Agriculture and Environment Research

unisq.edu.au/research

Contents

Research at the University of Southern Queensland

The University of Southern Queensland is a dynamic regional University that has established its position as a prominent teaching and research institution, providing education worldwide from three physical locations across South East Queensland (Toowoomba, Springfield, and Ipswich) with an extensive online presence. The University's mission is to drive economic and social development through higher education and research excellence.

University researchers are working directly with local communities, industry, and our international partners to form strong and enduring research partnerships that deliver tangible benefits and real impact. The University's world-class research institutes, centres and schools are home to unique state-of-the-art facilities enabling our researchers to deliver a broad range of research outcomes across multiple disciplines.

The University's Flagship Research Areas

Agriculture and Environment, including Climate Science, Drought Mitigation and Adaptation, Crop Health, Agricultural Technology and Environmental Science.

Space and Defence, including Astrophysics, Hypersonics and Rocketry, and Materials Engineering.

Regional Development, including Agribusiness, Energy, Sustainable Economic Development, Regional Decarbonisation, Innovation, Workforce, Wellbeing, Climate Variability, Culture and Heritage.

Health, including Sport and Exercise Science, Mental Health and Allied Health.

Research Excellence

The global reach and world-class quality of the University's research is confirmed by International Rankings and the Australian Research Council's Excellence in Research for Australia (ERA) Report. In the most recent ERA Report, the University's research was rated as 'world standard or better' in 30 areas of research, and 18 fields of research were rated as 'well above world standard'.

The following 18 fields of research received the ultimate accolade of 'well above world standard'

Astronomical and Space Sciences
Materials Engineering
Mechanical Engineering
Numerical and Computational Mathematics

Environmental Science and Management
Agriculture, Land and Farm Management
Crop and Pasture Production

Physical Sciences
Medical and Health Sciences
Human Movement and Sports Science

Clinical Sciences
Psychology
Nutrition and Dietetics
Public Health and Health Services

Chemical Sciences
Inorganic Chemistry
Macromolecular and Materials Chemistry
Microbiology

In the 2024 Times Higher Education World Rankings, the University of Southern Queensland was ranked in the 350-400 band and is ranked #154 in the world for Research Quality.

In the 2024 Times Higher Education Young University Rankings, the University of Southern Queensland was ranked #55 in the world.

The University of Southern Queensland's Agriculture and Environment Research Portfolio

The University is home to the Agricultural Science and Engineering Precinct; a state-of-the-art facility.

Agricultural and Environmental Research

The University of Southern Queensland has longstanding research expertise in agriculture, crop health, natural resource management, environmental and climate sciences. The University's Institute for Life Sciences and the Environment leads this work and is supported by strong partnerships with state, national and international governments, and industries, which play key roles in developing and enhancing research capacity to meet emerging needs.

Research Capabilities

- **Crop Health** to ensure healthy crops for global food security and on-farm profitability.
- **Agricultural Engineering and Technology** delivering applied, practical and profitable research solutions that strengthen agricultural productivity and address environmental management challenges in Australia and across the world.
- **Environmental Science** to address key agricultural and environmental challenges at both local and global scales, with the aim of conserving and sustaining natural resources, whilst enhancing productivity.
- **Climate Science** to solve climate-related problems by combining research and practical applications in climate and meteorological science across a range of industries.
- **Drought Mitigation and Adaptation** to evaluate and manage the risks and opportunities associated with climate change, variations in climate, and weather and climate extremes.

Infrastructure

The University's agricultural and environmental research is supported by state-of-the-art facilities and equipment that enables researchers to deliver outcomes across multiple fields.

Agricultural Science and Engineering Precinct

The University of Southern Queensland supports a range of research endeavours in the areas of crop protection, plant pathology and biotechnology.

The headquarters of this work is the Agricultural Science and Engineering Precinct (ASE Precinct), a nexus between microbiology labs through to processing labs, state-of-the-art glasshouses and field research units.

This facility enables researchers to investigate the entire spectrum of crop development and health that underpins crop protection in Australia. The ASE Precinct was supported by the Grains Research and Development Corporation and the Broadacre Cropping Initiative through the Department of Agriculture and Fisheries Queensland.

ASE Precinct features include:

- 10 laboratories featuring specialist quarantine facilities.
- Four glasshouses with separate, individually controlled bays.
- Netted and irrigated facilities for field research.
- Four state-of-the-art controlled environment rooms.

Molecular Laboratory

The University has invested in significant research infrastructure and equipment to deliver an expansive molecular facility.

Key equipment includes:

- **Illumina MiSeq Platform** capable of short-read sequencing to support research into metagenomics and whole genome sequencing of fungal isolates.
- **Oxford Nanopore minION** capable of long-read sequencing to support research into whole genome sequencing.
- **Biomek FXp Automated Workstation** capable of automating liquid handling processes for next-generation sequencing or standard molecular procedures.
- **Digital Droplet PCR** for absolute quantification of target DNA copies with high precision and sensitivity and a low limit of detection.
- **PIXL Precision Microbial Colony Picker** a robotic colony picker that automates imaging, colony recognition, colony selection and picking.
- **Microscopes** currently used for taxonomic work on novel endophytic fungi, for example, from rainforest plant hosts, and mycorrhizal fungi, particularly the genus Serendipita.
- **E600 Nikon Fluorescence Microscope** for characterising the mode of action of bioactive molecules isolated from the fungal endophytes.

The Molecular Laboratory enables a range of diagnostics across a number of fields, particularly in crop health research.

Crop Health

The University of Southern Queensland is home to world-class crop health research expertise that is contributing to the ongoing sustainability of important food crops and the broader mission of global food security. The University's Centre for Crop Health leads this research and focuses on the sustainable management of diseases in summer and winter cropping systems in Australia.

Researchers in the centre are internationally recognised for their expertise in the development and selection of resistant and tolerant germplasm, advanced crop diseases diagnostics, biosecurity research, biological control and genetics, and genomics of both crops and pathogens.

The Centre for Crop Health actively seeks to enhance capacity for surveillance and diagnostic expertise across government and industry programs to recognise, collect, identify and catalogue new and emerging pathogens that present biosecurity risks with the potential to impact Australian agricultural production. For example, powdery mildews are increasingly being detected by national border security and quarantine programs, yet they remain a largely understudied group of plant pathogens in Australia.

Research Capabilities

- **Crop Disease Management** including the management of soil-borne and foliar diseases of crops using genetic, genomic, phenotypic and pre-breeding approaches. Research aims to broaden the scientific knowledge of the causal agents, including crop pathogenic fungi, bacteria, nematodes, and viruses and viroids.
- **Crop Pathogen Genomics and Biology** to improve crop disease management by better understanding the genetics, genomics, biology, and infection cycle of crop pathogenic fungi, nematodes, and bacteria.

- **Biological Control of Weeds, Crop Pests and Pathogens** focusing on suppressing crop pathogens with mycoparasites; insect pests with entomopathogenic fungi; and invasive weeds with specialised fungal plant pathogens.
- **Biosecurity Research** through the precise identification of fungal and bacterial pathogens using classic and state-of-the-art molecular diagnostic methods.

Associate Professor Anke Martin is drawing on her expertise in fungal genetics to lead a project that aims to future-proof the Australian barley industry.

Research Projects

Protecting Australian Barley Crops from Fungal Disease

Each year, plant pathogens cause millions of dollars in damage to Australia's barley crops. A research project led by the University of Southern Queensland is set to equip Australian barley growers with novel biological and genetic tools to aid in their fight against a fungal disease through the development of disease-resistant barley varieties.

Project lead Associate Professor Anke Martin is aiming to produce poly-virulent fungal strains containing multiple disease-causing genes. These poly-virulent strains will drastically reduce the costs involved in testing barley germplasm for resistance as the number of assays needed are reduced.

The team is also studying international barley germplasm for potential resistance genes that could be incorporated into Australian barley varieties. A key project outcome will be the release of a barley variety that has durable resistance and will reduce pathogen impact and the need for chemical inputs, improving yield and profitability for the grower and enhancing food security.

This project is funded by an Australian Research Council (ARC) Linkage Grant and has received support from the Broadacre Cropping Initiative and has also received funding from industry partner InterGrain Pty Ltd. The research team includes partners from Curtin University, The University of Melbourne, the Queensland Department of Agriculture and Fisheries and Ackermann Saatzucht GmbH and Co.

In December 2014, The University of Southern Queensland entered into the Broadacre Cropping Initiative (BACI), a research and development partnership with the Queensland Department of Agriculture and Fisheries to build synergies, critical mass and research capacity to enhance the sustainability of broadacre, or large-scale grain cropping industries and operations, across Queensland. This longstanding partnership is focused on the fields of wheat pathology, winter crop nematology, summer grain pathology, agricultural engineering and agricultural systems modelling.

Broadacre crops such as wheat, barley, sorghum, and legumes are a vital pillar in Queensland's agricultural industry, contributing around $5 billion every year to the state's economy.

During the last decade, the suite of BACI projects, funded by the Queensland Department of Agriculture and Fisheries and the University, have resulted in significant direct impact, including enhanced plant protection, production system innovation, and the development of enabling technologies.

Dr Noel Knight's research is helping barley growers to remain one step ahead of fungicide resistance.

Early Detection of Fungicide Resistance in Queensland Barley

Research monitoring for fungicide-resistant diseases in barley plants across southern Queensland has found that resistance is more common than growers might have suspected. Fungicide resistance generally only becomes apparent when there is a fieldwide crop failure. At that point a large shift in the pathogen population has already occurred, making the problem challenging, or even impossible, to control.

University Research Fellow Dr Noel Knight took net blotch disease samples from 10 barley fields across southern Queensland and analysed them using a DNA surveillance method. Dr Knight investigated whether any of the genes responsible for fungicide resistance were present in the samples and, if so, how prevalent they were. From the samples taken, Dr Knight was able to detect fungicide resistance genes in 34 per cent of the regional population, and up to 68 per cent in individual fields. While this may seem concerning, these results highlight the importance of growers using this knowledge to their advantage and adjusting their strategies to enable early intervention while management is still possible. Dr Knight's research was conducted in collaboration with Curtin University and the Centre for Crop and Disease Management, the Queensland Department of Agriculture and Fisheries and the University's Broadacre Cropping Initiative.

Sustainable Agriculture

Research at the University of Southern Queensland addresses key agricultural and environmental challenges at local, national and global scales, to deliver multifunctional landscapes that conserve and sustain our natural resources while enhancing productivity.

This work is led by the Centre for Sustainable Agricultural Systems, which focuses on the delivery of practical solutions for the sustainable management of complex agricultural enterprises and agroecosystems.

Centre researchers assist decision-makers to diagnose system constraints and make informed decisions that improve productivity, profitability and environmental sustainability; address problems and capitalise on opportunities; and analyse, develop and implement policies, practices and designs.

Research Capabilities

- **Agricultural Systems Modelling** to facilitate on-farm practice change, by providing innovative decision support systems and apps to help farmers make informed decisions to improve profitability and social and environmental sustainability.
- **Sustainable Agroecosystems Research** to enhance productivity, profitability and environmental sustainability of agricultural enterprises and agroecosystems. This work spans a range of approaches including soil science, environmental science and agrimetrics.
- **Wildlife Management** to reduce human-wildlife conflict and improve agricultural and environmental sustainability.

Professor Keith Pembleton applies agricultural modelling frameworks to local farming management practices to maximise production.

Research Projects

Unearthing the Secrets of Soil Management

Soil is a critical resource, providing the nutrients, water and oxygen needed to support our food systems. It's also an intricate system with complex interactions, which need to be managed appropriately to maintain its health and productivity.

The University of Southern Queensland's Dr Chloe Lai, an agricultural systems modelling scientist, has been awarded funding by Australia's Soil Cooperative Research Centre (CRC) to find the best ways to manage multiple soil constraints, such as sodicity, acidity and salinity, which are known to limit a soil's yield.

Dr Lai's project combines existing modelling tool APSIM (Agricultural Production Systems sIMulator) with machine learning technology to identify and prioritise the management factors that are most critical in maintaining soil productivity. The project team will use Soil CRC's extensive field trial data to train APSIM, which robustly reflects plant and cropping system processes, to generate synthetic data to be fed into machine-learning algorithms that are structured to reflect the scientific understanding of soil processes.

The project will ultimately deliver a tool that provides practical and easy-to-use solutions directly to farmers to identify, prioritise, and manage soil constraints that are backed by robust science. Critical to the success of this project is the participation of grower group partners West Midlands Group, Mallee Sustainable Farming, Riverine Plains and Burdekin Productivity Services, who are at the frontline of adopting new science and informing the development of the tool to ensure it addresses the challenges growers face.

Protecting the New Holland Mouse

A chance sighting of a threatened mouse species has sparked a new conservation project, focused on determining the habitat and distribution of the small rodents in Queensland. University of Southern Queensland lecturer Dr Meg Edwards was on a student field trip in Emu Creek, when the team caught a New Holland Mouse; the northernmost record of the species to date.

Dr Edwards and a team of colleagues are continuing their research into the species with funding from the Department of Environment and Science's Queensland Threatened Species Research Grants program. The New Holland Mouse is considered Endangered in Victoria and Tasmania and Vulnerable in Queensland, and the project will be a preliminary investigation into where the mice populations are in Queensland to gain an understanding of their ecology and assess their biggest threats.

The project is a collaboration of the University of Southern Queensland, the Department of Environment and Science and the Turner Family Foundation. Additionally, the project will investigate the effects of the New Holland Mouse on the soil fungal communities, as digging mammals have shown to be important ecosystem engineers turning around soil, which contributes to nutrient release and soil fungal dispersal in ecosystems.

Dr Meg Edwards is investigating the habitats and ecology of the endangered New Holland Mouse.

Agricultural Engineering

Through the Centre for Agricultural Engineering, the University delivers applied, practical and profitable research solutions that strengthen agricultural productivity and address environmental challenges in Australia and overseas. The Centre is an internationally recognised leader in research focused on improving the profitability, environmental sustainability and socio-economic wellbeing of rural industries and their natural resource bases, as well as the manufacturing and service sectors that support them.

Research Capabilities

- **Irrigation and Water Management** to develop 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.
- **Farming Systems Innovation** combining agricultural sciences, agricultural inputs and practices, agronomic production databases and precision agriculture technologies to efficiently manage agronomic and livestock production systems.
- **Energy and Bioresource Recycling** exploring alternative energy, waste recovery and energy efficiency options that enable industry to generate self-sustaining energy systems and ultimately cater for their own energy needs. A key area of research focus is the conversion of agro-industrial waste into profitable clean energy with a focus on biogas and biofertilisers from organic waste.
- **Robotics, Automation and Machine Vision** including the development of advanced robotic sensing technologies to enhance autonomy in crop production, biosecurity and animal welfare on-farm, with aims for on-farm adoption in the commercial farm conditions of today.

Research Projects

Improving Chicken Welfare Through Automated Monitoring

Poultry farming in Australia is set for a major advancement thanks to revolutionary research. Associate Professor Cheryl McCarthy, a mechatronic engineer at the University's Centre for Agricultural Engineering, was named the 2023 AgriFutures Australia Researcher of the Year for her groundbreaking work on automated chicken monitoring.

Associate Professor McCarthy's research project, funded by AgriFutures Australia, has successfully been able to track the weight and movement of a flock of chickens using only a camera and image analysis, thus reducing the need for farmers to manually handle their flock.

This automated system not only reduces the stress placed on the animal; it also saves time and provides more frequent and accurate data for the farmer through the application of an algorithm, developed by Associate Professor McCarthy, which can automatically calculate a sample of the flock's weight. The next step for this feat of mechatronic engineering is commercialisation and turning this research into a technology farmers can buy off the shelf and install in their own sheds.

Climate Science and Drought Mitigation

The University of Southern Queensland conducts climate research spanning multiple disciplines, which helps communities and industry to manage the risks and opportunities they face from climate change, climate variability, and weather and climate extremes. Much of this work is done in collaboration with our partners and communities to solve their climate-related problems by combining cutting-edge research and practical applications in climate and meteorological science with agricultural, mining and energy, tourism, hydrological, health, ecosystem, value chain, and economic modelling.

Ground-Breaking Algorithm Redefines Cotton Irrigation

The Cotton Research and Development Corporation (CRDC) has successfully facilitated the commercialisation of groundbreaking research by the Centre for Agricultural Engineering, empowering cotton growers to optimise scheduling from the crucial first irrigation. Through collaborative efforts between CRDC, Australia's national science agency CSIRO, the University of Southern Queensland, and the Smarter Irrigation for Profit program, an algorithm has been licensed to Goanna Ag, providing a vital tool to support growers in their irrigation decision-making process.

The introduction of a new algorithm, pioneered by University mechatronic engineer Dr Alison McCarthy, marks a significant advancement in this field. Leveraging multiarray sensors, this state-of-the-art solution distinguishes between canopy and bare soil temperatures. This advancement allows for early-season canopy temperature measurements, particularly pertinent for the crucial first irrigation, while eliminating the necessity to adjust the height of sensors throughout the crop's growth cycle.

The collaboration across institutions and geographic locations in the Smarter Irrigation for Profit program enabled the development and testing of the algorithm under a range of conditions and is now available for use by cotton farmers, who will benefit from reduced labour and improved precision in sensing for irrigation management.

Turning Waste into Nutrients

The Centre for Agricultural Engineering is partnering with local Toowoomba company Pyrocal Pty Ltd and Logan City Council as part of an ARC Industry Transformation Hub 'Nutrients in a Circular Economy' to investigate the agronomic value of waste-derived biofertilisers. The project is researching the environmental impacts and nutritional benefits of biosolids-derived biochar using glasshouse studies and field trials, including engineering novel granulated biofertiliser mixes using a first-of-its-kind lab scale granulator in Australia.

Outcomes of this work include contributions to regulatory guidance and best practice management. This work also has the potential to be applied across a variety of applications such as mine site rehabilitation. Projects such as these, which develop guidelines for the appropriate use of biochar, highlight how University partnerships with local businesses, councils, and State Governments help the agriculture sector adopt circular solutions to increase profitability and improve sustainability.

Research Capabilities

- **Climate Science and Applications** integrating cutting-edge research and practical applications in climate and meteorological science with agricultural, mining, energy, hydrological, health, ecosystem, and economic modelling.
- **Climate Change Adaptation** to develop and prioritise risk management strategies for rural policies based on the latest climate models to support adaptation and response to extreme events, such as drought, flooding and heat & cold waves, and to build regional resilience.
- **Climate Variability and Extremes** analyses of historical climate variability and extreme risks (such as drought, flood and heat & cold waves) involving ocean (such as El Niño, La Niña, and the Indian Ocean Dipole) and land drivers (such as soil moisture feedbacks and land use). Provision of forecasting services and products tailored to meet the client's unique needs (ClimateArm, Cattle Comfort Index, Heat Load Index).
- **Climate Impacts on Economic Systems and Financial Risk Management** developing sophisticated economic models to assess wide-ranging economic impacts of climate variability and change, and co-designing integrated adaptation and financial risk strategies to manage the impact of climate and weather extremes on agriculture and rural communities.
- **Disaster Risk Reduction and Early Warning Systems** strengthening national and regional capacities and delivering effective early warning and response services, especially for vulnerable populations. This is crucial for enhancing climate change adaptive capacities and building climate and disaster resilience.
- **Climate Systems Modelling in Agriculture and Water Resources** integrating climate forecasts with biophysical models related to agriculture and water using user-friendly risk management tools and services, designed in collaboration with stakeholders, including Drought Monitor and GreenDate.
- **Enhance Awareness and Build Capacity** working closely with the World Meteorological Organization (WMO), Bureau of Meteorology (BoM), and others to provide training, innovative distance education, mentoring, and capacity building for key personnel in developed and developing nations. Supporting research, extension, and technology adoption while fostering collaboration and improving climate knowledge to enhance economic, environmental and social outcomes.

Professor Shahbaz Mushtaq, Dr Vivekananda Mittahalli Byrareddy and Dr Jarrod Kath conduct important work directly with coffee farmers to provide them with access to climate risk management strategies and tools.

Research Projects

Queensland Drought Mitigation Centre

The University has partnered with the Queensland Department of Agriculture and Fisheries and the Queensland Department of Science, Environment and Innovation to form the Queensland Drought Mitigation Centre. The Centre offers a range of decision support tools to help farmers adapt to the current climate and prepare for future climate variability, to enhance their resilience to events such as droughts. These tools can assist farmers with decisions such as when to destock in times of potential drought, which crop variety to sow or how to better manage feedlots and trading systems.

University researchers analyse climate data and work with 'dynamical general circulation models' linking with international climate modelling centres to identify future long-term patterns and the impact of key climate systems such as El Nino and La Nina. This climate science is providing the data behind the Queensland Drought Mitigation Centre's decision support tools, to assist farmers to use improved seasonal forecasts in their planning, and stronger predictive capability for regional agricultural, water planning and environmental management.

Improved Seasonal Climate Forecasts for the Coffee Industry

Coffee is extremely sensitive to climate variability and change. Extreme climate events such as excessive rainfall and drought can significantly impact coffee plants' growth and development. The rainfall variability affects the critical stages of crop growth, resulting in substantial yield loss and loss of income. Enhanced understanding of climate variability and change risks, as well as knowledge solutions, can aid in the development of resilient climate risk management systems for coffee.

Having access to improved climate information can facilitate discussions and support coffee farmers and the industry in making well-informed decisions. A better grasp of climate tools and implementation of climate tools in coffee farm management can help minimise the impacts of climate risks.

Climate tools, primarily developed by the University of Southern Queensland, such as station tools, targeted seasonal climate forecast tools, and seasonal and sub-seasonal climate tools, can be effectively utilised to develop suitable risk management strategies. Ultimately, the success of the future coffee industry will hinge on how well the industry prepares for unfavourable seasons and can take advantage of potential opportunities during favourable seasons.

Future-Proofing Food Production with Weather Insurance Optimisation

Australia has long been home to a variety of farming and food production industries, supplying both domestic and international markets. In recent years, climate events and changing weather patterns have significantly increased the financial risk faced by producers and food supply chains. As a step toward minimising the impact of weather events, Dr Jenny Wang, a climate finance researcher, has received funding from the Australian Research Council's Early Career Researcher Industry Fellowship program to develop customised weather index insurance products.

The project is being conducted in partnership with climate risk insurtech company CelsiusPro and is investigating the use of more accurate and specific weather data to improve insurance product offerings. Currently, weather index insurance policies use data from local weather stations, providing a payout when the weather parameter moves beyond a pre-specified point. The placement of the weather stations often means that these parameters cover large areas. For locations close to the weather station, the parameters can be quite accurate, however for those locations that are further away, these parameters become less precise.

This leads to a phenomenon known as spatial basis risk, where the weather observed by a weather station does not match the weather experienced on a farmer's property, resulting in an insurance payout that may not cover the damage. The purpose of this project is to overcome this disadvantage and improve consumer confidence when it comes to choosing weather index insurance.

The Northern Australia Climate Program

The Northern Australia Climate Program is a collaboration between the University, Meat and Livestock Australia, the Department of Agriculture and Fisheries, and MLA Donor Company. The program aims to build the capacity of the pastoral grazing industry to better manage drought and climate risks through a range of research, development and extension activities. A key element of the Program is ensuring that the climate information needs of stakeholders are used to inform research and development endeavours, so that the science is directly targeted at end-user requirements.

A key initiative of the program are the 'Climate Mates', spread across regions of Queensland that support 15 million head of cattle. The Climate Mates are regionally based extension advisors with a background in industry and existing relationships in their communities, who focus on improving the knowledge and skills of producers across the grazing industry to support proactive management of climate variability. This approach minimises exposure to environmental, profitability and productivity losses due to drought or drier-than-normal wet seasons, and maximises opportunities presented in above-average seasons.

Climate Mates deliver local agricultural and meteorological expertise directly to producers in their local region.

Agriculture and Environment Research

University of **Southern Queensland**

Contact

Dr Gudrun Seynsche
Director (Research Partnerships)
Deputy Vice-Chancellor's Office
(Research and Innovation)
Gudrun.Seynsche@unisq.edu.au
+61 7 3470 4419

unisq.edu.au