Department of Primary Industries
Department of Regional NSW

Primary Industries Climate Change Research Strategy

Findings and recommendations

Energy

Carbon Opportunities

Climate Resilience

NSW GOVERNMENT

Contents

Acknowledgement of Country

The Department of Primary Industries acknowledges that it stands on Country which always was and always will be Aboriginal land. We acknowledge the Traditional Custodians of the land and waters, the knowledge and wisdom they hold in managing the landscape, and we show our respect for Elders past and present.

Foreword

Farmers have always adapted to changing circumstances to ensure their businesses can continue to be productive and sustainable. NSW Department of Primary Industries has always supported them in this.

In 1890, when the NSW Department of Agriculture was first established, it was stated:

"The welfare of this country being intimately bound up with the prosperity of agriculture, it is of paramount importance that the Government should be well informed and advised as to all matter affecting the general interest of the community, so as to be prepared to take action... Steps will be taken to lay the best procurable advice before the farming community - advice dictated by scientific investigation combined with practical experiments."

With this legacy of providing the best available, science-driven advice to farmers, we launched the Primary Industries Climate Change Research Strategy in late 2018.

The strategy has three targeted areas of focus: energy, sequestration, and emissions reduction and climate resilience.

We defined these focus areas to ensure our research met the needs of NSW producers. As various projects were undertaken as part of this Strategy, we have remained cognisant of the background of constant policy and technological change, and this has been incorporated into the body of work.

Since the Strategy was first launched, our understanding of climate change and its impacts on primary industries has changed. Producers are already embracing a range of climate friendly technologies in efforts to make their businesses resilient and able to reach new markets.

Across various industries and regions, we have seen improved management practices for livestock, crops and pastures as well as new infrastructure such as protected cropping structures and digital technology.

Meanwhile, energy use on farm continues to change as energy prices rise and renewable alternatives become available and affordable.

Market dynamics are also shifting, with a growth in carbon markets and consumers increasingly seeking lower embodied emissions in agricultural products.

The completion of the Primary Industries Climate Change Research Strategy has helped us fill knowledge and practice gaps.

The research will support innovation in farm technology, help open doors to complex carbon markets, promote options for emissions reduction, and most significantly, it will ensure government and industry have the best available research on which to base their climate-related policy and investment decisions.

Scott Hansen
Director General
NSW Department of Primary Industries

Introduction

The Primary Industries Climate Change Research Strategy was designed to help answer critical questions for primary industries in the drive to reduce emissions, sequester carbon, address rising energy costs and increase resilience to climate.

At the beginning of the strategy we knew that the challenges of a changing climate, energy security and energy affordability were becoming increasingly critical issues for primary industries.

Whether it's for pumping water for irrigation, fuelling tractors and boats, or refrigerating packing sheds; energy is a fundamental input to the primary industries sector.

Over the course of the strategy these pressures have only increased.

Added to these are the pressures of considering greenhouse gas emissions and sequestration opportunities and operating in a more variable climate as the impacts of climate change are felt. Farmers have never faced more complex environmental and business conditions.

Through the strategy, we also found that there are real opportunities for all primary industries sectors from climate change.

The changing climate can allow new industries to establish and existing industries to expand into new areas of NSW while potentially contracting in others.

Recent policy responses have created opportunities for the sector to participate in new markets in carbon sequestration, energy production and storage.

The Primary Industries Climate Change Research Strategy had 3 themes which reflect the main concerns on-farm:

- Energy: including energy efficiency, renewable energy, diesel alternatives and opportunities for farm biomass to be used for energy and on farm co-benefits (such as biodiversity and shelter);
- Carbon Opportunities: identifying sequestration and emissions reduction options and improved access to carbon markets, and
- Climate Resilience: assessing the vulnerability of economically important commodities and biosecurity risks, exploring current adaptation actions being taken by producers and investigating the role of near real-time data in on-farm decision making in light of a changing climate.

All main findings and recommendations will be presented in the following pages.

CCRS key statistics

3,400 FARMERS ENGAGED ACROSS 7 PROJECTS

34 RESEARCH REPORTS SUPPORTING INNOVATION AND REMOVAL OF BARRIERS

20 PILOT PROJECTS WITH VIDEO CASE STUDIES

19 FARMER STORIES OF CLIMATE ADAPTATION & RESILIENCE

100+ WEB PAGES OF INFORMATION & VIDEOS

290k READERS OF ARTICLES IN 'THE CONVERSATION'

65k MAPS HELPING INDUSTRY INTERPRET CLIMATE IMPACTS

6,000 MODELS RUN PROJECTING EMISSIONS OUTCOMES

Energy Efficiency Solutions & Clean Energy Solutions

Introduction

Energy is a crucial input into all farming systems.

Farmers are now subject to increasing and volatile energy costs, eroding their profitability and competitiveness in national and international markets.

Australian farmers are also highly dependent on diesel with more than 80% of energy consumed on-farm coming from diesel (**see Figure 1**).

This leaves farmers highly exposed to the volatility of the global oil price, and potential supply interruptions with 90% of Australian diesel supplies imported.

Similarly, the electricity grid in some rural and regional areas (especially for farmers at the fringe of the grid) can be unreliable or non-existent in remote areas.

If carbon border tariffs on agricultural products are introduced in countries to which Australian farmers export, as appears possible in the future, Australian products will become less competitive relative to lower carbon products.

These factors - energy costs, security of energy supplies and sustainability - are major drivers for farmers to improve energy efficiency and adopt renewable and low carbon energy solutions in their operations.

The Clean Energy and Energy Efficiency Solutions projects are sister projects which work together because farmers consider energy supply and efficiency options together rather than separately.

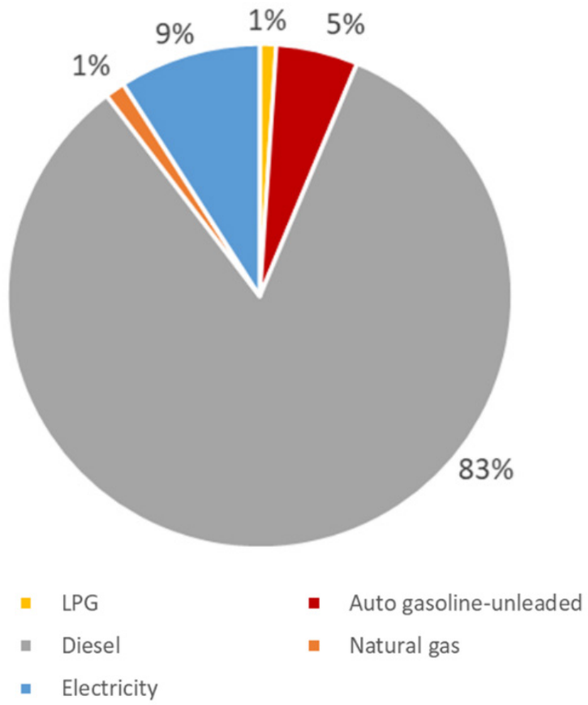


Figure 1: *Energy consumption in Australian primary industries (% of gigajoule).*

The projects explored opportunities for farmers to improve energy efficiency and deploy on-farm renewables and low carbon energy sources to respond to on-farm energy issues.

Activities and findings

Overview

The Clean Energy and Energy Efficiency Solutions projects found that adopting energy efficient practices and equipment, and replacing fossil fuels with renewable energy generated on-site and/or low carbon fuels can improve the profitability and competitiveness of farming businesses.

The specific benefits of this approach include:

- Lower energy costs and less exposure to energy price rises
- Reduced risk of energy supply interruptions
- Smaller carbon footprint.

Depending on the particular operation and solution adopted, examples of other possible co-benefits include:

- Reduced labour costs
- Avoidance of diesel engine maintenance costs
- Automation of electrified equipment
- Utilisation of waste to produce bioenergy
- Avoidance of product spoilage due to interruptions in refrigeration energy supply
- Better animal welfare and staff safety resulting from more reliable energy supply
- Improved sustainability credentials and social licence to operate.

The Clean Energy and Energy Efficiency Solutions projects conducted a significant number of research, demonstration and extension activities to identify and reduce barriers to the adoption of innovative, implementable energy solutions and delivered information to increase energy awareness and literacy across the agriculture sector in NSW.

On-farm energy pilots

Seven pilot projects at eight farms across NSW demonstrated innovative technologies and practices to improve on-farm energy efficiency, energy security and productivity and to reduce on-farm energy use, costs and emissions. Technological solutions demonstrated in the pilot projects include:

- solar thermal chilled water storage and control systems for milk cooling;
- electrification of irrigation pumps powered by a solar photo voltaic tracking system raised above the ground to enable livestock grazing in the same location;
- solar photovoltaic and battery storage systems;
- electrification of LPG and diesel fuelled equipment; and, peer to peer energy trading.

The pilots have enabled the communication of case study information to the sector more broadly thus reducing risks associated with the early adoption of innovative energy technologies in agriculture.

MORE INFO:
Scan the QR code or click here

Left: Agrivoltaics – allow the simultaneous use of land for both solar PV power generation and agriculture. In this case the PV panels have been raised and the frames structurally reinforced to allow grazing of cattle in the same paddock as the panels.

Right: Solar powered electric irrigation pumps – electrification provides greater control of the irrigation system, with it being able to be turned on and off using an app on the farmer's phone. Transitioning from diesel to electric irrigation pumps has resulted in significant energy, labour and maintenance cost savings for this farm.

Activities and findings

The H2Cuts trailer

A renewably powered mobile barber shop themed as a shearing shed offered free haircuts at field days and other events. The H2Cuts trailer is a novel way of starting conversations with people in the agriculture sector about pathways to reduce energy costs and move towards low or zero emissions energy sources.

The trailer demonstrates hydrogen fuel cell, solar panels and lithium ion battery storage technologies and also provides information about energy efficiency measures.

Exploring Beyond Diesel webinars

This series of free online forums featured Australian and international experts discussing evolving alternatives to fossil diesel in the agriculture sector, particularly for hard to electrify applications such as heavy vehicles and heavy mobile machinery.

A consistent message from the webinars has been that while electrification options are likely to become more viable in the future, the existing fleet of heavy mobile machines and vehicles and many of the heavy mobile machines and vehicles that will be added to the fleet in the foreseeable future, will continue to include internal combustion engines in their design.

It seems likely decarbonisation of these heavy applications will occur in the shorter term by replacing fossil diesel with low carbon fuels such as renewable diesel.

In the longer term, emerging electrification technologies such as hydrogen fuel cells and batteries, depending on developments in their chemistry and the functionality of exchange systems, are likely to become increasingly common, displacing internal combustion engines to an extent.

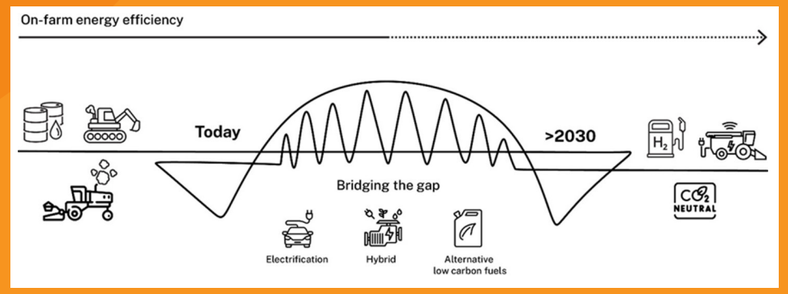


Figure 2: *Energy transition in agriculture*

__Left:__ Energy Smart Farming community of practice logo. __Right:__ The H2Cuts Trailer in action.

Energy Smart Farming community of practice

This portal is a collaboration between NSW DPI and Agriculture Victoria providing farmers, service providers and anyone living on the land with information about practice change and efficient and renewable energy technologies to improve farm energy productivity and resilience.

MORE INFO:
Scan the QR code or click here

Other resources

Research reports prepared by industry experts covering topics such as diesel use in NSW agriculture and emerging alternatives, and a technical and commercial analysis of scenarios for trading renewable energy generated on farms can be found here:

NSW DPI also engaged in collaborations with the agriculture industry and technical experts to examine issues of reliability in sourcing electricity from the distribution grid and cost-effective opportunities to improve energy security by investing in on-farm energy solutions.

MORE INFO:
Scan the QR code or click here

Recommendations

To cost-effectively improve on-farm energy efficiency and transition to renewable and low carbon energy sources it is recommended the following steps are followed:

1. Understand current on-farm energy use

- Undertake an energy assessment to identify the types of energy used on farm and which activities are high energy users. Consider installing an energy monitoring system or engaging an energy auditor.
- Estimate the annual cost, reliability and emissions intensity of each energy source used on farm.
- Review the energy efficiency of current practices and plant/equipment.

2. Optimise on-farm energy use

- Focus efforts on activities that are higher energy users or critical to operations. Activities that involve heating, cooling, pumping water or mobilising heavy machinery are typically high energy users.
- Learn about the components of your energy bill and negotiate a better rate. Consider GreenPower and renewable power purchase agreement options to reduce the emissions intensity of electricity supplied by a retailer.
- Shift energy use, where possible, to a time of day that takes advantage of off-peak electricity tariffs, reduces peak demand charges and/or maximises self-consumption of energy generated on-site.
- Implement more energy efficient practices for use of farm plant and equipment.
- Develop a plan to replace inefficient plant and equipment with more efficient options at end of life.

3. Consider renewable energy

- Evaluate the feasibility of electrifying light vehicles and stationary equipment and powering them with renewable energy or utilising emerging low carbon fuels such as renewable diesel for hard to electrify applications such as heavy vehicles and heavy mobile machinery.
- Generate renewable energy on farm to reduce operating costs and emissions and improve energy security. Solar PV is typically the most cost-effective form of on-farm generation, but other forms of generation such as small-scale wind, hydro and bioenergy may be suitable depending on the situation.

NEXT STEPS

NSW DPI is a founding member of the NSW Decarbonisation Hub https://www.decarbhub.au/ The Hub supports, accelerates, and attracts investment in decarbonisation technologies and services in NSW. Future energy work will be conducted in collaboration with other partners in the Hub.

This work will include Beyond Fossil Diesel project, which will utilise NSW DPI's H2Cuts trailer as well as a new hybrid diesel/electric tow vehicle fuelled with renewable diesel to demonstrate partial electrification, emerging low carbon fuels, hydrogen fuel cell, solar PV and lithium ion battery technologies at field days and a series of community symposiums.

Biomass for Bioenergy

Introduction

‘Sustainable biomass use presents a great opportunity for dispatchable electricity generation in NSW’

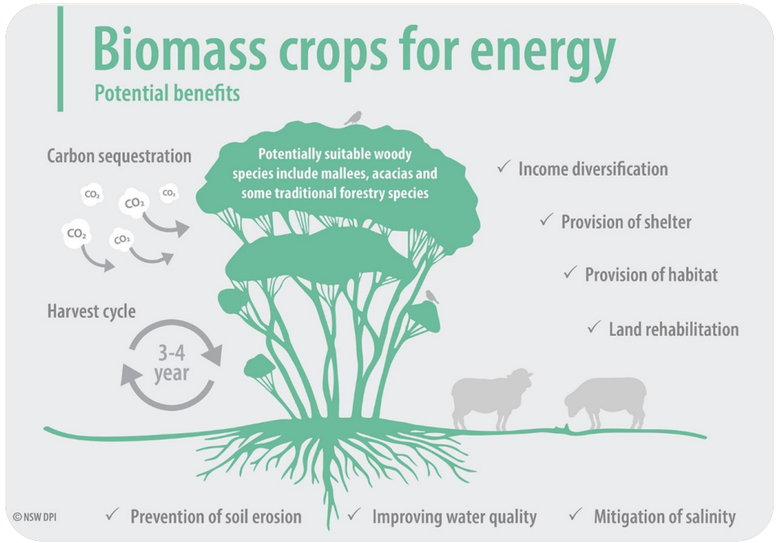
Biomass is a renewable and storable feedstock that can be used for electricity generation as dispatchable power, creating grid stability that allows for the expansion of intermittent renewables (solar and wind) without the need for expensive storage solutions such as batteries.

Bioenergy can play an important role in supporting the transition of the NSW electricity grid to a low-carbon energy system needed to meet net zero targets. The Biomass for Bioenergy project investigated opportunities to increase the amount of sustainable biomass used in NSW electricity generation. The purpose of the project was to identify available and potential feedstocks for bioenergy generation and develop an understanding of techno-economic options and social constraints.

This project was carried out in collaboration with the University of Newcastle, University of Sydney, University of Technology (UTS) and CSIRO.

Objectives:

1. Identifying and testing the suitability of growing and coppicing native woody crops in 3-4 year short-rotation cycles across NSW;
2. Conducting techno-economic assessments on using biomass for electricity generation, including co-generation with coal, stand-alone biomass power stations and hybrid solar-biomass plants with a focus on regional energy generation;
3. Investigating optimal material handling for the transport and storage of biomass, as well as trials to determine mass loss, greenhouse gas emissions and self-heating characteristics of different feedstocks while in storage;
4. Analysing the emissions reduction potential of bioenergy in NSW, considering biomass supply, alternative bioenergy technologies and integration within current energy systems;
5. Understanding community perceptions of bioenergy through community engagement and social impact assessments in selected regions.



Activities and findings

Native woody crop trials

These trials determined the feasibility of growing native woody biomass for use as a range of bioproducts in NSW. Potentially suitable native tree species were identified in partnership with CSIRO and trials were established as 12 locations across NSW. 60,000+ trees were planted in collaboration with DPI research stations, farmers and mining companies. This included mallees, acacias and some traditional eucalypt forestry species.

The trials were designed to assess biomass productivity, carbon sequestration potential and the long-term capacity of these species to coppice (natural regrowth after being cut down) following harvest.

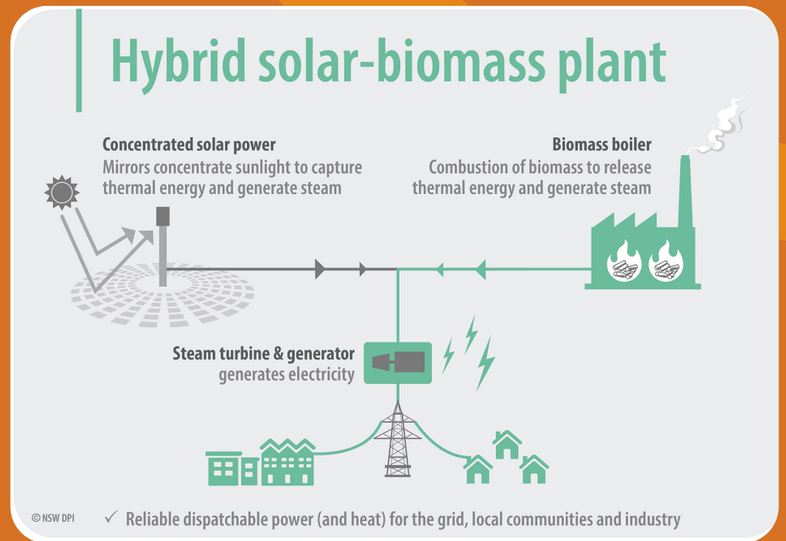
Soil samples were collected from selected sites to determine the impact of trees (particularly acacias) on soil nutrient levels.

The trials have shown that there are several native woody species suitable for growing as short-rotation crops in various parts of NSW. A detailed analysis of the findings will be reported in late 2023.

Use of sustainably derived biomass, such as from dedicated plantings, will result in lower emissions, greater energy security and promote economic growth in regional areas. The trials have attracted significant interest, with a number of companies considering the establishment of large areas of short-rotation woody crops in less productive land.

Techno-economic assessments

NSW DPI and the UTS investigated the potential for hybridised biomass and concentrated solar power (CSP) power stations in regional NSW.



The study identified several locations that are suitable because they have both reliable solar radiation as well as large biomass volumes that could support a hybrid design. A case study in the Griffith region demonstrated the feasibility of establishing a 30 MW hybrid biomass and CSP power station which would be capable of generating electricity at a lower price than a CSP system alone.

Work in collaboration with an abattoir in Northern NSW highlighted the flexibility of application of the technology. Overall, four peer-reviewed papers have been published as a result of this work.

NSW DPI worked with Future Metrics to develop techno-economic assessments of biomass co-firing with coal and stand-alone biomass power stations.

The work demonstrated that there are no technical impediments for biomass co-firing in coal-fired power stations in NSW, with costs of generation comparable to those from similar systems overseas. In addition, several feasible NSW locations for electricity generation from stand-alone biomass power stations were identified.

Material handling

NSW DPI and the University of Newcastle investigated biomass handling systems, involving different biomass types and sizes such as loose cut straw versus baled straw and various transport options.

The density and compaction of these materials was tested to determine optimal methods and costs for handling biomass material. Biomass storage scenarios were trialled to determine mass loss, greenhouse gas emissions and the self-heating characteristics of different feedstocks following varying storage periods.

Integration of bioenergy into the electricity grid

Research developed in partnership with the University of Sydney, identified the contribution that biomass can make towards a 100% renewable grid in Australia, which is required to achieve long-term emissions reduction targets. The work demonstrated that biomass has an important function in firming up

Activities and findings

electricity supply, especially in times when generation from other renewables such as solar and wind are reduced.

Biomass was shown to be highly competitive when compared to other dispatchable energy sources. Several papers have been published.

NSW Biomass Assessment Tool

NSW BioSMART (Biomass Spatial and Modular Assessment of Resources Tool) was designed in partnership with CSIRO to allow users to determine the potential for using biomass in NSW for a range of applications. In addition to a variety of existing biomass sources, the tool also allows users to identify potentially suitable lands where woody biomass crops could be planted to provide a new source of biomass material.

The user can select regions of interest and the tool will display potentially available biomass volumes and calculate optimal transport routes to processing facilities.

The tool includes electricity generation options using the selected biomass and estimates the resulting greenhouse gas emissions. Future versions of the tool will include other pathways for biomass use such as liquid biofuels and biochar.

NSW BioSMART delivers a platform enabling users to understand where existing biomass is or where it could be planted across NSW to underpin a sustainable biomass supply for the bioenergy and broader bioproduct sector.

Community perceptions

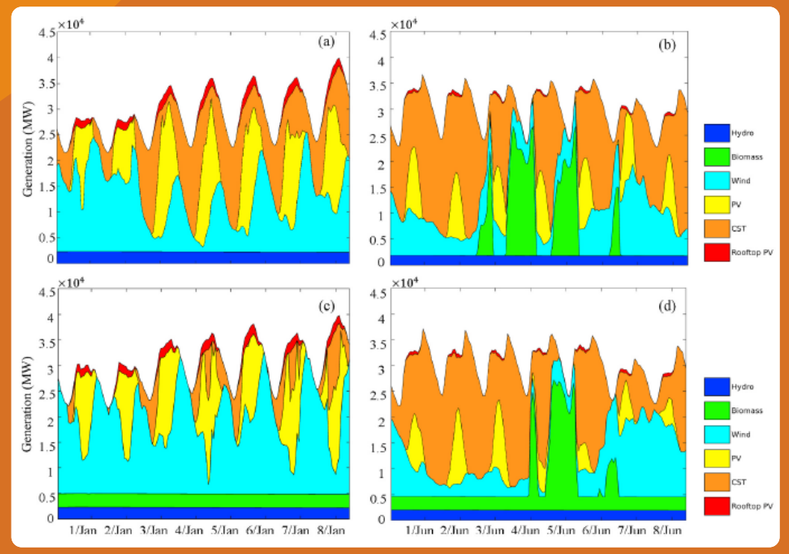
Community understanding and perception of bioenergy is an important factor in the successful uptake of biomass for bioenergy.

The team worked with the UTS to investigate community perceptions through case studies in three regional locations and one in Sydney.

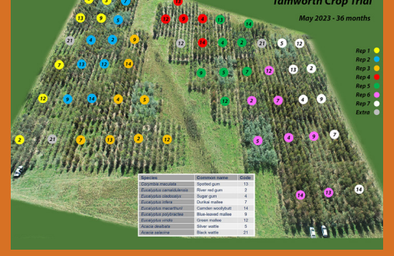
These case studies involved direct community engagement through forums. In those forums, participants were presented with technical information about biomass and bioenergy, followed by an outline of potential future projects.

Feedback from the forums was used to identify region-specific challenges associated with potential projects.

This information will help guide future bioenergy project proponents when engaging with communities in those regions.



Above: *Role of biomass and CSP in a 100% renewable electricity supply in Australia.*
Below: *Photos taken of the biomass tree crop trials*



Impacts

The key deliverables of this project were:

- Field-based estimates of productivity and carbon sequestration of native woody crops managed on short-rotation cycles for bioenergy use for various regions of NSW;
- Demonstrated feasibility of the use of biomass for grid-scale electricity generation; and
- A biomass assessment tool that identifies biomass residues and estimates bioenergy generation potential across NSW, considering both existing mapped biomass residues from agriculture, forestry, horticulture and solid organic urban waste and new potential biomass sources in the form of short-rotation native woody crops.

This project has already delivered positive impacts around industry adoption (e.g. biomass crop establishment) and more broadly raising awareness around the benefits of using biomass as a renewable and sustainable energy source.

The key benefits of this project include:

- A clear demonstration of the diversification opportunities for landholders across NSW with biomass production from energy crops and associated co-benefits such as carbon sequestration, soil improvement and greater biodiversity;
- Identification of hot spots for grid-scale electricity generation from biomass in NSW; and
- Provision of robust information to inform policy development in NSW, assisting with climate, energy and socio-economic goals.

RECOMMENDATIONS:

- Biomass to be more actively considered in discussions around renewable energy pathways for NSW;
- Active consideration be given to the establishment of short-rotation woody crops on marginal, less productive land to support a growing bioeconomy in NSW.

Li M, Lenzen M, Yousefzadeh M and Ximenes F. (2020) The roles of biomass and CSP in a 100% renewable electricity supply in Australia, Biomass for Bioenergy, 143: 105802

Next steps

There are several new projects coming as a result of the positive impact of this project and they include:

- Integrating short-rotation woody crops in farming systems;
- Demonstrating rapid assessment methods to estimate biomass in woody biomass crops;
- Updating the biomass assessment tool – NSW BioSMART;
- Updating existing NSW mapped biomass residues and assessing other resources for a range of primary industries;
- Developing a screening methodology to identify the bioproduct potential of important feedstock types in NSW; and
- Unlocking the potential for liquid biofuel production in NSW for hard to decarbonise sectors.

MORE INFO:
Scan the QR code or click here

Emissions Reduction Pathways

Introduction

Investigating the costs and opportunities of different emissions reduction strategies in agriculture

Agriculture contributes around 15% of NSW emissions (excluding fuel use on farm and emissions from land clearing).

Livestock are responsible for over 80% of these emissions, with enteric methane (CH_4) from sheep and cattle digestion being the largest source.

Other sources include methane from manure management, and nitrous oxide (N_2O) emitted from soil (from nitrogen fertiliser and legumes).

There is substantial potential to reduce agriculture's emissions through the implementation of a range of strategies.

Furthermore, the agriculture sector has potential to sequester carbon through vegetation and soil management and the use of biochar. This could counterbalance the sectors' emissions and potentially offset hard-to-abate residual emissions from other sectors such as transport and industry.

This project aimed to identify effective strategies for emissions reduction and carbon sequestration, that are compatible with productive and profitable agriculture.

It identified technically feasible options, considered their economic feasibility, and identified barriers to adoption. It aimed to quantify the abatement potential from realistic rates of adoption and determine the potential to contribute to the NSW target of net zero GHG emissions by 2050.

Definitions:

Biochar: stable, carbon-rich material produced by heating biomass in an oxygen-limited environment. When used as a soil amendment, biochar can improve soil functions and reduce GHG emissions. Biochar carbon persists for hundreds to thousands of years in soil.

Methane: a relatively-short lived but potent greenhouse gas (GHG). Enteric methane is methane produced by the digestive processes of ruminant livestock – sheep, goats and cattle.

3-NOP (3-nitrooxypropanol): a promising and extensively evaluated feed additive that reduces methane emissions from ruminants in feedlot conditions.

Nitrate: nitrate (NO_3) supplements can reduce rumen methane emissions as well as providing valuable nitrogen that is converted to protein in the rumen.

CO2e (carbon dioxide equivalent): this is used to compare different greenhouse gas impacts on the climate. For example 1kg of methane is 28kg CO2e, while 1kg of nitrous oxide is 265 kg CO2e.

Activities and findings

Managing ruminant livestock methane

Methane from ruminant livestock is the largest source of agricultural emissions.

Hence, managing livestock methane is critical to achieving NSW emissions reduction targets. Enteric methane emissions are lost energy to the animal, so reducing emissions can increase productivity.

The project reviewed available and emerging strategies for reducing ruminant methane.

A meta-analysis of studies on feed additives revealed that seaweed (particularly Asparagopsis), 3-NOP, oils such as linseed and nitrate are the most promising options for direct abatement of methane in the next 10 - 20 years.

Trials suggest that seaweed and 3-NOP, when consumed daily, can reduce emissions by 50% or more. However, delivering these additives daily to stock in the paddock, as opposed to an intensive feedlot situation, is complex and is currently being intensively researched.

Combining management of livestock with improved feed management could deliver smaller reductions. Livestock and feed management practices that reduce emissions include:

- early breeding,
- culling less productive stock,
- optimising maternal nutrition to enhance fertility,
- improving animal health,
- sowing pasture species that reduce enteric methane,
- managing pastures for improved quality and
- supplementary feeding to speed animal growth.

Genetic selection for low methane production is expected to deliver a steady reduction in emissions in the medium to long term.

These strategies have potential to reduce both total emissions from the livestock sector and the carbon footprint of meat, wool and milk.

They could also reduce the land required for production freeing up land for woodlots or restoration.

The feasible abatement from cattle through a combination of dietary additives and herd management is estimated at 1.5-2.0 Mt CO2e per year in 2030, and from sheep is estimated at 0.4-0.5 Mt CO2e per year. Manure management could contribute a further reduction of 0.12-0.20 Mt CO2e per year in 2030.

Mitigation in the cropping sector

The largest emissions source from cropping is nitrous oxide which is emitted from soil and is a powerful greenhouse gas.

Nitrous oxide emissions can be reduced through improving the efficiency of fertiliser use. Past cropping practices have also reduced soil carbon levels so there is potential for carbon sequestration.

However, the potential of specific practices to raise soil carbon levels under climate change is not well-understood.

Therefore, the project undertook detailed modelling of crop management practices to determine their effect on nitrous oxide emissions, soil carbon and resulting net emissions.

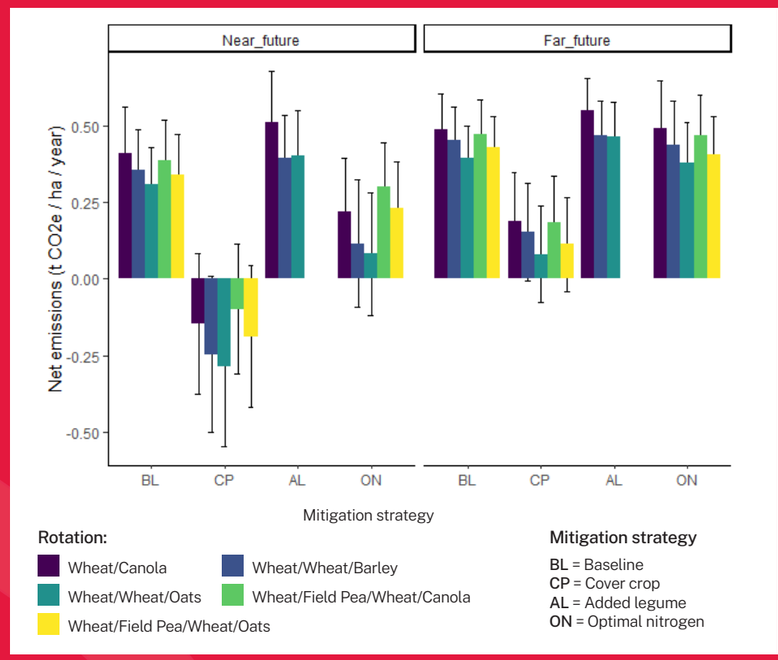


Figure 1: Shows the impact of different mitigation strategies and crop rotation cycles on net emissions in the near future and the far future. The key finding here is that cover crops provide net sequestration in the near future and the smallest emissions in the far future compared to baseline activities, highlighting the impact of climate change on the effectiveness of mitigation strategies.[1]

Activities and findings

The biophysical crop model APSIM was applied to 600 sites across 3 major cropping regions in NSW, for two future climate scenarios.

Case Study: Riverina Region

Comparing the impact of three different crop management strategies on net emissions in the Riverina region, the project results indicate that, on average:

- **cover crops are effective, delivering negative emissions (net sequestration) in the near future (CP in Figure 1)**
- **optimising nitrogen fertiliser application reduces emissions compared with the baseline (current practice) in the near future (see ON in Figure 1).**
- **in the far future (Figure 1, right side), none of the options show net sequestration, but cover crops have the lowest emissions.**
- **additional legumes in the rotation provide no mitigation benefit compared with the baseline (AL in Figure 1).**

The effect of management strategies varies across the Riverina region due to differences in annual rainfall and soil type. For example, Figure 2 shows that in the drier west, cover crops reduce the gross margin quite considerably in both the near and far future, compared with no cover crop, with stubble retained. This is because water used by the cover crop reduces the yield of the following crop, especially for field pea and canola.

Underlying regional rainfall has an important influence on the profitability of mitigation strategies. For example, while cover crops lower net emissions across the Riverina, their use in more western drier parts of the region result in large declines in profitability.

In contrast, in the wetter eastern Riverina, cover crops give both net sequestration and increase gross margins, particularly on lighter soils. Overall, the project identifies that there could be a substantial economic trade-off in maximising climate change mitigation through the use of cover crops in the drier parts of the Riverina.

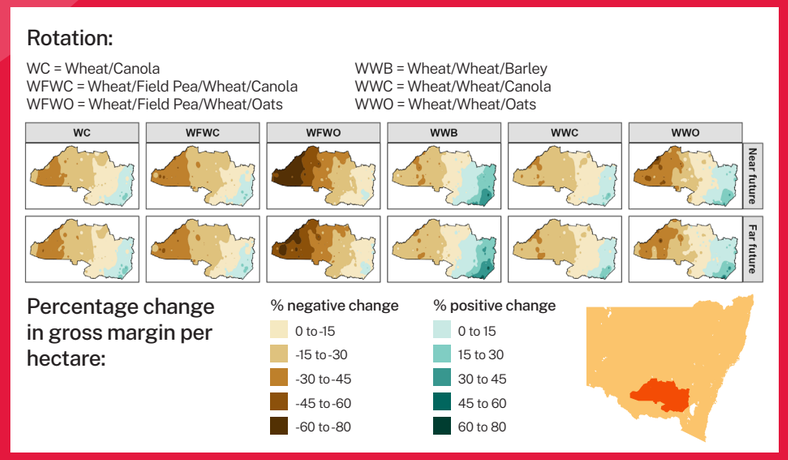


Figure 2: *Shows the economic impact of applying different mitigation strategies on different crop rotation cycles in the near future and far future. Cover crops increase gross margins in the east (blue) but reduce gross margins in the drier central and western parts of the Riverina (brown), illustrating the costs and benefits of applying this mitigation strategy in different parts of the Riverina.*[1]

In contrast, in the wetter eastern Riverina, cover crops give both net sequestration and increase gross margins on lighter soils. Optimising nitrogen fertiliser gives a smaller mitigation benefit compared with cover crops, but a greater increase in gross margin, in the lighter soils in the east.

These findings highlight the importance of detailed spatial assessments to support decision-makers in government and industry to identify the most effective mitigation strategies depending on their regional circumstances.

The project produced a large dataset of crop modelling outputs, that contain a wealth of information about soil carbon dynamics, crop growth and greenhouse gas emissions across the cropping zone. Further results will be published in 2024.

Biochar

We undertook a comprehensive review of the scientific literature to assess the benefits and risks of biochar production and application to agricultural soils, identify barriers to adoption in NSW, and recommend measures to facilitate its adoption in NSW.

The review found that the benefits of biochar application include:

- **improved nutrient retention,**
- **carbon sequestration,**
- **reduced soil N_2O emissions,**
- **reduced soil acidity,**
- **higher phosphorus availability and**
- **improved soil biological health and resilience.**

The main barriers to adoption of biochar technology in NSW are:

- **regulatory environment that constrains the use of biomass residues,**
- **lack of carbon market opportunities for biochar, and**
- **lack of awareness of biochar.**

The abatement potential of biochar for NSW was based on the available biomass, potential adoption rate, and estimated biochar conversion rates for each feedstock. Feedstocks included:

- crop and forestry residues,
- animal manure,
- food processing residues such as nut shells and grape marc,
- food, garden and demolition waste,

Recognising logistical and economic challenges to the collection of crop residues, and the importance of retaining residues for erosion control, we conservatively assumed retention of 2.5 dry t/ha residue, with residues in excess of this threshold removed from 20% of cereal crops and 10% of non-cereal crops and sugarcane.

Assumed recoveries for accumulated materials ranged from 50% for sawmill residues to 95% for nutshell residues.

We estimated that NSW could potentially produce around 2.0 Mt biochar/year, stabilising around 1.04 Mt C/year, which represents carbon dioxide removal of 3.81Mt CO2e/year.

Further mitigation benefits include:

Above: *Biochar made from macadamia shells and (inset) from pelletised canola stubble, a form ready for use.*

- displaced emissions by co-produced bioenergy (1.3M t CO2e/yr);
- reduced soil nitrous oxide emissions by treating around 200,000 ha of cropping land at 10t/ha (0.025 Mt CO2e/yr); and
- avoided emissions from residue burning by converting 20% of crop residue to biochar (0.062 Mt CO2e/yr).

In total, we estimate that the conversion of biomass residues from primary industries and urban organic wastes to biochar can potentially deliver emission reduction of 5.20 Mt CO2e/yr. This represents ~4% of NSW emissions in 2021.

Conclusion

Evidence indicates the potential for numerous strategies to reduce livestock emissions, but these need to be refined for NSW grazing systems.

For cropping systems, cover crops effectively increased soil carbon, substantially reducing net GHG emissions in the near future (to 2050).

However, cover crops reduced profitability, particularly in the drier western areas. Furthermore, the projected mitigation benefits were diminished in the far future (to 2090), as warmer temperatures under climate change hasten organic matter turnover.

Production and use of biochar from organic wastes and residues could make a significant contribution to reducing NSW emissions and enhancing soils.

In addition, biochar systems can provide further mitigation by reducing soil N_2O emissions, avoiding residue burning, and displacing coal-fired electricity.

Deployment of biochar is constrained by regulatory barriers that could be overcome through reform of waste management policy.

MORE INFO:
Scan the QR code or click here

1. He, Q., Li Liu, D., Wang, B., Cowie, A., Simmons, A., Waters, C., Li, L., Feng, P., Li, Y., de Voil, P. and Huete, A., 2023. Modelling interactions between cowpea cover crops and residue retention in Australian dryland cropping systems under climate change. Agriculture, Ecosystems & Environment, 353, p.108536.

NEXT STEPS

Further investigation is required to assess the use of these methane mitigation strategies in combination to determine the net effect on emissions. While the project has identified effective mitigation strategies that have potential to significantly reduce NSW emissions, it has also identified economic and regulatory barriers to adoption.

Expansion of eligible mitigation strategies recognised by the Australian Carbon Credit Unit Scheme and development of policy incentives outside the carbon market are recommended, to overcome economic barriers to adoption of mitigation measures in livestock and cropping systems.

Accessing Carbon Markets

Introduction

Carbon farming has emerged as an opportunity for land managers to earn a new income stream and contribute to Australia's emissions reduction targets.

The Australian Governments' Australian Carbon Credit Units (ACCU) scheme (formerly known as the Emissions Reduction Fund, ERF) is the main mechanism for participation in carbon markets, but it is complex and difficult to navigate.

A central limitation to participating in carbon markets is the inability for land managers to identify viable opportunities which do not compromise long-term sustainable agricultural production.

When this project commenced, carbon project activity was almost exclusively confined to the rangelands of western NSW.

Here, key uncertainties around the co-benefits of carbon farming to the farm business, regional, and landscape resilience were being raised.

Increasing access to carbon markets and expanding participation of land managers in higher rainfall areas would reduce the risk of relying on a large volume of abatement being delivered from one of the most exposed regions in terms of future climate impacts.

However, expanding carbon farming activity would also increase uncertainties around the co-benefits in more productive areas of NSW.

Key information gaps included trade-offs between land use for carbon and agricultural production and how carbon accumulation (income flow) across NSW regions may be influenced by future climate. This limited the ability of farmers to identify the value proposition for participating in carbon markets.

Regional NRM bodies such as NSW Local Land Services (LLS) also require an understanding of the socio-economic and environmental co-benefits of carbon farming to support regional planning and prioritisation.

These knowledge gaps were creating missed opportunities for farmers to participate in carbon markets and constraining the ability of the NSW government to understand the impacts of land-use change under carbon farming.

The first objective of this program was to build an evidence bank for the co-benefits of carbon farming and abatement delivery to support strategic decisions making by the NSW government.

The second stage of the program was to develop a decision support tool that can provide information on viable carbon market opportunities across NSW.

Activities and findings

Phase 1:

An initial industry survey and focus groups provided an understanding of the perceptions around carbon farming.

Financial benefits were identified as a primary motivation for adoption of carbon farming[1]. The study found the key uncertainties related to a lack of understanding of methods, eligibility requirements and management activities for project methods[2].

Two technical expert workshops were conducted (National Carbon Farming Co-benefits and Identification of Co-benefit indicators) to identify data sources and metrics [3,4] as well as a set of environmental co-benefit indicators which could be used to assess and verify the impact of carbon farming activities in the rangelands.

Phase 2:

Spatial mapping tool & scoping on-farm optimiser tool

A major project activity was the development of the online Carbon Farming Opportunities for NSW tool[5] undertaken in collaboration University of South Australia (UniSA).

The tool provides a dashboard interface (see figure 1) where users can explore the potential sequestration for the two main vegetation-based Australian Carbon Credit Units methods:

- Human-induced regeneration of a permanent even-aged native forest
- Reforestation by environmental or Mallee Plantings (Mallee) – note that the tool has split this method into environmental plantings and mallee plantings to better reflect the local conditions.

Indicative financial implications of changing land use from current agricultural production to 'carbon farming opportunities' can be estimated by the tool for different Local Land Services regions. Modelled sequestration under projected future climates is also provided.

The tool was designed to help support decisions on whether participation in these Australian Carbon Credit Units Scheme methods represents a value proposition allowing for carbon price and future climate.

Other opportunities to sequester carbon were also included in the tool. These include the potential soil organic carbon increase from a 10% increase in the long-term vegetation cover (woody or ground cover) (See Figure 2 overleaf).

During tool development, testing with a range of stakeholders provided feedback to iteratively refine the tool.

All the data underpinning the tool development has been published in scientific journals. The 'soil carbon sequestration potential with enhanced vegetation cover over NSW' spatial layer can be accessed on the Central Resource for Sharing and Enabling Environmental Data in NSW (SEED). A 'proof of concept' tool to optimise production and carbon on-farm was tested using a number of case studies[6].

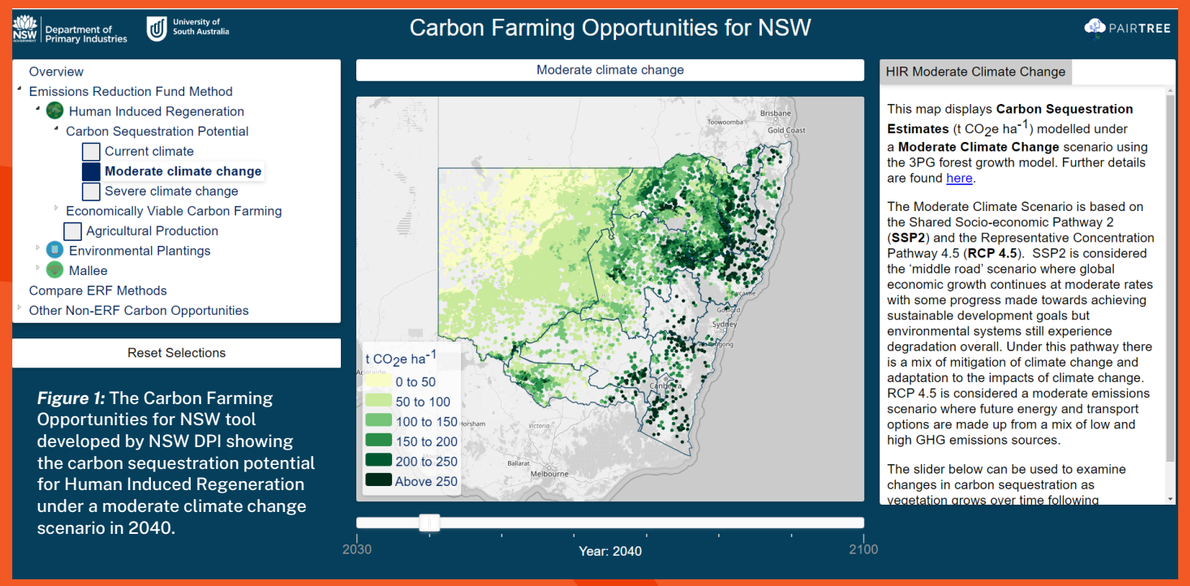


Figure 1: The Carbon Farming Opportunities for NSW tool developed by NSW DPI showing the carbon sequestration potential for Human Induced Regeneration under a moderate climate change scenario in 2040.

Activities and findings

This research has supported ongoing tool development for farm-scale optimisation for multiple outcomes (production, carbon and biodiversity).

The Carbon Farming Opportunities tool is currently undergoing review and being updated. It will be re-published in late 2023.

Collaborating with UniSA, resulted in a successful Australian Research Council (ARC) Linkage grant which created a high resolution spatio-temporal land degradation index for NSW. This spatial layer and a 'biodiversity prioritisation index for NSW under current climate' will be included in the Carbon Farming Opportunities for NSW tool in mid-2023.

The ARC Linkage project has also delivered a high resolution (5 km) profit at full equity high spatial layer which will be used in developing a farm-scale decision support tool for future work in farm scale carbon planning.

Phase 3:

Development of web-based content

Key highlights include

- Assessment of feasible abatement opportunities under vegetation and soil-based methods for NSW
- Soil carbon sequestration associated with a 10% change in vegetation cover for all NSW LLS regions
- Simplification of all major land sector ACCA scheme methods to guide farmers in understanding the eligibility requirements and activities allowed under methods. Figure 3 is a visual representation of the Environmental Planting Method.

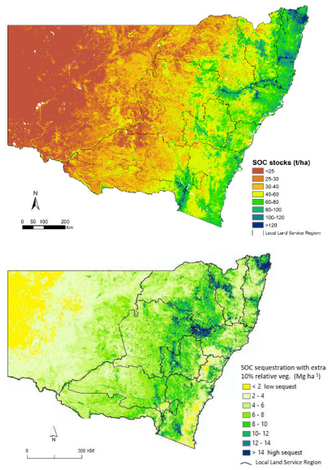
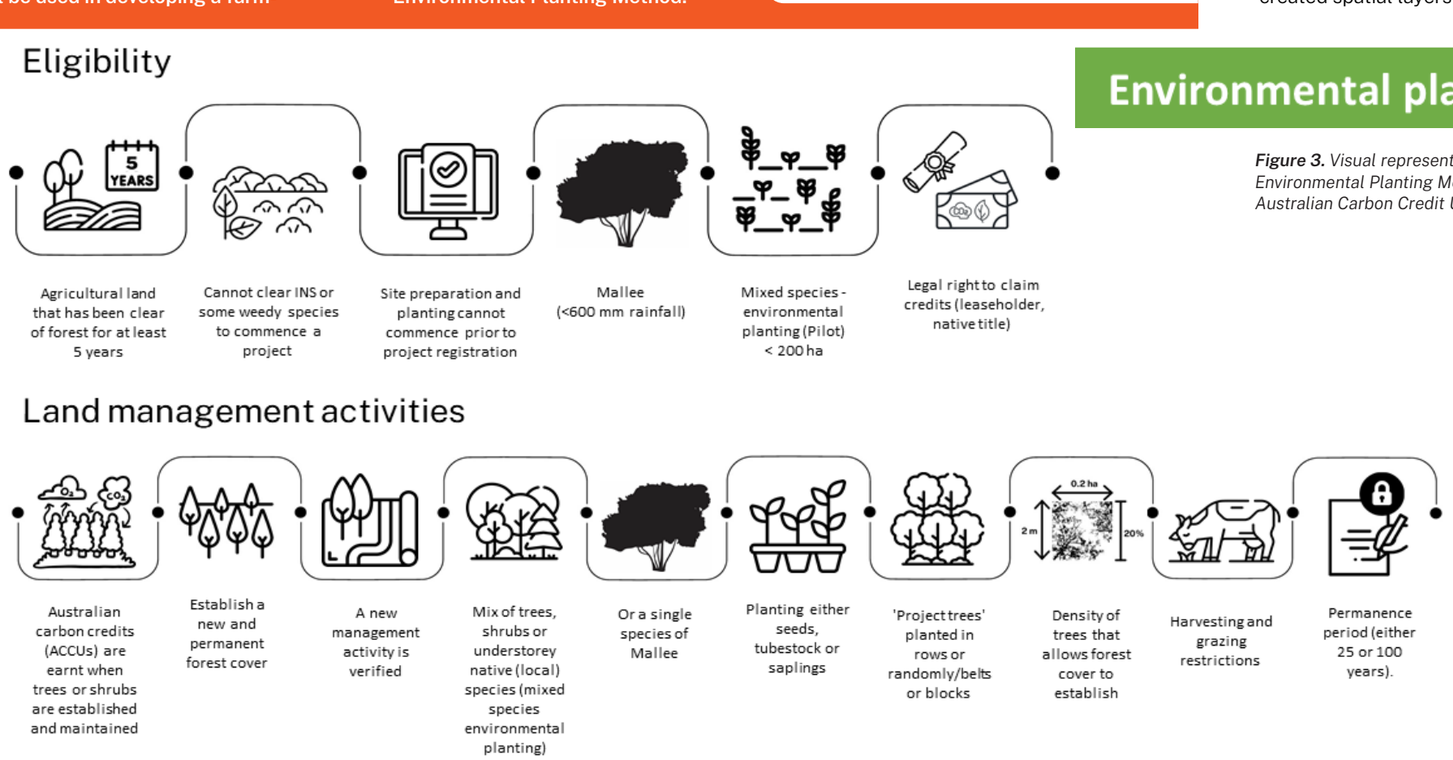


Figure 2. *Current soil carbon stocks in NSW (top) and potential increase in soil carbon stock with a relative 10% change in vegetation cover (bottom).*



Environmental plantings

Figure 3. *Visual representation of the Environmental Planting Method from the Australian Carbon Credit Unit Scheme.*

Conclusion

The project developed an integrated tool which allows the economic trade-offs between agricultural land use and carbon under ACCU scheme methods to be used by land managers and NRM bodies.

The project demonstrated significant differences across NSW LLS regions in the volume of economic supply of abatement under different carbon prices and delivered the first assessment of abatement driven carbon markets under future climates.

Economic and carbon accumulation data layers created by the project have also been shared with the Biodiversity Conservation Trust for use in the quantification of carbon and biodiversity co-benefits in NSW.

The project identified opportunities for retention of native vegetation and created spatial layers which were used by NSW Department of Environment in undertaking clearing risk assessments.

A major project impact was to present project results to the Clean Energy Regulator which informed ongoing Australian Carbon Credit Units method modification and development.

Predictions for current soil carbon stocks in rangelands and at least four scientific journals/report arising from this project also informed the Review of the Australian Carbon Credit Units Review (Chubb Review) which led to the implementation of major reforms to the Australian Carbon Credit Units Scheme.

The project showed that land managers require information on carbon market opportunities to be considered within the individual farm business and accommodate the wide range of understanding and perceptions of the agricultural sector.

NEXT STEPS

The project created new knowledge and insights which are being applied to the delivery of current initiatives to improve the capacity of farmers to manage carbon more efficiently and participate in carbon markets under the NSW Net-Zero Plan.

Results of the project also supported the business case for the development of the Primary Industries Productivity and Abatement Program[7] and the NSW Decarbonsiation & Innovation Hub, major initiatives under the NSW Net-Zero Plan.

MORE INFO:
Scan the QR code or click here

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2. Baumber, A., Cross, R., Waters, C., Metternicht, G. and Kam, H (2022). Understanding the social license of carbon farming in the Australian rangelands. Sustainability. https://doi.org/10.3390/ su14010174

3. Waters, C.M., McDonald, S., Reseigh, J., Burnside, D., Grant, R. (2020) Insights on the relationship between total grazing pressure management and sustainable land management: key indicators to verify impacts The Rangeland Journal https://doi.org/10.1071/RJ19078

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5. The Carbon Farming Opportunities tool https://carbon.pairtree.co/tool/

6. OnFarm Carbon Optimisation. https://www.dpi.nsw.gov.au/dpi/climate/Carbon-and-emissions/carbon-opportunities/on-farm-carbon-optimisation

7. Waters C., Cowie, A., Wang, B., Simpson, M., Gray, J., Simmons, A and Stephens, S (2020). Abatement opportunities from the agricultural sector in New South Wales: Modelling to support the development of the Primary Industries Productivity and Abatement Program NSW Department of Primary Industries. ISBN: 978-1-76058-415-3

Vulnerability Assessment

Introduction

Climate changes offer opportunities and challenges for primary industries in NSW.

Primary producers in New South Wales are increasingly being impacted by climate change.

These industries are critical to ensuring food security for communities, and so developing viable pathways to climate change adaptation for primary industries is becoming increasingly pressing.

There is a driving need for comprehensive information and data on the potential impacts of climate change on primary industries to inform effective policy and planning at a state and regional level.

The Project has estimated mid-century (2050) climate change impacts for agriculture (extensive livestock, broadacre cropping, horticulture and viticulture), marine fisheries and forestry, and important cross-cutting biosecurity risks to inform sound planning, risk management and adaptation decisions.

These commodities and biosecurity risks were selected based on economic value to NSW, the size of the industry in NSW or their importance as an emerging or growing industries in NSW and the availability of expertise within NSW DPI.

The resulting sector-wide climate impact assessment of various industries provides guidance to the industry sector on navigating the challenges and opportunities of climate change.

The objective has been to provide primary industries and the NSW Government with a comprehensive and consistent assessment of medium-to long-term climate risks, supporting adaptation to identified climate vulnerabilities as well as taking advantage of future opportunities.

Activities

The Vulnerability Assessment Project team and scientific experts within DPI collaborated to develop the suite of 28 commodity and 14 biosecurity models.

The Vulnerability Assessment Project team won the DPI One Award in 2021 for exemplifying collaboration with more than 70 staff across DPI working on the project to develop and inform climate change risks and impacts.

The results of this project are both complex and comprehensive.

We are undertaking stakeholder engagement to support understanding and adoption of the findings across industry and government.

The method developed for the project uses a transparent multi-criteria analysis modelling approach, combining data from published research with expert scientific opinion.

With significant knowledge gaps around the sensitivity of commodities and biosecurity risks to climate variables, we worked with experts to draw out their knowledge to inform assessments.

We also worked with experts to draw out their knowledge and allow for the modelling of under-researched commodities and risks.

A focus group of experts was convened for each commodity and risk to review, design and ultimately endorse the model for future projections.

A key feature of this project is that models were developed in a consistent way across all industries, and the climate impact assessments use the same historical and future climate projection data.

This allows direct comparison and integration of the outputs between commodities and biosecurity risks.

Future climate projection data for NSW were sourced from Climate Change in Australia's 'Application Ready Data.

Mid-century (2036 to 2065) future climate suitability and water demand were modelled for intermediate (RCP4.5) and high (RCP8.5) greenhouse gas emissions scenarios using data from an ensemble of eight Global Climate Models representing a range of plausible future climates.

Our models were applied spatially across NSW at a resolution of 0.05° (~5km²).

Vulnerability Assessment Scorecard

137 FOCUS GROUP PARTICIPANTS

WINNERS OF THE 2021 DPI ONE AWARD

28 COMMODITY MODELS

14 BIOSECURITY MODELS

1.5m MAPS OF NSW PRODUCED

53 DEPARTMENT OF PRIMARY INDUSTRIES MODEL LEADS

Horticulture & Viticulture	Broadacre Cropping	Forestry	Extensive Livestock	Marine Fisheries	Biosecurity Risks
• Almond • Blueberry • Cherry • Citrus • Macadamia • Walnut • Wine grapes	• Chickpea • Dryland and irrigated wheat • Dryland barley • Dryland canola • Irrigated cotton • Irrigated lucerne • Irrigated maize • Irrigated rice • Lupin	• Radiata pine	• Cattle • Sheep • High rainfall zone pastures • Mixed cropping feedbase • Rangeland pastures	• Bonito • Dolphinfish • Kingfish • Spanish mackerel • Spotted mackerel	• Buffalo fly • Oriental fruit fly (a) • Parthenium weed (b) • Queensland fruit fly • Sclerotinia stem rot • Serpentine leafminer (c) • Serrated tussock • Wheat stem rust (d) • Verticillium wilt • Wheat stripe rust • Barber's pole worm* • Biting midge* • Blowfly* • Cattle tick*

Notes: List of the primary industry commodities and biosecurity risks studied by the VA Project. Notes: (a) exotic biosecurity risks not yet found in NSW; (b) eradication ongoing in NSW; (c) biosecurity risk new to NSW (an incursion occurred during the VA Project); (d) biosecurity risk not currently found in NSW (most severe epidemic in Australia was in 1973). †results to be released in 2024.

Climate impacts:
What to expect in the fisheries industry in NSW

Developing industry-informed climate planning information

Climate change is altering the estuarine and ocean conditions many fisheries operate in along the coast of NSW.

Fishers and fishery managers need evidence-based information about the changing climate conditions and the risks and opportunities these changes will likely bring.

With a diverse range of marine and freshwater ecosystems, NSW has a rich seafood industry supplying domestic and international markets.

Fisheries are crucial to the state's primary industry sector, providing local communities with employment and economic growth opportunities.

In 2020-21, NSW wild-caught fisheries' gross value production (GVP) was approximately $100 m.

New South Wales fisheries operate in one of the most rapidly warming regions of the global ocean.

This makes it imperative to assess the emerging impacts of climate change in order to manage the associated risks and opportunities proactively.

The Vulnerability Assessment Project provides information and data to help the sector better plan for and respond to climate change.

Climate projection data were downscaled by NSW DPI scientists for the NSW marine environment, enabling an assessment of the suitability of the NSW marine environment for coastal fish species under future climate change.

Kingfish case study

Climate impacts: What to expect for Kingfish in 2050

Likely changes to climate suitability for Kingfish in NSW marine bioregions by 2050 under a changing climate include:

- Climate suitability for Kingfish during spring is projected to increase within southern regions of the NSW marine environment, specifically within the Batemans Shelf bioregion and the northern portion of the Twofold Shelf bioregion.

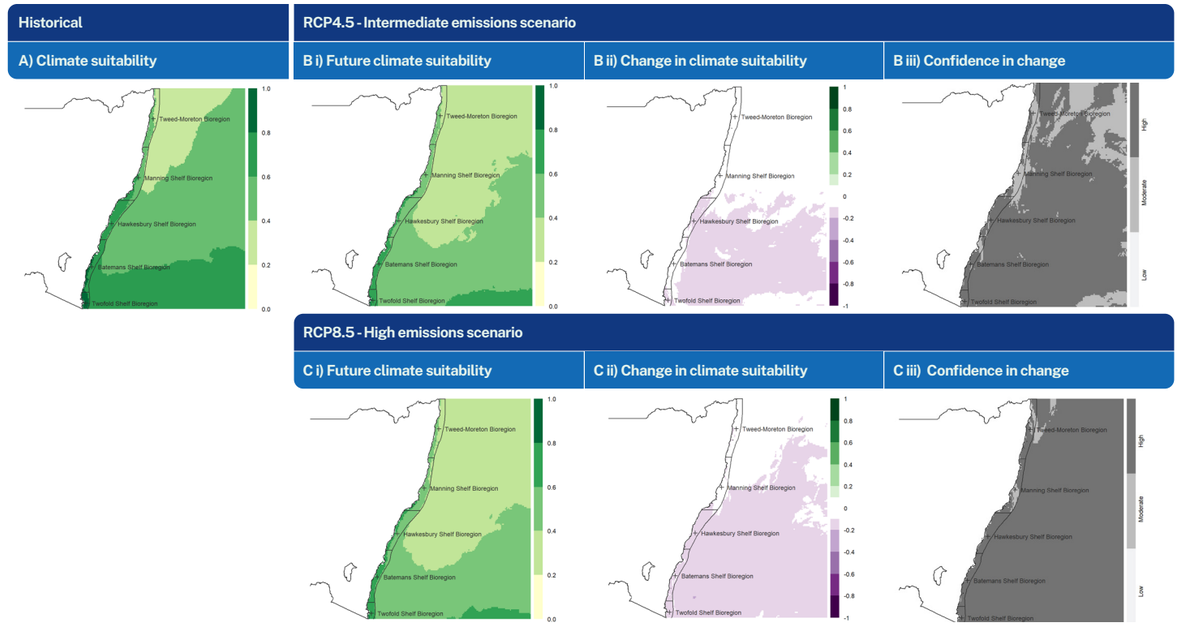


Figure 1: The summer climate suitability panel for kingfish is shown. *NSW's marine bioregions are shown in black extending along the coast and eastwards to the boundary of the continental shelf. The panel is made up of 7 maps: A) shows the historic climate suitability (calculated as the mean of years 1993-2012), and B) and C) show future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability for 2050 (calculated as the median of an ensemble of 5 global climate models for years 2040-2059), ii) shows the change in climate suitability by comparing 2050 with 1995 to determine where negligible (white), positive (green) or negative (purple) change will occur, and iii) shows the confidence in this change (low, moderate or high), based on the agreement between the 5 GCMs.*

- Minimal negative changes in climate suitability for Kingfish are projected for the Hawkesbury Shelf, Batemans Shelf and Twofold Shelf bioregions in summer.
- Minimal negative changes in climate suitability for kingfish are projected for the Tweed-Moreton and Manning Shelf bioregions during autumn and winter.

Together, these changes may result in minimal reductions in fishing opportunities for Kingfish in summer and autumn by 2050, while minimal increases in fishing opportunities may prevail off southern NSW in spring.

Given the expected small magnitude of projected changes, it is pragmatic to expect that minimal climate-driven changes to fishing opportunities for Kingfish are likely to occur off NSW by 2050, and that many of the same opportunities to catch Kingfish that currently exist will continue.

Results from the other 27 commodity and 10 biosecurity models will be released later in 2023.

Conclusion

The project has enhanced our understanding of potential climate vulnerabilities for primary industries under future climate conditions across NSW.

This has provided unique insights into the adaptation priorities that may be needed to support resilient primary industries in NSW in 2050. It has further identified opportunities for potential industry expansion outside of current growing regions due to increasing suitable climate conditions under climate change scenarios.

Over the coming months, the project team will engage with key stakeholders in government and all primary industry sectors to communicate the findings of the work.

Each industry will be informed of the likely vulnerabilities, adaptation priorities and opportunities to help them better prepare their industries for 2050.

MORE INFO:
Scan the QR code or click here

Champion, C., Lawson, J.R., Pardoe, J., Cruz, D.O., Fowler, A.M., Jaine, F., Schilling, H.T. and Coleman, M.A., 2023. Multi-criteria analysis for rapid vulnerability assessment of marine species to climate change. Climatic change, 176(8), p.99. https://link.springer.com/article/10.1007/s10584-023-03577-2

NEXT STEPS

Adaptation

The current project highlights adaptation priorities and options to address climate vulnerabilities.

Still, these adaptation strategies must be tested to ensure that they adequately address relevant climate impacts and do not inadvertently increase vulnerability at another point in the production cycle.

The modelling approach already developed by the project can also be used to assess the effectiveness of adapting to climate change.

We will input the expected or observed impacts of those actions into the model to assess its value.

This more detailed assessment of adaptation will provide industries with insights into the value of adaptation for reducing the impacts of climate change, and this will be the focus of new work.

Biosecurity Integration

Government and industry must also understand the impact of climate change on the biosecurity risks, which may lead to changes in the seasonal occurrence or geographic extent of pests and diseases in NSW.

The Vulnerability Assessment project has made important progress towards understanding some of these issues.

More work is needed to cover a greater range of biosecurity threats, including assessing exotic biosecurity risks currently not present in NSW and assessing the impact of adaptations on productivity. This is the priority of new work starting in 2024.

Climate-Smart Pilots

Introduction

Adaptation enabled by digital technology and access to information creates a pathway to climate resilience for growers.

The changing climate brings production risks for primary producers in New South Wales and in many instances new opportunities.

Producers and growers need information about these risks and opportunities to guide planning for the future.

Through on-farm pilots and engagement with primary producers, Climate-Smart Pilots has demonstrated that adaptation responses, including new digital technologies, can support primary producers to meet and profit from short term variability including extreme events and water scarcity.

A multi-disciplinary team of agricultural and computer scientists, working directly with farmers and DPI research staff piloted new adaptive approaches.

Demonstration farms were established with commercial producers to showcase the role of digital technology as a tool enabling adaptation to climate change, increasing climate variability and improving response to extreme weather events.

Working directly with farmers – on their farms allowed the DPI Digital Agriculture team to tackle real-world issues affecting farmers today and those expected into the future.

The pilots and data collected will provide a key resource for researchers and industry into the future through an open and accessible data repository .

Climate-Smart Pilots aimed to showcase the experience and ingenuity of primary industries through their adaptive responses to the changing climate.

The Farmer Stories series of videos and podcasts highlights the innovative actions undertaken by farmers across NSW.

These first-voice stories compliment the case studies published on the NSW DPI website and in trade and academic journals.

These resources will enable producers to learn from their peers, whilst demonstrating to the broader community the responsiveness of primary industries in NSW.

Activities and findings

Oysters

Oyster producers on the Clyde River at Batemans Bay, identified two important climate impacts that they need to understand:

- unexpected summer heatwaves which can decimate their crops very quickly; and
- extreme rainfall events leading to reduced salinity and prolonged harvest closures.

The team designed a relatively low cost sensor buoy and placed them in the estuary system to measure water salinity and temperature, sending data to the cloud. Portable, wireless temperature loggers enabled monitoring of air temperatures around exposed crops.

The real-time data from these sensors has equipped the farmers with new information through a tailored dashboard that enables them to quickly respond to these events, and plan through longer events that were disruptive to their operations and markets.

The oyster growers on the Clyde continue to access the real-time data through a DPI developed dashboard.

Horticulture

Apple and cherry growers in Orange experience climate change through changing rainfall patterns that include extreme rainfall events that can damage crops.

Warming conditions means irrigation of their perennial tree crops will be critical to the quantity and the quality of their fruit.

The Climate-Smart Horticulture pilot used digital soil moisture sensors to measure the efficiency of the irrigation system and its capacity to deliver water to the tree roots at critical times.

Preliminary adaptation trials have shown that covers over cherries may not only reduce cherry splitting caused by rainfall, but can lower maximum daily temperatures within the canopy. Further research will be instrumental in helping this industry to adapt to future climates with anticipated higher maximum temperatures.

Livestock

Livestock producers are also concerned with the changing rainfall patterns affecting their operations and their ability to adequately deliver water to stock where and when it is needed.

Sheep and cattle producers that participated in our pilots reported that remote tank and trough monitors allowed them to easily check water levels across their farms, enabling them to have greater peace of mind while they attended to other tasks or even relaxed while off farm during family holidays.

Activities and findings

Irrigated cropping

Monitoring water is a key focus for irrigated cropping enterprises to create efficiency in managing water and minimising losses in their operations.

From the arrival of water at the farm, through to its application on the field via the lateral move irrigator and then into holding dams water is a critical resource.

The Trangie Agricultural Research Centre hosted a trial of new sensors including radar flow meters to monitor water movement and accurately account for water uses and losses.

The radar sensor provided valuable data that complemented other, cheaper sensors which was supported by a bespoke water balance equation that enabled better tracking of water through the system. This work was presented at an international irrigation conference in Adelaide in 2022.

Demonstration days

Across all pilots, field days were held for primary producers, industry representatives and technology partners to showcase the role that technology can play in adapting to climate change and how impactful these tools can be in making better decisions.

For citrus, almond and walnut growers in the Riverina and Sunraysia districts Climate-Smart Pilots provided an Irrigation Masterclass that included on-farm support for participants to adopt learnings in their own operations.

The workshops were very hands-on for farmers and included topics such as how plants use water, how to calculate water demand, available sensors to monitor water availability and how to interpret the data.

Farmers also got the opportunity to discuss their experiences and learn from each other.

Demonstrating Adaptation projects

Peer to peer learning is important for farmers, particularly in sharing their experiences and impacts of climate change.

19 videos have been created of farmers directly telling their story of how climate change has impacted them and their operations and what they've done to change their business.

This series covers a broad swathe of NSW and many different primary industries. A companion podcast series will be released in late 2023.

Other projects include:

- Monaro Farming Systems developed a new tool to help farmers manage and estimate livestock needs during confinement feeding and destocking. This is now part of the highly successful GrassGro decision support tool.
- The Mulloon Institute developed a model to predict where catchment rehydration is feasible and would be beneficial to local communities.
- Rangelands farming near Cobar experimented with localised ripping and ponding to be better prepared for and more resilient to drought conditions.
- A precision agriculture pilot is enabling farmers to choose from a suite of adaptation strategies based on their local environment.

New technology

The Climate-Smart Pilots team expertise was used to:

- Prototype new low-cost animal weighing technology to assist livestock producers with simpler solutions;
- Predict when extreme rainfall events will impact oyster growers using machine learning techniques. This helps to predict when the fishery will close, and importantly when they can expect to be open again;
- Develop new hardware telemetry systems to collect environmental data and transmit to the cloud, and
- New software systems to simplify data pathways enabling simpler access to the Internet of Things.

Conclusion & impacts

Farmers have shown how they have been impacted by climate change, how they've responded to these changes with innovation and research and how they continue to care for their lands and waters.

The Farmer Stories show the passionate, innovative and adaptive nature of farming, and how farmers are preparing today for the challenges of the future.

The partner farms in this research project were deliberately chosen as targeting those aspects of climate change that are having impacts today and will increasingly affect their operations into the future.

Participating farmers were clear that the solutions trialled needed to be feasible and ready to adopt. The case studies developed through the project highlight the actions that can be taken today with available technology.

The demonstration farms, irrigation workshops and field days have been impactful by talking with primary producers directly about knowledge and opportunities for how they might adopt these technologies to be better prepared for future climates.

The environmental data collected across these projects provided participating farmers with greater certainty about the climate impacts on their operations and gave them confidence in the decisions they made to address them.

"The information and skills learned will help us strengthen our irrigation management practices and better prepare us for the next drought."

Stahmann Webster - walnut producer (2023)

One grower in our horticulture pilot saw that their current spray irrigation wasn't reaching the roots of their trees and decided to change to a more efficient drip irrigation system.

The technology and data access meant that they could observe the results immediately.

Another observed the change that shade covers made in protecting their crops and now have confidence in pursuing innovation and investment to prepare for future climates.

These results are made available to all growers who can see the impacts of those decisions and have greater confidence in adopting those changes themselves.

The data from the oyster pilot and much of the source-code for software and data analysis that was delivered through the program has been made publicly available.

This project has demonstrated the value of partnerships between DPI researchers and commercial farmers and piloting technology on working farms.

Research projects can unlock novel solutions developed on farm, and in the laboratory, and give confidence to primary producers to adopt new techniques, and technologies and adaptations for their businesses to be prepared for the future.

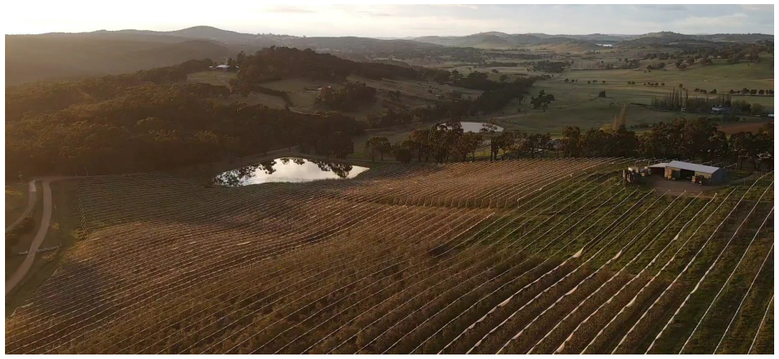
NEXT STEPS

There are climate challenges that can't be addressed by available technology. This suggests that more research and development is needed to fill gaps, and provide solutions that are 'farm-ready'.

The team's expertise is now being used to help assess the value of different adaptation actions by installing digital sensors in and around crops.

This information can then be used by other teams to determine the effectiveness of the adaptation and its usefulness to industry.

MORE INFO:
Scan the QR code or click here



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