Australia's National
Science Agency

Putting Land Management Knowledge into Practice

Final Project Report

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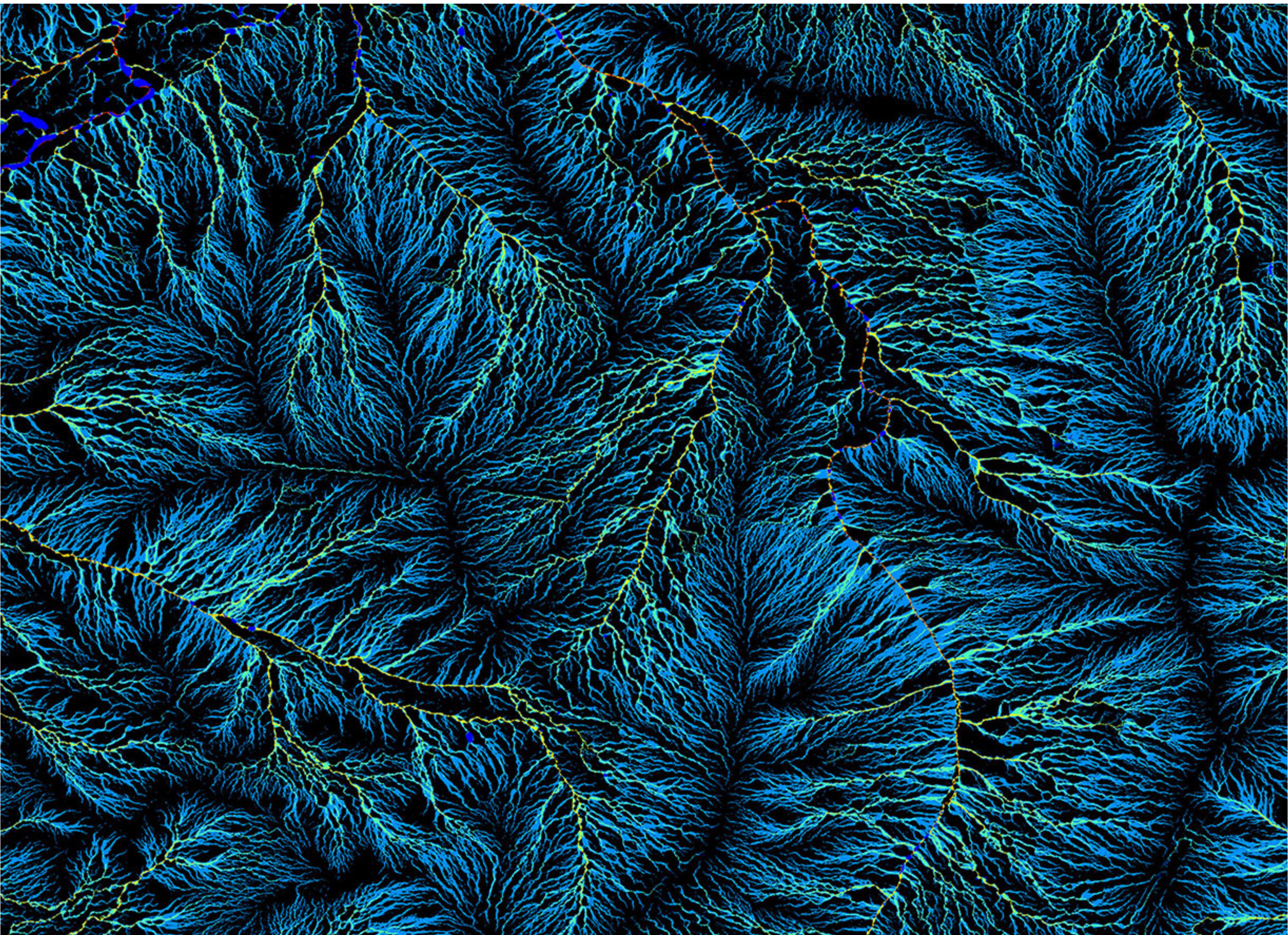
Report to the Gas Industry Social and Environmental Research Alliance



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Contents

Figures

Tables

Acknowledgments

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Executive summary

The Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory provided 135 recommendations to “reduce the identified risks associated with any development of any onshore shale gas industry in the Northern Territory to acceptable levels”. Furthermore, a large amount of research has been undertaken by the Gas Industry Social and Environmental Research Alliance (GISERA) to manage risks arising from onshore gas developments in other areas of Australia. This project sought to see knowledge gained from GISERA’s projects “put into practice” within the Northern Territory, especially in the areas of agricultural land management.

Two main efforts were undertaken within this project:

1. Demonstration of Digital Twins to inform management and design decisions
2. Use of existing research communications tools for stakeholder engagement

The use of digital twins in communicating issues arising on agricultural lands during gas development is well developed and usually involves use of large scale surveys covering many well sites. However, given the size of this project and the remote and distributed nature of the possible gas development, this project evaluated a possible alternate approach using a low cost, smaller scale or localised approach to data capture. A digital twin for a small case study area of 256 km^2 (16km x 16km) was developed to demonstrate its utility for an area undergoing early gas exploration. Whilst the approach used here was successful, technical and logistical issues suggest that the approaches commonly used with larger scale data capture are likely to provide a better product for landholders and gas companies looking to minimise erosion risks.

Great value has been obtained from direct engagement by CSIRO agricultural research staff with community stakeholders in gas developments in other areas within Australia. These are usually undertaken in local events such as agricultural shows, trade events, farmer meetings, or gas company farmer meetings. Technologies such as the digital twins described above have proven valuable in communicating many of the issues. Other communication tools, such as reports, fact sheets, animations, presentations, and online media have also been used in these efforts. The effects of the pandemic made direct engagement difficult and so an alternative approach was investigated to ensure effective information sharing and longer-term impact. The project team has worked with the Northern Territory Cattlemen’s Association (NTCA) and CSIRO communications staff to develop a communications plan which could see CSIRO research communicated through the NTCA’s existing processes for the Northern Territory. A total of 26 topics from nine previous agricultural projects within GISERA were identified as having likely importance for land managers. Furthermore, 11 fact sheets, 5 videos, and 4 presentations were highlighted from existing communication tools available online. Opportunities were considered for GISERA researchers to train and assist NTCA and CSIRO communicators in extending this information to relevant stakeholders in the Northern Territory.

1 Introduction

1.1 Project Background

Much of the following project background is contained in project documentation available at https://gisera.csiro.au/research/agricultural-land-management/putting-land-management-knowledge-into-practice/.

1.1.1 Objective

To assist communities of the Northern Territory to meet recommendations of the *Scientific Inquiry into Hydraulic Fracturing in the Northern Territory* through the provision of high-quality spatial data to farmers, regulators, and the gas industry to:

a) assist their evaluation of design and placement of gas infrastructure options

b) protect surface water and vegetation and reduce erosion, soil damage and dust as required by the recommendations from the NT Hydraulic Fracturing Inquiry

c) create novel communication tools to improve the exchange of data between different individuals and groups.

This project directly addresses the **Recommendations 7.1, 8.13 and 8.14** of the NT Hydraulic Fracturing Inquiry and will also assist with preliminary information for **Recommendations 8.7, 8.8, 8.11 and 8.15.**

1.1.2 Description

The Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory recommended that construction of infrastructure should be guided by best practice, designed specifically for the NT, and minimise possible unacceptable impacts on wet season surface water flows and erosion. Furthermore, the Inquiry also stated that there should be careful large-scale design of all roads and pipelines to avoid issues arising from *ad hoc* or incremental development. A significant body of research has been completed for gas development in Australia (Queensland and South Australia) and overseas with many of these lessons relevant to agricultural lands in the Northern Territory. This project seeks to evaluate this existing knowledge for use in informing decisions by farmers and gas companies in the Northern Territory. There are two main efforts within this project:

1. Demonstration of Digital Twins to inform management and design decisions
2. Use of existing research communications tools for stakeholder engagement

2 Digital twins to inform decisions

2.1 Background

Previous work has shown that a better understanding of landscape processes has helped land managers in agriculture and the gas industry to design gas infrastructure whilst also helping regulators in policy consideration. However, many of these processes, such as hydrology, soil loss and pasture dynamics are difficult to see with the naked eye because they occur over large scales in space or time. The use of digital twins, as developed in previous research projects, has demonstrated its utility for the communication of these processes and potential risks, and lessons on best management practices to mitigate these. By presenting these data within a virtual landscape in which gas development will occur, we make the invisible, visible, and inform better decision making.

CSIRO has used these techniques successfully in communicating issues of environmental risk for farmers and the gas industry in other areas where there have been impacts to soils, pastures and livestock on farms, but also impacts to access tracks, pipelines and well pads, with significant impacts on rehabilitation costs. Furthermore, the techniques have been sought by regulators to assist in policy formulation. The same requirement for information and risk management have been captured in the recommendations of the Northern Territory Hydraulic Fracturing Inquiry and so this capability will be useful for the Northern Territory gas development.

In particular, this project has sought to help land managers and gas developers with methods to

- understand wet season surface water flows so that erosion risks can be managed.
- identify existing farm infrastructure (e.g. farm tracks for re-use) and their existing environmental issues (e.g. existing erosion threats or grazing pressures) to ensure that the design of gas development accounts for these. Research in other gas developments has demonstrated ways for gas development to add value to existing farm operations.
- determine the locations of surface water features (e.g. dams, watering points) whose quality must be maintained (e.g. sediment, spills) and the related catchment areas that need to be considered in infrastructure design.
- determine pasture/land condition across a development area to highlight zones that may be vulnerable to disturbance or highly productive and requiring protection.
- know where cattle graze, camp and move to ensure protection of productive areas, and to manage overlapping pressures from both cattle and gas development.
- prioritise revegetation efforts to protect soil rehabilitation from erosion and livestock to save time and money for both graziers and the gas industry.
- understand variation in soil types and their management requirements across a development (in conjunction with hydrological processes described above).

The project explores the deployment of spatial data through an online service which integrates data layers available within the service with those already owned/operated by the farm enterprise. This platform allows 3D visualisation of the agricultural area, existing infrastructure and the natural processes to be protected. In this project we evaluate the capacity of such a digital twin to demonstrate environmental issues for both agriculture and gas industries using modern techniques.

2.2 Case Study Methodology

The methodology used within this project builds upon efforts already developed, tested and evaluated with landholders in previous work for Coal Seam Gas developments in Queensland. A case study location (Figure 1) was identified during the early stages of the project in collaboration with the Project's Technical Reference Group. The case study includes a range of environmental conditions (soils, vegetation, hydrology) in an area of proposed gas development. The project used the following methodology:

1. Photogrammetry was used to derive high resolution vegetation and soil surface elevation maps for the case study area. Previous GISERA projects have developed ground elevation maps at 20cm resolution over areas > 100,000 km^2. These have been determined to be highly accurate via direct comparison to surveyors' measurements (Huth et al, 2015).
2. High resolution terrain analysis to map large catchment processes and fine-scale water flow paths (<1m resolution) to highlight natural water flow processes and the exact location of likely erosion risks.
3. Long term satellite data (c.30 years) to show spatial variability in land condition (e.g. pasture cover/persistence, tree cover) as indicators of likely areas of fragile or vulnerable soil/vegetation conditions. These were analysed to derive maps of land condition score, a standard within the northern grazing industry (Pettit, 2008).
4. Simple soil characterisation undertaken within the case study area to demonstrate the types of soils within the region and explain some of the risks associated with disturbance within these agricultural regions.
5. Deployment of spatial data through an online service integrating data layers developed within the project. This platform allows 3D visualisation of the agricultural area, existing infrastructure and the processes to be protected.

As stated above, the use of digital twins in communicating issues arising on agricultural lands during gas development is well developed and usually involves large scale surveys covering many well sites on many farm enterprises. However, given the size of this research project and the remote and distributed nature of the possible gas development in the Beetaloo Basin, this project evaluated a possible alternate approach using a low cost, smaller scale or localised approach to data capture. Such an approach could be used in smaller, isolated areas of concentrated gas development. Therefore, a digital twin for a small case study area of just 256 km^2 (16km x 16km) was developed to demonstrate its utility on an area undergoing early gas exploration.

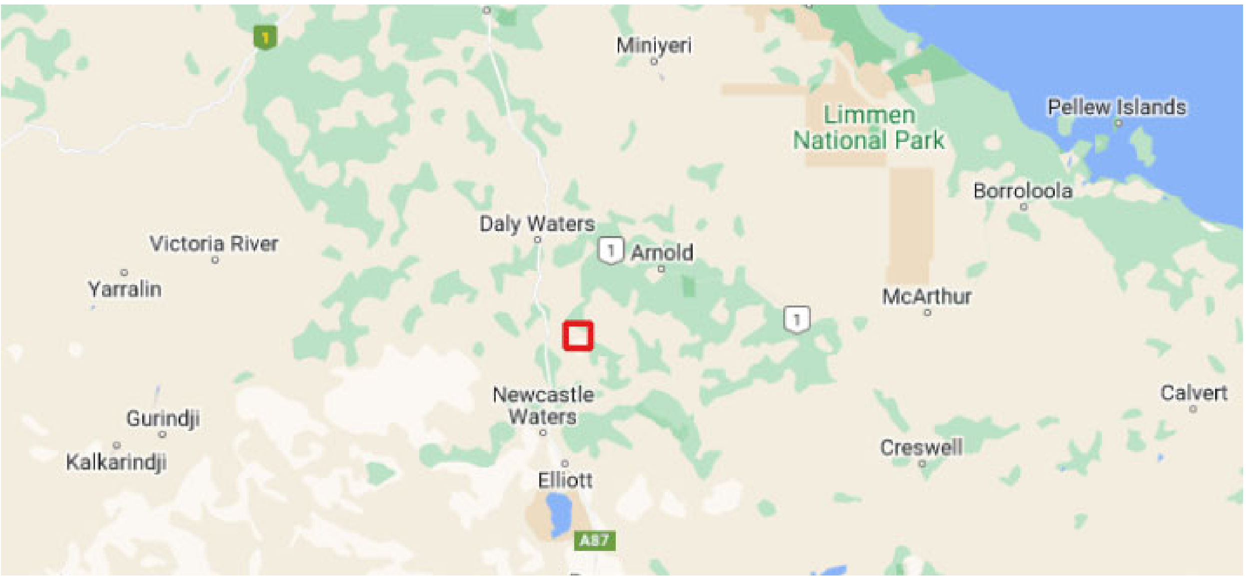

Figure 1 Case study location (Red polygon) chosen for demonstrating the digital twin approach for communicating environmental risks to stakeholders to better inform management decisions.

2.2.1 Photogrammetry

Photogrammetry is a well-established technique for developing three-dimensional models of the ground surface from aerial photography. The approach is illustrated in Figure 2. Basically, within this approach, the location of a ground point is determined by identifying the same point in overlapping photographs so that the location can be is calculated via triangulation.

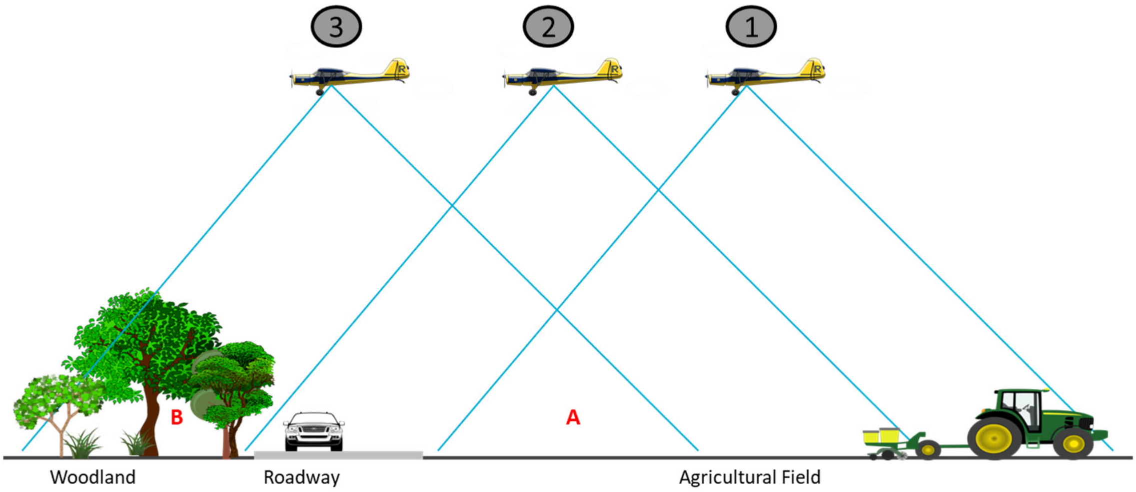

Figure 2 A point "A" in an agricultural field is identified in three overlapping images. If the position of the aircraft is known for locations 1,2 and 3, the position of A can be calculated. Ground surface points within wooded areas (e.g. Point B) may need to be inferred from other nearby visible points if the view is obscured by foliage.

Eight ground control points were selected based on ease of access via farm roadways, freedom from visual obstruction and distribution across the dimensions of the selected case study area.

Figure 3 Example of ground control point. Eight were established across the property prior to aerial photography. Post Processing Kinematic (PPK) units (see photograph) were used at each ground control point to correct location data.

2.2.2 Water Flow Path Predictions

Previous studies into the impacts of access tracks on soil erosion risks during gas development in Queensland have performed aerial surveys of 1300 km^2 between Chinchilla, Miles and Condamine in 2013 and 2015. These surveys have been used to create a 3D model of the soil surface with a spatial resolution of 20 cm. These ground surface models were tested against corresponding ground surface elevation measurements using standard surveying techniques. Water flow path predictions were undertaken on these surfaces to create high resolution water flow maps, which have also been compared to observed water flow paths in both farmland and native forests. Further detail about the methods used here can be found in Huth et al (2015) or from the GISERA web site (https://gisera.csiro.au/project/making-tracks-treading-carefully/).

The same approach was applied to the digital ground elevation model generated for the case study area in this project to provide predictions of water flow paths. Whilst an independent test data set via on-ground survey was not undertaken, ground control points were used in overall surface correction. Colour representations for displaying flow paths and differing sizes of catchment areas were chosen according to previous evaluation with landholders in other gas developments.

2.2.3 Basic Soil Classification

Soils within the case study were classified to put detailed mapping of erosion risks into a landscape context for communication with stakeholders. Surface and landscape analysis conducted across five locations within the study area indicated that the soils were variations of the greater soil group of Kandosols. Kandosols are red, yellow and grey 'massive earths' (ie when disturbed, the soil separates into fragments which can be crushed into ultimate particles). They lack strong texture contrast and generally have a sandy to loamy-surface soil, grading to porous sandy-clay subsoils (clay content that exceeds 15%) with low fertility and poor water-holding capacity. Kandosols are widely distributed across Australia (Figure 4).

Generally, Kandosols have low to moderate cropping potential and therefore are more suited to pastoral land use rather than cropping unless there is access to irrigation and high inputs of chemical fertilisers. Surface soil pH (Raupach soil pH method, Raupach(1954)) was measured at each of the 5 locations and ranged from 6.5 to 7.5. However, where these soils are acidic, they have limited supply of K and P and in the absence of applied fertilizer are best suited to native species.

These soils are highly erodible in the absence of ground cover, pasture grass species and trees. Amelioration of damage from soil disturbance can require long time frames because of the lack of structure and the generally low nutrient status. This is of important because of the ground disturbance that occurs during the development of gas infrastructure.

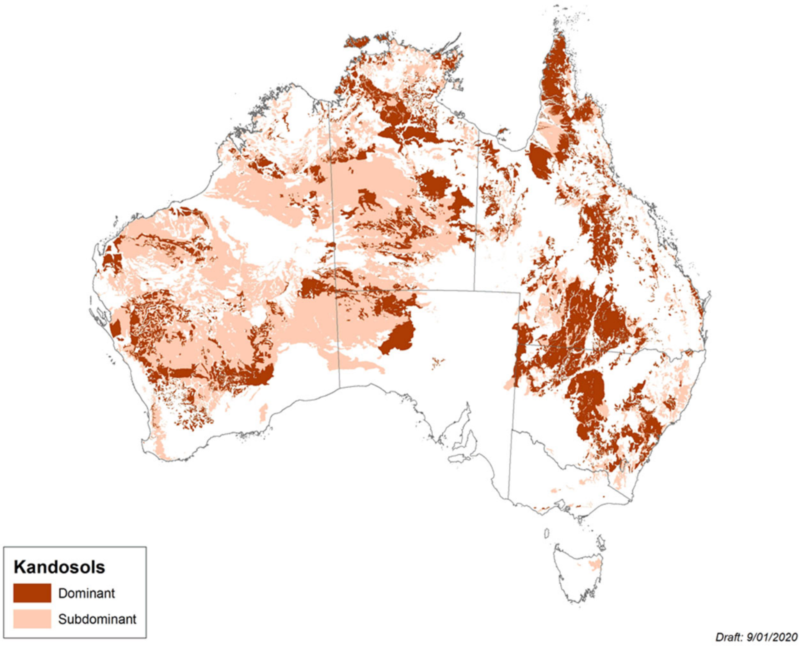

Figure 4 Distribution of Kandosols in Australia. (Source: https://www.soilscienceaustralia.org.au)

a) Red Kandosol

b) Grey Kandosol

Figure 5 Examples of a) Red Kandosol, b) Grey Kandosol and c) erosion gullies forming within an area of Red Kandosol within the case study area.

Figure 6 Erosion gullies forming within an area of Red Kandosol within the case study area.

2.2.4 Land Condition Score

Many biological and physical factors contribute to the productivity and resilience of grazing land. These include cover provided by vegetation and surface litter, weeds or undesirable grass species, soil type and degradation. The science-based Land Condition Framework provides a measure of health for grazing land that considers its capacity to produce useful forage, ability to infiltrate water, and risk level for soil erosion that can assist landholders to understand and manage the physical, biological and chemical elements of soil (Karfs et al, 2009; Pettit, 2008). In determining a land condition score, four major features of the landscape are considered: pasture structure and composition, soil condition, presence of weeds and woodland structure (Pettit, 2008).

On-ground estimates of land condition were undertaken to calibrate model predictions of spatial variation in land condition. Assessments were undertaken using CSIRO's PatchKey software (Abbott & Corfield, 2012) as demonstrated in a previous GISERA project studying the impacts of coal seam gas development on a grazing property in Queensland (Huth et al, 2018). Trends in long term vegetation cover derived from long-term satellite imagery were used to identify sites likely to cover the range in land condition within the case study area. Nine sites were chosen and two transects were sampled at each of these sites.

a) Site 2 b) Site 3

Figure 7 Photographs of ground conditions for sites 2 and 3. In all, nine sites of varying land condition were used in the ground surveys.

Eight calibration quadrats of 1 m^2 were scored as per the methodology within PatchKey, including estimates of plant dry matter. The entire plant biomass was removed from each quadrat after scoring. These samples were dried and mass recorded. These data were used to quantify likely observer bias in biomass estimates and this was used to correct biomass estimates used within the land condition scoring.

Figure 8 Photographs of two calibration quadrats of 1 m^2 used to account for observer bias in estimates of pasture biomass when entered into the Patchkey software.

The Land Condition scoring system provides a simple ABCD framework to score parts of the landscape into meaningful categories. The higher scores for land condition (ie A and B) would exhibit limited erosion processes or risk, good coverage of 3P grasses (ie Palatable, Productive and Perennial), few weeds and limited woody thickening. Lower scores for land condition (ie C and D) would higher levels of erosion and ongoing risk, declining or absent pasture cover, weeds or woody thickening. To demonstrate areas of high erosion risk, areas with lower land condition (ie scores of C or D) were visualised within the digital twin. These scores were based on long term satellite-based estimates of plant cover fraction and change over time to estimate landscape condition of grazed lands, matching condition estimates to ABCD on-ground measures. This approach uses free high resolution Landsat imagery (25m pixel).

2.3 Demonstration of Digital Twin

A digital twin of the case study was developed for use within the web based AgTwin platform (https://agronomeye.com.au/). This platform allows users to navigate a 3-dimensional visualisation of a landscape and overlay various spatial data products to provide insights on agricultural and environmental processes to land managers.

The value of the digital twin to illustrate natural processes and environmental risks is demonstrated using an example location within the Case Study site (Figure 9). At this location, a farm track has been created across an area of degraded surface soil condition. Ground cover within this area is low and, as a result, much of the surface soil has been lost to erosion processes. Gullies have formed and the farm access track cuts through these water flow paths.

An "aerial view" can be simulated within the digital twin, allowing the user to observe the site and the landscape context of key natural processes (Figure 10). The high-resolution imagery used to create the digital twin allows the user to start identifying spatial variation in ground cover or water flow paths and possible erosion processes. However, the photography only provides a single snapshot in time and only allows a qualitative assessment on such natural processes. Many of these processes can occur over extended time periods and involve significant temporal variation (e.g. variation in ground cover). As mentioned earlier, the Land Condition Score is a measure of health for grazing land that considers its capacity to produce useful forage, ability to infiltrate water, and risk level for soil erosion (McIvor, 2012). Therefore, land condition estimates can be visualised within the digital twin (Figure 11) to further inform the observer about such longer-term natural processes and to assist them in interpreting observations within the three-dimensional model of the landscape.

Finally, predictions of water flow paths across the landscape can also be added to identify areas erosion risk where water flows are concentrated, and land condition is low (Figure 12). In these visualisations, colours used to highlight water flow paths provide information on upstream catchment area with each colour change representing a 10-fold increase in the area of water catchment (0.1 ha – 1 ha – 10 ha – 100 ha – 1000 ha).

The data visualisation available within the digital twin provides information that would not be easily determined by direct visual observation within the case study. Such visualisations have proved valuable in previous work with land managers in areas undertaking agriculture or resource development.

Figure 9 Farm access road on a remote property within the Beetaloo Basin, NT. (Note the low ground cover on fragile soils and subsequent formation of erosion gullies on the right-hand side of the road).

Figure 10 Visualisation of the access road and surrounding area shown in the photograph from Figure 9. The orange circle shows the location of the intersection of the farm access road and local water flows shown in the previous figure.

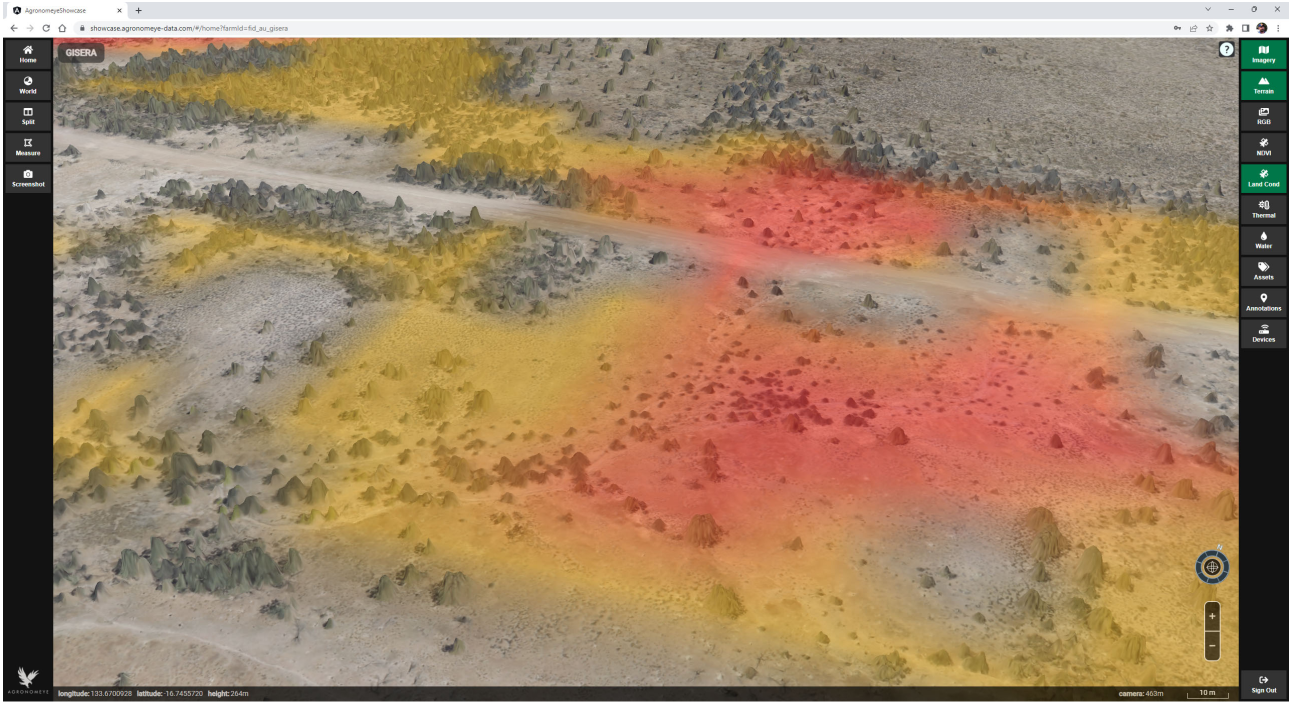

Figure 11 Areas with lower levels of land condition superimposed into digital twin to visualise spatial variation in erosion risk.

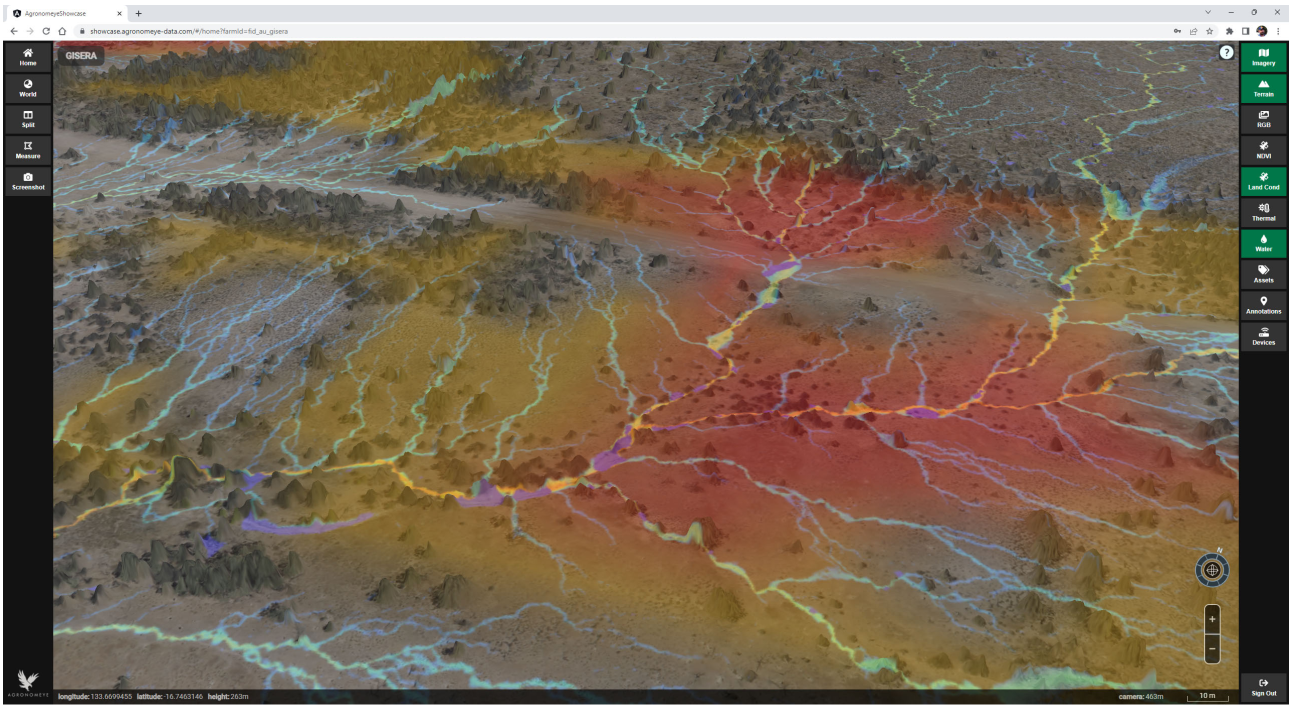

Figure 12 Water flow paths and land condition used to identify areas of highest erosion risk.

2.4 Lessons for broader application in the Northern Territory

The demonstration provided within the project shows the effectiveness of modern digital approaches for identifying and communicating risks within these landscapes. The approaches used to great effect in agricultural areas within Queensland gas developments have proven successful for grazing properties within the Northern Territory. In remote areas, such as the Beetaloo basin, these tools become increasingly important as direct observation of environmental risks can be difficult because of distances involved and decreased access during the wet seasons. The web-based product allows virtual inspection of issues online within an environment that facilitates collaboration between dispersed stakeholders. This not only allows more frequent and effective communication, but also reduces time and costs involved in demonstrating risks between dispersed stakeholders. However, some lessons do arise from the case study within this project.

This project trialled a different approach for data capture to that used in previous studies arising from differences in the nature of the agriculture within the Beetaloo Basin to that of Queensland developments. Application of these technologies within the Surat basin undertook a single larger survey area to cover a large number of farm enterprises. Farms are much larger within the Beetaloo Basin and gas development could be dispersed within these areas. Therefore, a new approach using smaller-scale or localised digital twins was evaluated to explore options for more targeted use within a larger development area.

Issues arising from logistics and data quality suggest that approaches previously used in other gas developments may still provide better outcomes in the Northern Territory. The remote nature of the development areas can provide logistical challenges for airborne surveys, and ground-based efforts required during the survey for maintaining data quality. Whilst these issues can usually be overcome, the possible impact on data quality and the resultant digital twin is evident in the case study with impacts on visualisation of surface water flows (Figure 13). The use of large-scale aerial surveys incorporating higher-quality survey instrumentation will likely provide a better product for agricultural and gas industry stakeholders whilst better managing requirements for ground-based work in remote areas. The benefits arising from an economy of scale may provide comparative costings or cost savings. Many catchment processes occur across larger scales and so data capture and analysis at larger scales would likely provide better information for users of that data. Finally, it is worth noting that the application of spatial analysis and development of landscape digital twins has already been used in studies of areas comparable to the Beetaloo Basin, requiring only a single effort to provide benefits to many users. These all suggest that greater efficiency and quality may be possible using larger scale application of digital twin technology across an entire gas development.

Provision of mapping for estimates of land condition does not require the same considerations given that such products are developed using long term satellite data. In fact, there are opportunities for the use of products which already have a growing community of practice within the region of interest. Whilst the research team has developed and tested approaches developed within CSIRO to enable on-ground verification for the small case study site within this project, we would recommend that products and processes developed locally should be evaluated for use during any gas development within the Beetaloo basin. For example, spatial products for land condition have been developed by the Northern Territory government as part of the rangeland monitoring programs by their Department of Environment, Parks and Water Security (https://depws.nt.gov.au/rangelands/information-and-requests/about-rangelands-monitoring). These data should be investigated for broader application within the digital twin technologies demonstrated within this project. Furthermore, a community of practice has been developed locally, with publications explaining land condition scoring within the context of the local landscapes (e.g. Pettit, 2008). Such use of local knowledge and data services should be encouraged.

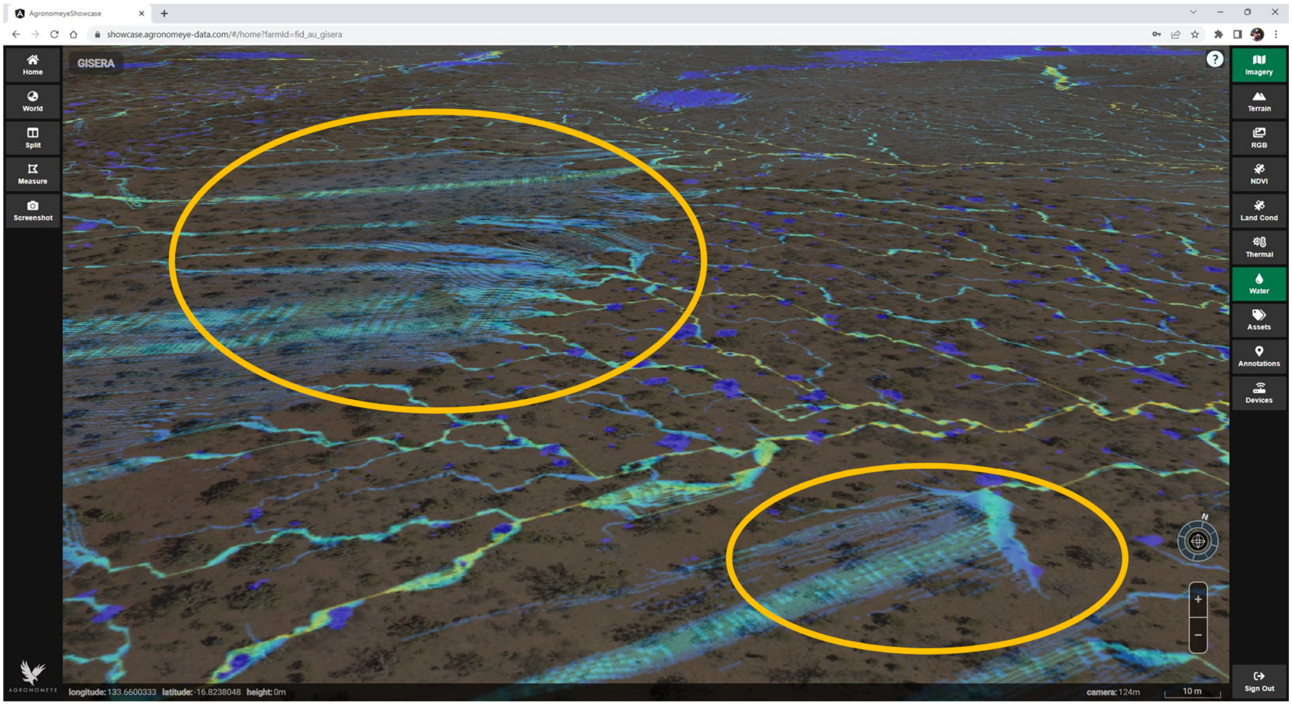

Figure 13 Artificial patterns in water flow path predictions arising from errors in aerial survey data within the case study. In these areas, water flow paths show unnatural features such as large diffuse flow areas with geometric patterns (e.g. smooth curves or hatching). Examples of such are evident within the highlighted areas (orange circles).

Interest in the use of digital twins for communicating and managing environmental risks was received from various stakeholder groups during demonstrations within this project. The project has evaluated and demonstrated methods for the technical elements involved in providing such a service. Subsequent discussions have commenced on the possible methods for resourcing and providing access to such systems. This will require collaboration between government, resource developers and agricultural stakeholders. The current study suggests that large-scale areal surveys would be most suitable, requiring relatively large up-front investment. However, the long term benefits from managing environmental risks may support such an investment.

3 Community Engagement

3.1 Engagement with key agricultural stakeholders

The original project plan included engagement processes similar to those used extensively in agricultural communities in Queensland during coal seam gas development. These were to include involvement of CSIRO staff at relevant industry or community events such as field days, rural shows or trade fairs where one on one conversations would allow community members to explore research topics with researchers directly. These have proven useful in reaching many stakeholder groups. In Queensland, for example, researchers have been able to engage with local, state and federal politicians, agribusiness, academics, farmers, concerned citizens and other researchers at a single rural agricultural show (Huth et al, 2016). Such activities were not possible during the pandemic and so an alternative approach was developed to investigate options for effective information sharing and longer-term impact. The Northern Territory Cattlemen's Association (NTCA) has been funded by the Northern Territory Government to provide ongoing extension work to pastoralists across the Northern Territory. The project team has therefore worked with the NTCA and CSIRO communications staff to develop a communications plan which could see CSIRO research communicated through the NTCA's existing processes for the Northern Territory. Such a plan would likely be more effective in dealing with stakeholders across large distances and remote locations as found in the Northern Territory.

3.2 Evaluation of existing communications tools

The project leader met with key NTCA staff to consider the information needs of agricultural, government and gas industry stakeholders. Over a period of two days, information and messages from existing GISERA research were explored in detail. Forty-nine messages/concepts documented within a wide range of research outputs (e.g. videos, fact sheets, reports, presentations) developed from the 10 projects within the Agricultural Land Management portfolio were tabled for discussion after review of the material by the project leader. These were discussed with, and evaluated by, NTCA staff for relevance to the Northern Territory. Approximately half of these were chosen as relevant and prioritised for further communication work. Existing communication pieces, currently available online, were evaluated for use as rapid path for information transfer. Twelve fact sheets, five videos, and four presentations were selected as useful for extension work by the NTCA. These included communications pieces developed within other GISERA research portfolios, including general information on gas development, community perceptions and wellbeing. Processes for CSIRO to assist NTCA extension staff in understanding and communicating existing research outcomes were developed. The role of CSIRO communications and research staff in this process was explored.

A follow up meeting with NTCA, CSIRO and our collaborators was planned but was again not possible due to impacts of the pandemic on the wellbeing of people involved. Online sessions were therefore used to further develop ideas for the communication process. These discussions involved NTCA and CSIRO research and communications staff. Discussions found that CSIRO research staff could use several methods to assist NTCA staff in understanding and communicating the existing communications materials. This could involve online Q&A sessions between researchers and communicators, and further annotation of fact sheets and reports for added clarity where required. The advantage of involvement of CSIRO staff in branch meetings and extension activities was discussed, noting possible logistical problems for remote locations. Empowering of local operatives was therefore deemed more important. Opportunities may exist for NTCA stakeholders to attend CSIRO events in the Northern Territory.

Table 1 List of topics from previous GISERA projects

Project 1 – A Shared Space (Qld)

- Impacts of Dust, Light, and Noise on farms, farm households and farm businesses
- Impacts of gas development on Mental Health of farm families
- The importance of Place Identity for Australian farmers
- Farmers dealing with multiple companies during development
- Managing costs of time commitments during gas development

Project 2 – Preserving Agricultural Productivity (Qld)

- Methods used in mapping of spatial and economic footprints

Project 3 – Gas Farm Design (Qld)

- Costs of gas development on farms (impacts on machinery, crops, soils)
- Costs of gas development arising from impacts on timeliness of farm operations
- Recommendations for farmers – list of important things to consider

Project 4 – Making Tracks (Qld)

- The magnitude of erosion risk from unsealed rural roads
- Photogrammetry and methods for mapping surface water flow paths
- The important role for visualisation in communication erosion risks
- Methods for improved road placement to manage erosion risks

Project 6 – Telling the Story (Qld)

- Changes to water flows observed during gas development
- Helping others to understand how farmers see their farm
- The differing communications needs of different community groups
- Helping people to engage with information on their own terms
- Visual aids help to stakeholders interpret and process the problem

Project 7 – Inside the Herd (Qld)

- Mapping of livestock movements within a gas development

- Water flow path predictions for a case study grazing property
- Vehicle Movements on a gas development and dust emissions
- Increased risk of soil damage from combined impacts of cattle and gas infrastructure
- Footprint of various gas infrastructure on a grazing property

Project 8 – Gas Impacts and Opportunities on Agriculture (SA)

- The diversity of views within a rural community and the need to hear different voices

Project 9 – Perspectives on risks to local markets (SA)

- The value of regional branding in customer purchasing decisions
- Risks pathways for regional brands during gas development

Table 2 List of relevant communications items identified as highly relevant in existing GISERA on-line material (https://gisera.csiro.au/research/)

Fact Sheets

- Cattle, pastures and coal seam gas – a case study (4pp)
- Access Tracks and Soil Erosion
- Understanding the way farmers see their farm
- Soil Compaction
- Putting land management knowledge into practice in the Northern Territory
- Impact of Gas on Regional Brands (TBC)
- Local attitudes and perceptions of CSG development: 2014 – 2018
- Community wellbeing and local attitudes to conventional gas development in south east South Australia
- Community resilience and adapting during CSG development: 2014 -2018
- Decommissioning coal seam gas wells
- Attitudes to Coal Seam Gas development in the Narrabri Shire of New South Wales

Videos

- Predicting water flow
- Shale Gas
- Telling the story
- Inside the herd
- Looking to the Future: Job forecasts for the Surat Basin 2014 to 2034

Presentations

- CSIRO 2016 Community Wellbeing and Responding to Change
- Economic and socioeconomic impacts of CSG development
- Opportunities for agricultural communities
- Decommissioning CSG wells

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