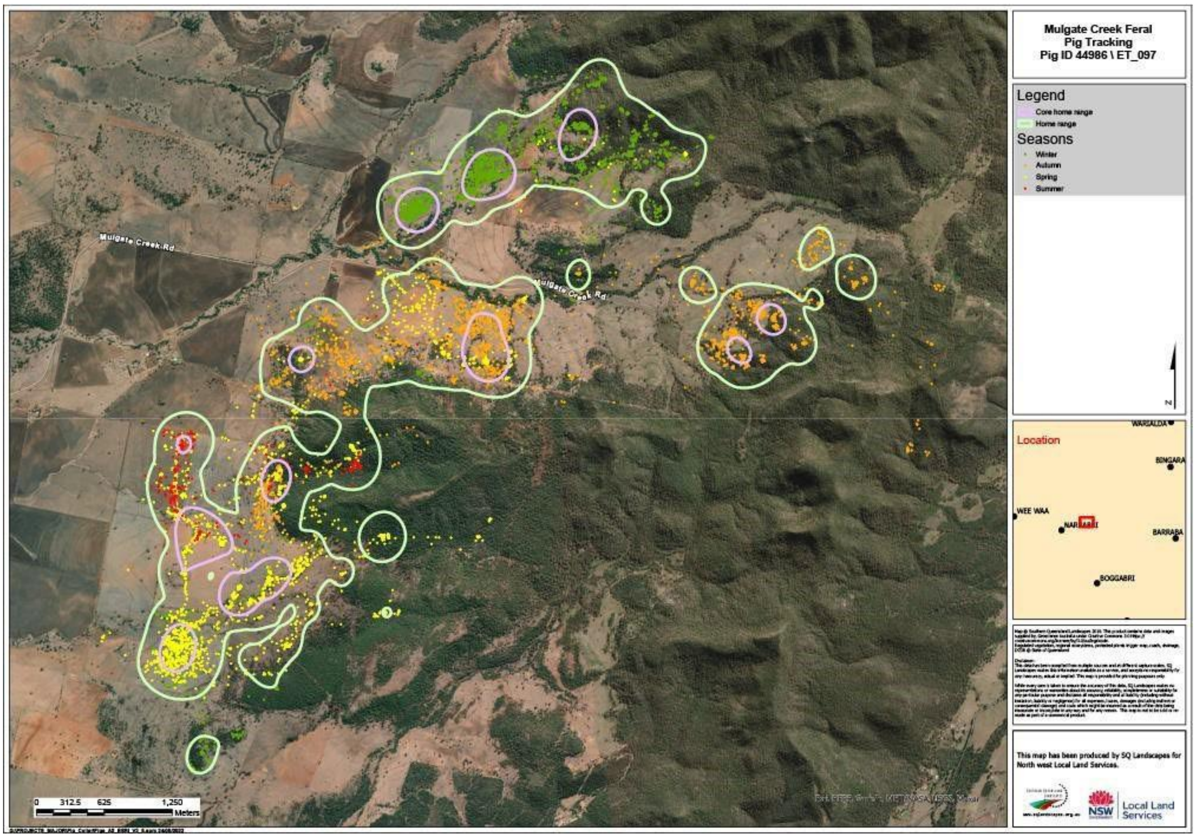

Figure 20: Map depicting the movement data for Pig ID 97

4.9 Activity 9 – Natural Capital & Biodiversity:

Figure 21: Filming with ABC Catalyst team for an episode titled 'The Wildlife Revolution' which aired on 3rd August 2021 at 8:30pm.

Figure 22: New England North West Landcare Conference visitors on Llara discussing biodiversity on farms – August 2019

Figure 23: Photo of Tree Martin, Petrochelidon [formerly Hirundo] nigricans, a partly migratory type of small swallow during a benchmarking bird survey on Llara farm, Narrabri in May 2019. A flock of these was found around the dam at the back of Llara in May.

4.10 Activity 10 – Managed Native Grasslands & Food

Figure 24: Threshing, Discussions & Sharing Food During 3-Day Paddock to Plate Workshop - April 2022

Figure 25: Activities from the Networking Session Demonstration Day. Top Left – Threshing and sorting grain, Top Right – Processing tall oat grass, Bottom Left – Children learning about native grasses, Bottom Right – Learning about native grains at the NDCAS Youth Centre – February 2023