ID: AE2101
Jonathon Welsh
Climate, energy and business analysis for cotton growers (including CottonInfo technical lead)

Organisation: Ag Econ
App Type: Full Research Proposal
Report Type: Final Report
R&D Manager: Susan Maas

Due: 30 September 2023
Submitted On: 22 June 2023
Report ID: 119

▼ Grant Summary

CRDC ID:	AE2101
Project Title:	Climate, energy and business analysis for cotton growers (including CottonInfo technical lead)
Project Start Date:	1 July 2020
Project End Date:	30 June 2023
Principal Researcher:	Jonathon Welsh
Email:	jon@agecon.com.au
Manager/Student Supervisor:	Jonathon Welsh
Administrator:	Jonathon Welsh
Organisation:	Ag Econ

▼ Final Report

Confidential or for public release? Public Release

Recognition of support: Edit the text provided and add additional funding partners and research collaborators.
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Ag Econ acknowledges the financial assistance of the Cotton Research and Development Corporation in order to undertake this project.

Research Questions & Project Milestone Updates

1. Project management milestones - climate			
#	**Description**	**Performance Indicator**	**Start - End**
1.1	Cotton industry extension on seasonal forecasting via a monthly cottoninfo e-news plus delivery of the UNE cotton course (24 days p.a)	Present at UNE cotton course annually, plus deliver e-news monthly	1/07/20 - 30/05/23
Created: 22 June 2023 | *Report: 119 - Final Report* **Final Update** | Status: Achieved Course content delivered			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
Created: 22 June 2023 | *Report: 119 - Final Report* **Final Update** | Status: Achieved All submitted			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
1.2	Represent cotton in multi-sectoral RD&E projects as the CRDC lead for MCV / R&D4P (6 days p.a)	Attend 2x MCV meetings as directed by Allan: conferences, interstate forums, phone meetings.	1/07/20 - 30/05/23
Created: 22 June 2023 | *Report: 119 - Final Report* **Final Update** | Status: Achieved No activity for FWFA this year, although other project collaboration has occurred with BOM and CSIRO and climate projects			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
1.3	Cotton Production Manual - Review & update the 'Climate for Growing Cotton' chapter (1 day p.a)	Annual reviews or as directed	1/07/20 - 30/05/23
Created: 22 June 2023 | *Report: 119 - Final Report* **Final Update** | Status: Achieved Submitted in Feb 2023			
Milestone Status: Green Accepted?: Yes Locked?: Yes			

2. Resource efficiency analysis			
#	**Description**	**Performance Indicator**	**Start - End**
2.1	Analyse and identify areas for hydrogen energy in cotton system and opportunities for export and	Complete a research report and deliver to CottonInfo communications manager	1/07/20 - 30/05/21

	regional fert hubs and fuel collaboration (Y1) (30 days – leveraged ARENA days)		
Created: 22 June 2023 | Report: 119 - Final Report **Final Update** | Status: Achieved This was a micro-hydro project delivered in 2021			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
2.2	Analyse and identify areas for hydrogen energy in cotton system, including GHG accounting impacts (Y2) (30 days – leveraged ARENA days)	Develop communications material: fact sheets, print media, podcast, YouTube and webinar	1/07/21 - 30/05/22
Created: 22 June 2023 | Report: 119 - Final Report **Final Update** | Status: Achieved Floating PV study delivered in 2022			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
2.3	Cotton system applied energy analysis (Y3) (40 days)	One BCA presented as either 1 x fact sheet for CottonInfo, Spotlight article or 1 x published paper	1/07/22 - 30/05/23
Created: 22 June 2023 | Report: 119 - Final Report **Final Update** | Status: Achieved Floating PV, gin and ammonia/H2 study submitted to CRDC 13 June 2023.			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
2.4	Analyse carbon, biodiversity offset and natural capital opportunities for growers.(Y1 20 days, Y3 10 days)	Produce a summary or fact sheet (Yr 1 and Yr 3), plus industry article Yr 3	1/07/20 - 30/05/23
Created: 22 June 2023 | Report: 119 - Final Report **Final Update** | Status: Achieved Submitted			
Milestone Status: Green Accepted?: Yes Locked?: Yes			
2.5	Three mini impact analyses (annually) or similar studies as directed by CottonInfo Manager (project total 72 days)	Completed studies presented to CottonInfo manager annually. Extended as either fact sheets, webinars, Spotlight articles or conference papers	1/07/20 - 30/05/23
Created: 22 June 2023 | Report: 119 - Final Report **Final Update** | Status: Achieved Submitted as per CottonInfo sub-tasks directed by Warwick			
Milestone Status: Green Accepted?: Yes Locked?: Yes			

3. Business management			
#	**Description**	**Performance Indicator**	**Start - End**
3.1	Update Australian cotton industry gross margins	Every 2nd year updated gross margins for	1/07/21 - 30/09/21

	for irrigated, semi-irrigated and rain-fed cotton to assist with International surveys and reporting obligations (updated in mid-year only (Y2) (27 days)	irrigated, semi-irrigated and rain-fed cotton	

Created: 22 June 2023 | Report: 119 - Final Report
Final Update | Status: Achieved
Submitted as per MS in 2021

Milestone Status: Green
Accepted?: Yes
Locked?: Yes

3.2	General gross margin analysis and discussion including @RISK analysis and resilience/sensitivity testing of one key variable of production. (12 days Y1 & Y3)	Analysis presented in either; a fact sheet, cotton grower article or extension package for CottonInfo. 1st & 3rd project years	1/07/20 - 30/05/23

Created: 22 June 2023 | Report: 119 - Final Report
Final Update | Status: Achieved
Submitted as per MS tasks set by CottonInfo each year

Milestone Status:
Accepted?:
Locked?:

3.3	Cotton Production Manual - Review & update the 'Business of Growing Cotton' chapter (1 day p.a)	Annual reviews or as directed	1/07/20 - 30/05/23

Created: 22 June 2023 | Report: 119 - Final Report
Final Update | Status: Achieved
Performed reviews annually, with the most recent submission in Feb 23

Milestone Status: Green
Accepted?: Yes
Locked?: Yes

4. CRDC Reporting

#	Description	Performance Indicator	Start - End
4.1	Document / report project activities, outputs and impacts plus Cotton Conference attendance and presentations (project total 23 days)	Bi-Annual progress reports, Final Report, Cotton Conference presentations	1/07/20 - 30/05/23

Created: 22 June 2023 | Report: 119 - Final Report
Final Update | Status: Achieved
Only one CC in 2022, due to covid19. All in attendance

Milestone Status: Green
Accepted?: Yes
Locked?: Yes

Communication Activities

Publications

I confirm that I have reviewed the Publications module and added any publications produced in the project that are not yet submitted to CRDC. I ensured to add final published versions.	Yes

List proposed publications for future release. :

ACPM 2021-23: Climate, energy and Business chapters

Energy studies:

The economics of installing micro hydropower into broad acre cotton farms: A Farm Case Study at Wee Waa, NSW (plus e-news)

Assessing the economic and sustainability credentials of floating solar photovoltaic plants in Australia: an irrigated cotton case study (plus Spotlight article)

Floating solar PV, green hydrogen and ammonia production investment analysis: an Australian irrigated cotton case study (plus Spotlight article)

Biodiversity offsets schemes – an emerging market for cotton growers (e-news and case study article) (2021 & 23)

Summer rainfall and CRDC-funded research (Spotlight, Spring 2021)

Climate and agricultural risk: assessing the impacts of major climate drivers on Australian cotton production (European Journal of Agronomy 2022)

2022 - New cotton picker purchase: contractor or buy? (2022)

Northern Australian cotton GMs (2022)

Interchangeable Gross Margin (2022)

New BOM climate tools and FWFA project (Spotlight 2022)

Modelled outcomes of implementing N use myBMPs (spotlight 2023)

4m controlled traffic farming. Does it pay? (2023)

Nitrogen Fertiliser Use Efficiency and impact on Gross Margins (2023)

Economic analysis of variable rate fertiliser and yield mapping (2023)

Cotton nitrogen benchmarking analysis (2023)

Water benchmarking analysis (2023)

Project Outputs

3x energy studies as listed	
Output Type	**Description**
Reports	Analysis of various technology options that may fit for cotton irrigators: microhydro, floating solar PV and green hydrogen production

UNE cotton course 2021-23	
Output Type	**Description**
Scholarship, travel and learning programs	Lectures to UNE student doing the 'cotton course'

Moisture manager e-news	
Output Type	**Description**
Products	Monthly climate analysis for cotton growers

2x Biodiversity studies	
Output Type	**Description**
Publications	Opportunities for cotton growers to participate in biodiversity markets

Mini impact analyses	
Output Type	**Description**
Publications	Short studies focused on tailored research and cotton grower decision making, as listed above

Cotton climate paper	
Output Type	**Description**
Publications	Climate variability and extremes adversely impacts Australian cotton crop production and imposes a major constraint on farm planning, industry supply chains and resource allocation. This study reviews time-series yield and crop production methods to account for climate, as well as perform a cotton yield and climate time series analysis using rainfall and temperature data. This study demonstrates that dryland lint yield gains during average-to-moderate rain/temperature years while irrigated lint yields have improved during more frequent average rain/hot growing seasons (1997–2018). Results also discovered climate in central cotton growing areas is impacted by El Ni˜no Modoki and Ni˜no4 indices and the various phases of ENSO. These findings translate into meaningful actions for industry adaptation and in turn provide a valuable step in accounting for climate variability and yield related inputs such as fertiliser and water resources.

Project Outcomes

Improved cotton grower climate literacy	
Output Type	**Description**
Extension services and training accessed	Helping cotton growers with decision making and managing extremes

UNE cotton course 2021-23	
Output Type	**Description**
Extension services and training accessed	Present to 500-level students studying the 'cotton course'

Energy technology analysis	
Output Type	**Description**

Industry capacity building	3x energy technologies analysed: solar PV, microhydro and green ammonia/H2 production

Mini-impact analyses	
Output Type	**Description**
Industry capacity building	Small research focused on key areas of production that remain topical. I.e. cotton picker purchase, variable rate analysis.

Project Collaborations

CSD		
Collaborator/s Name	**Organisation Name**	**Dates**
Sam Lee	Ag Econ	1 April 2021 - 22 June 2023
Description Norther newsletter - climate analysis		
Report ID: 119 Created at: 22 June 2023		

Research Institute		
Collaborator/s Name	**Organisation Name**	**Dates**
Prof. Andrew Dicks	Griffith University	1 November 2022 - 30 June 2023
Description Co-author and reviewer of hydrogen study		
Report ID: 119 Created at: 22 June 2023		

Research Institute		
Collaborator/s Name	**Organisation Name**	**Dates**
Prof. Andrea Taschetto	UNSW / CLEX	1 June 2021 - 31 August 2022
Description Cotton climate paper		
Report ID: 119 Created at: 22 June 2023		

Other		
Collaborator/s Name	**Organisation Name**	**Dates**
Nigel Turner	GP Hydro	1 July 2021 - 30 June 2022
Description Technical analysis and cost of micro-hydro study		
Report ID: 119 Created at: 22 June 2023		

Other		
Collaborator/s Name	**Organisation Name**	**Dates**
Aaron Hilton	GEM Energy	31 October 2021 - 30 September 2022

Description
Technical assistance on floating PV

Report ID: 119
Created at: 22 June 2023

Consultant		
Collaborator/s Name	**Organisation Name**	**Dates**
Sarah Beitel	Epic Environmental	1 July 2021 - 30 June 2022

Description
Technical analysis on biodiversity studies

Report ID: 119
Created at: 22 June 2023

Consultant		
Collaborator/s Name	**Organisation Name**	**Dates**
Justin Couper	Project-e	2 January 2023 - 30 June 2023

Description
Costings for installation and connection of large-scale floating PV

Report ID: 119
Created at: 22 June 2023

Summary for Public Release

Executive Summary:

This project has undertaken extensive climate analysis and extension to help cotton growers manage risk in their businesses. The CottonInfo Moisture Manager is published monthly and showed good engagement with analytics showing high open rates throughout the project term. Climate risk was also presented to students enrolled in the UNE cotton production course annually. Ag Econ also helped direct cross-sectoral research via FWFA and MCV research projects, with a published study on changes in summer rainfall focusing on cotton-growing regions a highlight. A range of economic analyses was undertaken on farming practices alongside routine Gross Margin tasks throughout this project including: cotton picker investment analysis - buy or contract?, enhanced efficiency and fertiliser best practice analysis, irrigation water benchmarking, and two studies on emerging opportunities for grower participation in biodiversity markets. While AE2101 is an analysis-based project, e-news analytics for economic analysis showed good industry engagement as evidenced by record open rates and click-through's for the cotton picker analysis. Energy technology benefit-cost studies identified three possible investment areas to reduce emissions and lower energy cost: micro-hydro in irrigation, floating solar PV to offset pumping costs and save water and floating solar PV used to offset cotton ginning energy costs and produce green ammonia. While these results found reduced emissions and tardi investment returns in some cases, changes in future energy costs and growing demand for sustainable cotton may see these opportunities implemented in the future.

Micro hydro study:

Energy is at the forefront of agricultural issues in Australia. Two key concerns dominate the discussion of agrarian energy: pricing volatility of energy and greenhouse gas emissions from energy inputs impacting product sustainability. The Australian cotton industry exports its entire crop virtually and has been at the forefront of identifying means to lower its carbon footprint for an ever-increasing environmentally conscious consumer. Cotton, as a summer crop reliant on irrigation to supplement in-crop rain, the inclusion of micro hydropower can offer economical and sustainable small-scale solutions in some circumstances. Water is a clean, cheap, and emissions-free energy source widely adopted in other countries in remote rural areas for more than a hundred years. A low head micro hydropower system's main advantages are that the energy supply is predictable if enough water is available. However, a load source is generally required close to the point of generation. This study presents a theoretical inclusion of a micro-hydro turbine into a cluster of energy generation, including solar PV, underpinned with grid power to drive an irrigation bore pump at Wee Waa in New South Wales. Under the proposed investment scenarios, the study found the 5 kW micro-hydro turbine offered the best returns in combination with grid and solar PV, paying back in around five years. Sensitivity testing revealed that project returns improved further when vertical fall exceeded 1.5m and flow rates greater than 55 litres per second. Overall, the analysis showed a 70 per cent renewable penetration of the optimal solution (grid/solar PV/hydro) and substantial emissions abatement totalling 3,530 t CO2e over the modelled 25-year project life.

Floating PV study:

Agricultural industries are at the forefront of the impacts of extreme weather events, and equally at the forefront of identifying practices to adapt to a changing climate and to improve sustainability. The cotton industry is the largest broad-acre irrigator in Australia, with 90% of the nation’s crop reliant on water to maximise yield. On-farm earthen water storages are critical farm infrastructure used to collect and store water for irrigated cropping. However, evaporation losses from such storages can be very significant. While industry research into mitigating evaporation losses is ongoing, a practical and economic solution remains at large. In parallel, as the world moves towards decarbonisation, there is an increasing demand to build renewable energy systems on what is also highly productive farmland. Installing floating solar photovoltaic (FPV) systems on water storage has the potential to address the dual concerns of evaporation losses and high land opportunity costs, whilst at the same time contributing to decarbonisation and improving sustainability.

This study assesses the costs and benefits of installing a FPV system on the water storage of a case study irrigated cotton farm in Goondiwindi, Australia, under three different scenarios. The first two scenarios consider installing a small-scale FPV system sized to help serve the energy demand from a nearby bore or lift pump adjacent to the water storage in an on-grid scenario and in an off-grid scenario. The study shows that the investment offers a real internal rate of return (IRR) of 14.8% in the on-grid scenario and 11.9% in the off-grid, diesel-powered scenario. The returns are sensitive to several key assumptions, including the costs of the floating structures and the projected future cost of energy, such as diesel fuel. Whilst the benefits from reduced evaporation from a small-scale FPV system contribute to the investment returns, the water savings are small compared to the total size of the water storage. The emissions intensity per bale of cotton improves by 28 kg CO2e per bale in the off-grid scenario and by 59 kg CO2e per bale in the on-grid scenario. The third scenario considers the potential for a large-scale FPV system that covers the entire water storage. The results indicate potential economic benefits of $223,000 per year over the 25-year life of the FPV system from water savings when the gross margin value of water is used. However, a large-scale FPV system requires significant capital investment, expertise and proximity to the electricity transmission network and would likely need to be built and operated in partnership with a renewable energy developer.

The study identifies several areas for future investigation, including potential alternative uses for the electricity generated by an FPV system, such as the production and use of green hydrogen. Other areas include the potential for mid-scale grid-connected FPV systems in areas close to the distribution network but not the transmission network, and future integration between FPV systems, irrigation water storages, and government policy on renewable energy.

Green hydrogen study:

Agricultural supply chains are coming under increasing pressure to lower emissions to meet national and sector-wide emissions reduction targets. In Australia's cotton industry, strategies to mitigate emissions at the farm level have been the focus of research. New technology options involving green hydrogen are on the horizon that can potentially substitute or complement grid and gas power, diesel fuel, and fertiliser production to significantly lower emissions on farms and during early-stage processing at the cotton gin. An investment analysis applying floating photo voltaic (FPV) arrays on irrigation reservoirs, together with the production of hydrogen and/or green ammonia using a discounted cash flow over 25 years, showed that the cost of production remains in excess of traditional energy sources derived from fossil fuels. However, the scenario analysis revealed substantial cotton lint bale emissions reduction. Emissions were lowered by 6 kg CO2e per bale (34%) by adding FPV energy to the grid-powered gin, and a 15 kg CO2e per bale reduction from producing green ammonia used as crop nitrogenous fertiliser. A third combination of the FPV powering the seasonal demand of cotton ginning and out-of-season green ammonia production lowered emissions by 23 kg CO2e per bale. The study also emphasises the reliance on policy instruments to support the private sector for industry adoption of green hydrogen, as high carbon price remuneration is a prerequisite to achieving positive investment returns. The analysis also explores

technology benefit-cost studies identified three possible investment areas to reduce emissions and lower energy cost: micro-hydro in irrigation, floating solar PV to offset pumping costs and save water and floating solar PV used to offset cotton ginning energy costs and produce green ammonia. While these results found reduced emissions and tardi investment returns in some cases, changes in future energy costs and growing demand for sustainable cotton may see these opportunities implemented in the future.

the scalability of FPV as a regional source of green hydrogen and ammonia for fuel and fertiliser in the cotton industry, finding megawatt facilities can serve large areas of cotton production and crop nitrogen requirements. Ancillary benefits of applying FPV include addressing public concerns about water security and the alternative of irrigation reservoirs to house large-scale renewable energy facilities and in doing so, protect prime agricultural land.

Climate study:

Climate variability and extremes adversely impact Australian cotton crop production and impose a major constraint on farm planning, industry supply chains, and resource allocation. This study reviews time-series yield and crop production methods to account for climate, as well as performs a cotton yield and climate time series analysis using rainfall and temperature data. This study demonstrates that dryland lint yield gains during average-to-moderate rain/temperature years while irrigated lint yields have improved during more frequent average rain/hot growing seasons (1997–2018). Results also discovered climate in central cotton growing areas is impacted by El Ni˜no Modoki and Ni˜no4 indices and the various phases of ENSO. These findings translate into meaningful actions for industry adaptation and in turn provide a valuable step in accounting for climate variability and yield-related inputs such as fertiliser and water resources.

Objectives:

To investigate the feasibility of incorporating three separate green energy technology options into the cotton system and report on changes to sustainability

Background:

Grower interest in energy technologies to displace traditional grid or diesel-powered sources of fuel and fertiliser, for economic and sustainability reasons.

Research Activities:

Our research involved a detailed investigation of each technology to assess theoretical and practical approaches when integrated into an irrigated cotton system. Engineering experts were called upon to assist with identifying the costs and performance of each proposed technology option and review the results.

Outputs:

The overarching outputs found each of the three technology options made modest gains in sustainability when integrated into the irrigated cotton system. Economic outcomes were far less favorable in each, with a high capital cost of each option weighing negatively on payback and internal rates of return.

Impacts:

The impact and implications of this research are directing future industry research and aiding government policy that may help design incentives influencing technology adoption.

Key Publications:

Suite of Gross Margin publications:

Furrow irrigated, semi-irrigated, contracted irrigated, overhead irrigated, dryland, overhead irrigated, northern Australia GMs, changeable GMs and tabled assumptions.

Four metre controlled traffic machinery changeover study

The economics of N Management

The economics of irrigation management

Micro-hydro and irrigated cotton investment analysis

The economics of Enhanced Efficiency Fertilisers

Using cotton yield maps to improve profitablity

Biodiversity offset opportunities for Qld growers

Biodiversity offset opportunities for NSW growers

Cotton picker investment analyses: buy or contract?

Summer rainfall study MCV 2022

Floating solar PV and irrigation pumps: investment analysis