



# Centre for Agricultural Engineering

## Research Capability





## OUR PURPOSE

We believe global growth, prosperity and sustainability of agriculture is dependent on the advancement of innovation, technology and practices that will occur through engineering solutions.

*Prof Craig Baillie, Centre Director*

## About the Centre for Agricultural Engineering

The Centre for Agricultural Engineering (CAE), previously known as the National Centre for Engineering in Agriculture (NCEA) was established in 1994 to specialise in developing solutions for a sustainable and profitable rural sector.

CAE is a research centre of the University of Southern Queensland (USQ) based on the Toowoomba campus. The centre is focused on delivering applied, practical and profitable research solutions that strengthen agricultural productivity and address environmental management challenges in Australia and overseas.

The centre's research focus covers areas including sustainable agriculture, energy use, bioresource recycling, water resources management, farming systems innovation, sensing, automation and robotics. This is achieved through applied engineering research, training and commercialisation of technologies and precision farming techniques and related investigations.

Researchers work to identify and align national and global industry needs and opportunities with the University's considerable research capacity, targeting areas for development through co-investment and partnership, both nationally and internationally. This builds on 50 years of Agricultural Engineering at USQ.

### OUR VISION

- To be recognised internationally as a leader in research and development for agricultural engineering and to provide value to our research partners and stakeholders through high impact research.

### OUR MISSION

- To undertake engineering research in agriculture and related environmental areas relevant to improving the profitability, environmental sustainability and socio-economic wellbeing of

our rural industries and their natural resource base, as well as the manufacturing and service sectors which support them;

- To undertake high quality, impactful research through engagement and commercial interaction with industry; and
- To act as a focus for engineering in agriculture Australia-wide and internationally via development of collaborative research initiatives and partnerships.



**Dr Joseph Foley** is trialling automated furrow irrigation systems in a cotton field in Wee Waa.



**Dr Malcolm Gillies** demonstrates the smarter irrigation technologies available through the VARIwise research work.

## HIGHLIGHTS

Through the support of our research partners, we have delivered significant benefits to farming with some key highlights including:

- Automated surface irrigation systems able to apply water as efficiently (90%) as centre pivot and lateral move irrigation systems without the additional cost of labour and electricity or diesel.
- Decision support tools to improve resource efficiency, a notable example including the DSI Scheduler, an App which is used to assist irrigation water management at collaborating farmer field sites in 6 villages in Nepal and India.
- Assessment of controlled traffic farming systems which has identified zero till farming has the potential to reduce nitrous oxide emissions by 30%, informing carbon farming initiatives.
- Fine tuning nitrogen management guidelines in the Australian Sugar Industry to incorporate variable rate fertiliser

applications as a standard option for farmers.

- Commercialisation of weed sensing technology which can distinguish weeds from crop and operate at speeds of up to 20 km/h and apply 80% less herbicide.
- Providing industry with alternative energy, waste recovery and energy efficiency options to enable exact assessment that can provide multi-million dollar opportunities and cost savings.
- Research Master Agreement signed with John Deere, recognising USQ's world-leading technological innovation and providing opportunities for researchers and their counterparts at John Deere to work together to develop agricultural technologies.



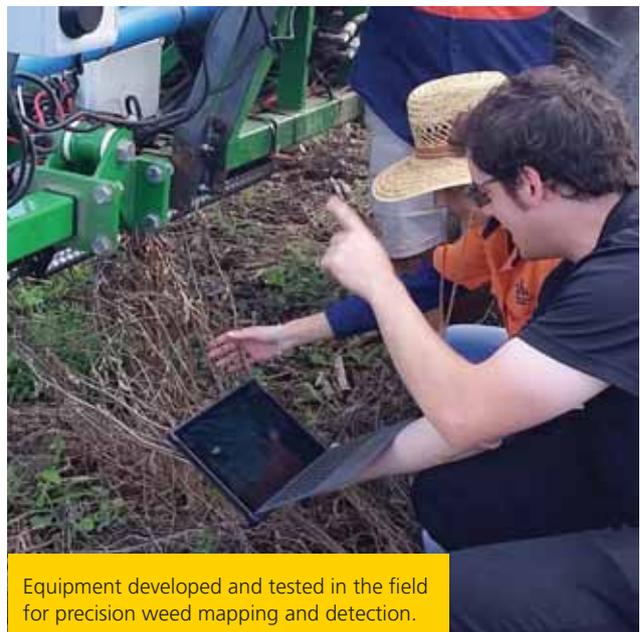
CAE staff work closely with industry to develop and test technologies.



Working directly with farmers in the field enables researchers to deliver outcomes to end users.



Smarter irrigation technologies are being developed and trialled by researchers.



Equipment developed and tested in the field for precision weed mapping and detection.

# Research Program Teams

## IRRIGATION AND WATER MANAGEMENT

For 25 years, the centre has been working with industry to develop more sustainable and efficient ways of using water to grow crops and support the environment. Irrigation research is conducted across a wide variety of agricultural industries nationally and internationally.

The centre is a national leader in precision irrigation and water management research. Modernisation and automation of both surface and pressurized irrigation systems is a key focus area, where we work closely with the cotton, sugar, dairy and other industries as well as commercial companies. Benefits achieved include reduced reliance on farm labour for irrigation management, improved crop production, improved irrigation efficiency, reduced pumping energy costs and reduced environmental impact.

Technical support and training is delivered to local industry and international organisations and a key focus is development of decision support tools and knowledge management systems to improve irrigation management.

We are also working internationally to provide small scale farmers with knowledge and skills to adopt new irrigation and water management technologies and approaches to improve their productivity and sustainability.

## FARMING SYSTEMS INNOVATION

The research team delivers outcomes by combining agricultural sciences, agricultural inputs and practices, agronomic production databases and precision agriculture technologies to efficiently manage agronomic and livestock production systems.

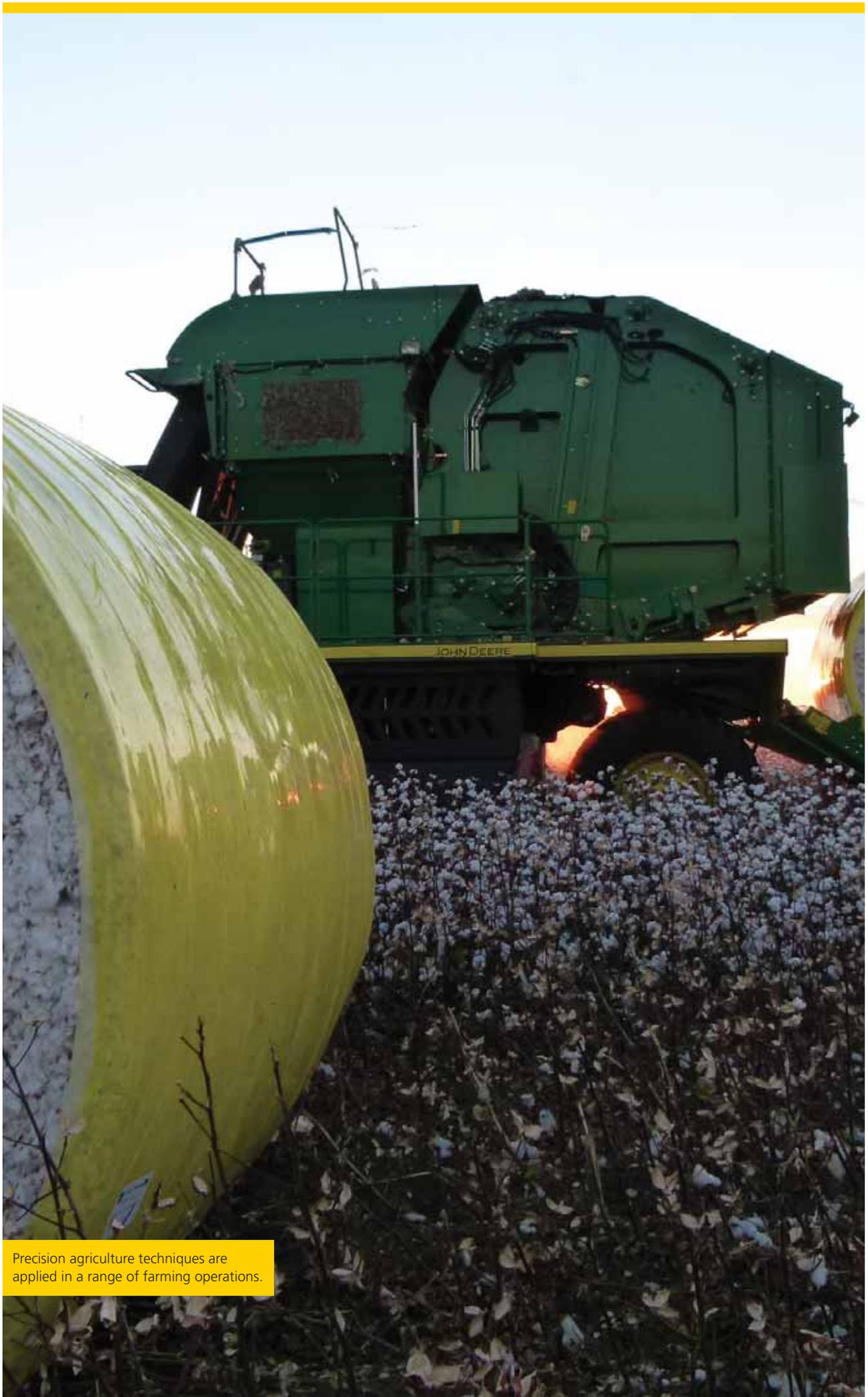
Our researchers are involved in investigating soil and crop nutrient management efficiencies and effects of fertilisers, treated water from the resource sector and controlled traffic farming on soils and catchments.

The team is able to gather on-farm information pertaining to the variation and interaction of site-specific spatial and temporal factors affecting crop and livestock production. Information is then integrated with appropriate data derived from field scouting, remote sensing and other precision agriculture technologies in order to facilitate on-farm decision making.

Information is used to prescribe and deliver site and enterprise specific application of agricultural inputs and management practices in agricultural production systems.



**Dr Alison McCarthy** works with automated irrigation systems.



Precision agriculture techniques are applied in a range of farming operations.

## ENERGY AND BIORESOURCE RECYCLING

Increasing energy costs are one of the major challenges facing Australian agriculture and a key driver of energy efficiency. Our team is investigating the viability of renewable energy sources and looking at ways to reduce consumption of non-renewable energy on farms and in agricultural industries. Information on optimising irrigation system performance, energy efficiency, selecting alternative farming systems or methods, best management practices and the benefits of emerging technologies is being developed and outcomes provided to industry.

Biogas produced from organic waste is one of the key areas investigated. The research program team have been involved in a number of projects which assess methane production from a range of agro-industrial wastes. Projects have involved red meat processing, pork, feedlot and waste water utilities, giving the team a well-rounded yet high level of expertise in anaerobic digestion and a good understanding of a range of feedstocks. Current projects in the meat processing industry through industry collaborations are working on developing tools and practices to better manage waste streams and biogas process optimisation. Research is identifying new opportunities for recovery of high value-added products throughout the supply chain to translate the uptake of novel waste management practices across Australia's red meat processing industry.

## ROBOTICS, AUTOMATION AND MACHINE VISION

The team develops advanced robotic sensing technologies to enhance autonomy in crop protection, biosecurity and animal welfare on-farm, with aims for on-farm adoption in the commercial farm conditions of today. The team also provides leadership on the integration of sensing systems with agricultural robotics into the future.

Primarily the advanced sensing systems involve machine vision technology, which also incorporates supporting mechanical structures for on-farm installation and deployment, electronic interfacing with controllable outputs like spray nozzles, drafting gates or remote notification in real-time and fusion of multiple digital data sources and decision support systems.

The team is applying automation to both crops and livestock. The challenge associated with machine interpretation with the natural environment and natural mediums has been met with successful innovation in sensing, UAVs and robotics. Automation in industrial meat processing, integrating robotics for cutting and handling, is a further dimension in which the team has considerable expertise and success.



Researchers undertake extensive lab analysis work in anaerobic digestion.



Weed detection equipment being tested on farm machinery.

# Engagement

CAE works closely with industry to accelerate access to smarter, technology-based ways of increasing productivity, reducing costs and maximising the efficient use of available resources. Our research is strengthening agricultural productivity and environmental management challenges in Australia and overseas.

The centre is developing solutions for a sustainable and profitable rural sector through collaboration with landholders and rural industry groups with research across a broad range of agricultural challenges faced by the growers on the ground.

These collaborations include the use of international locations for trialling equipment and technologies, and allows universities to explore opportunities to build partnerships in common research areas. The engagement with industry to determine their needs in relation to research requirements also contributes to the development of collaborative partnerships.

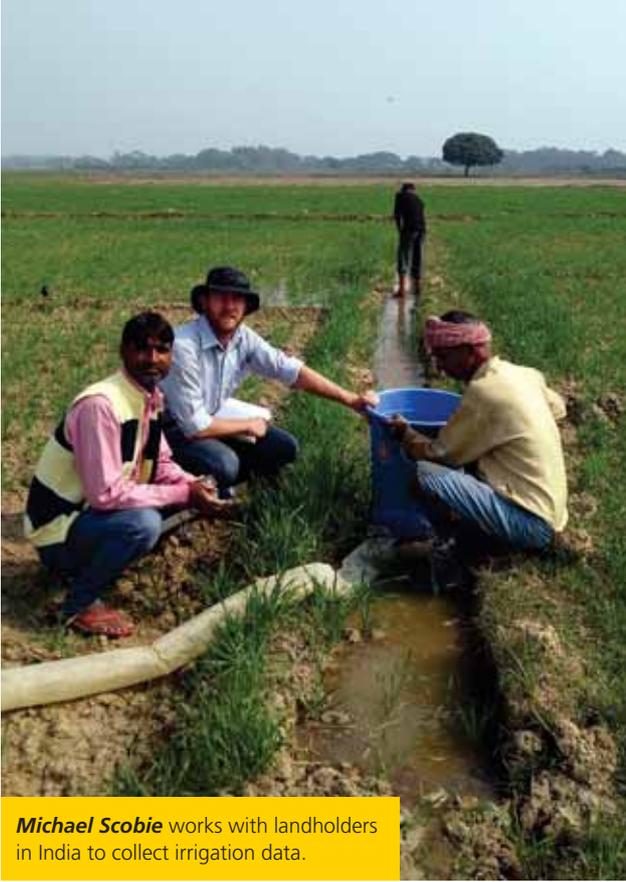
International research and engagement covers a wide scope of activities. Research areas include bioenergy, nutrient management in sugarcane production, weed detection and identification, and automation technologies. This work is undertaken through collaborative partnerships with funding organisations and industry partners internationally to ensure the research provides beneficial outcomes for all parties involved.

Internationally, CAE works on projects funded through ACIAR (Australian Centre for International Agricultural Research) in countries including India, Nepal, Bangladesh, Cambodia and Laos. Projects focus on improving dry season agriculture for marginal and tenant farmers, and integrated soil and water management in vegetable production. The demonstrated outcomes include providing local landholders with the skills, equipment and confidence to adopt new technologies to improve their productivity and create a viable farming future.

Researchers also hold positions on national and international committees and associations which enable staff to champion research initiatives and continually build research interests and capability.



International Energy Agency (IEA) Bioenergy Task 37 Energy from Biogas representatives meeting held at USQ with **Assoc Prof Bernadette McCabe** (front centre) and **Prof Craig Baillie** (back left).



**Michael Scobie** works with landholders in India to collect irrigation data.



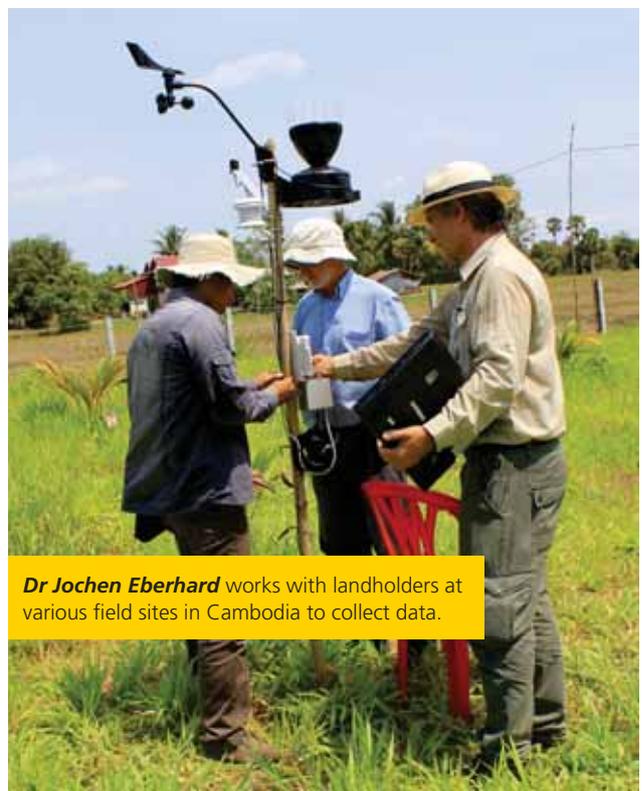
**Dr Jochen Eberhard** undertakes soil sampling at Acland Coal Mine rehabilitation site.



Installing irrigation control and monitoring systems on a farm as part of the Smarter Irrigation project.



Demonstrations at field days engage the community in our research activities.



**Dr Jochen Eberhard** works with landholders at various field sites in Cambodia to collect data.

# Impact of Research

USQ is a leading innovator in agricultural research, working together with industry to develop new technologies. This partnership, along with leading global machinery manufacturers is working to accelerate access to innovative driverless tractor technology, showcasing the benefits of this technology to key agricultural stakeholders.

In other research and central to the development of new agricultural technologies by USQ is a partnership with global agricultural machinery giant, John Deere. The focus of this collaboration is to develop the next generation of technology that will be encountered on farm including, machine automation and control to improve producer productivity in all aspects of the growing cycle. The research partnership will benefit growers in Australia and globally by reducing agricultural production costs through precise management of farming inputs and maximising yields and profits with greater intelligence.

Our research impact also extends to the intensive livestock and food processing sectors. On-farm, intensive feed and processing sectors from red meat, dairy and pork industries produce significant quantities of waste which costs these industries between \$100-200 million per year to manage. Converting these wastes into valuable products such as energy products, fertilisers, feeds and chemicals for use in agriculture can capture a market opportunity in excess of \$100 million per annum. Research into realising the potential of new revenue streams is being undertaken to understand key information gaps on waste composition and quantities produced by these industries

**“We are working alongside USQ’s respected researchers... providing tools for agriculture to feed, fuel and clothe the increasing global population.”**

**Peter Wanckel**  
Australian Managing Director  
(John Deere)



CAE is also a national leader in the agricultural application of sensor, robotic and computing technologies and now has a drone program that has taken flight with several industry collaborations. Tomorrow's farmers will look to the skies not just at the ground.

Using machine vision to identify unhealthy crop areas will mean direct benefits for the cotton, grains, pastures and viticulture industries. Farmers will have access to a different view of their paddock with diagnostics that detect where the problems exist and what they might be. This research is aimed at increasing on-farm productivity by heading off crop health problems and reducing the use of unnecessary or poorly timed applications of herbicide, pesticide and fertiliser.

Another area where the impact of our research can be evidenced is through the need to conquer the humble weed. A machine vision field-ready prototype was developed in 2014, which was able to discriminate between crops and weeds for targeted herbicide applications. Provisional patents have been lodged for this technology and a growing set of algorithms have since expanded to a number of agricultural industries. Typical applications include distinguishing grass weeds and broadleaf weeds in sugarcane, horticulture and cotton.

Compared to existing technologies available to farmers, this system will offer superior weed detection and differentiation capabilities. In a highly competitive international market, Australian growers must adopt cost-efficient methods to produce high-yielding crops, without sacrificing on quality. USQ's weed detection technology will enable growers to implement weed management strategies for strategic crop planning that reduce herbicide usage.

Researchers at CAE were responsible for the development and implementation of IrriMATE™ technology which has led to significant savings for one of Australia's largest rural export earners, the cotton industry. CAE identified that major water use efficiencies could be gained in the cotton industry by changing the way irrigation was managed on farms. Subsequently, IrriMATE™, a predictive software tool and methodology, was developed to optimise surface irrigation practices which were commercialised through license agreement.

A cost-benefit analysis commissioned by the Cotton and Research Development Corporation (CRDC) showed IrriMATE™ technology to be a major driver for greater water productivity in the cotton industry. The analysis showed that water savings across cotton systems were 28.5GL/yr with a corresponding economic gain of \$33m/yr. The average farmer utilising the technologies can generate \$83,000/year extra profit.

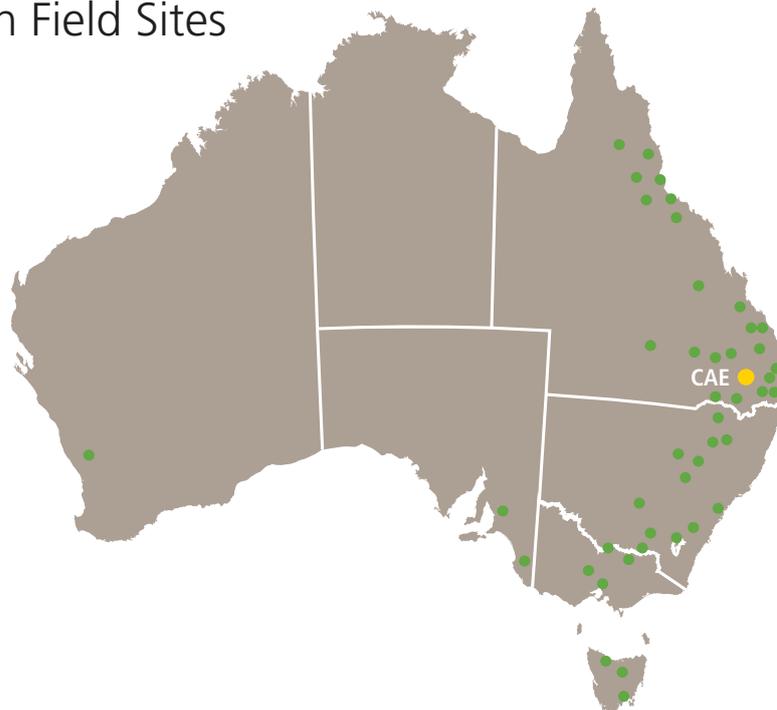
Building on these successes, CAE researchers are developing and demonstrating smart automated irrigation systems which are showing further benefits.



# International Engagement



# Research Field Sites



## USQ RESEARCH

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