

University of Southern Queensland

Disaster Resilience Research

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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.

The University's Flagship Research Areas



Agriculture, 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, Economic Development and Cultural Heritage.



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

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.

Research Excellence

Key to our research culture is working with industry to understand the problems they face, and collaboratively develop new ideas and technologies that deliver tangible benefits.

University of Southern Queensland is internationally recognised for its practical, world-class research and this global reach and world-class quality is further evidenced by University of Southern Queensland being rated as 'world standard or better' in 30 areas of research according to the 2018 Australian Research Council's Excellence in Research for Australia (ERA) assessment, which evaluates the quality of research conducted at universities around Australia.



The University of Southern Queensland's Disaster Resilience Research Portfolio

The University's disaster resilience research expertise spans all four research flagships and ranges from climate science and climate risk mitigation to materials sciences focusing on the development of resilient infrastructure and fire-retardant materials. University research is strengthening the ability of communities to prepare and recover from the physical impact and trauma of natural disasters.



The University of Southern Queensland has significant experience working with industry, as well as State and Federal Governments, to deliver programs supporting rural and remote communities. University staff and students live and work in rural areas that have been impacted by bushfires, floods and other climate extremes and many volunteer for the Rural Fire Service and the State Emergency Services.

Applied Climate Science

The University of Southern Queensland's Centre for Applied Climate Science is a national and international leader in the provision of climate science research and development which helps industry, governments and communities to manage climate variability, climate change and weather extremes, both in Australia and internationally. The Centre's research also includes practical aspects related to climate finance, in particular climate risk-related insurance and reinsurance, agricultural and water resource applications, and disaster risk reduction.

The Centre's research expertise spans climate risk management and innovative insurance systems for government and agribusiness; provision of improved climate science and decision-making systems for the Northern Australian grazing industry; and delivery of enhanced early warning of extreme weather and climate events relevant for agricultural production throughout Australia and the Pacific.

The University of Southern Queensland's leadership role includes innovative user-engaged developments in drought risk insurance through National Farmers' Federation and Queensland Government-funded programs, which are currently being trialled by major international and national reinsurance/insurance agencies such as Willis Towers Watson.

Centre staff are heavily engaged in major international drought and agricultural climate research and management programs within the United Nations' World Meteorological Organisation and the associated Integrated Drought Management Program. The Centre is home to the Queensland Drought Mitigation Centre (QDMC) which is a collaboration of national and international climate modelling expertise, established in partnership with the Department of Agriculture and Fisheries and Department of Environment and Science. The QDMC is one of the world's leading research centres for drought, climate factors, policy and associated economic systems. The University of Southern Queensland is one of only two universities globally recognised by the United Nation's Integrated Drought Management program to work in this area.

Research Projects

DeRISK Project

The DeRISK Project applies seasonal climate forecasting and innovative insurance solutions for climate risk management in the agriculture sector in South-East Asia. This is a joint project between the World Meteorological Organisation (WMO) in Geneva, Switzerland; the University of Southern Queensland and the International Centre for Tropical Agriculture (CIAT) in Hanoi, Vietnam. It is funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The DeRISK Project's key focus areas are:

- Development of seasonal to multi-year climate forecasts as an incremental approach to tackling climate change;
- Development of integrated climate forecast/ agricultural production models to aid lecisionmaking (across the agribusiness value chain) in Vietnam, Cambodia, Lao PDR, Myanmar;
- Provision of innovative (index-based) insurance vstems to address the issue of 'residual risk' those aspects that cannot be addressed through climate risk management;
- Implementation of participatory approaches with farmers, agribusiness, and government agencies; and
- Provision of climate change projections tailored to industry to assist decision-making.

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Risk Pooling Through Discretionary Mutual Funds for Tropical Cyclones

Tropical cyclones are among the most destructive natural disasters in Australia. The impacts of a tropical cyclone can be severe and widespread, with strong winds and heavy rains. It is estimated that Tropical Cyclone Debbie caused approximately \$450 million of damage to Queensland's agricultural industries in 2017. The effective financial management of disaster risks remains a key challenge for individuals, businesses and governments in developed and developing countries. Alternative Risk Transfer (ART) programs, such as re-insurance, discretionary mutual funds, and capital market instruments (cat bonds), are emerging to provide protection from the financial impacts of tropical cyclones.

Working with key collaborators, Willis Towers Watson, the Queensland Farmers Federation, and the sugar industry, University researchers have developed Discretionary Mutual Funds for Tropical Cyclones, which protects cane growers from the financial impacts of high impact cyclones.

Key Contact Professor Shahbaz Mushtaq

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Resilient and Sustainable Built Environments

University of Southern Queensland's Centre for Future Materials is enhancing the disaster resilience of Australia's built environments and critical infrastructure. The Centre conducts pioneering research in the design and development of innovative materials for diverse engineering applications, with a strong focus on polymer and concrete composites.

Building Materials

Researchers in the Centre for Future Materials are developing innovative early fire warning sensors for new and existing buildings and fireretardant materials and structures for buildings, including cladding, facades, and thermal insulation.

The University's existing testing facilities are enabling the development of fire ratings for electrical cables and wires, building materials and structures, and standards for fire warning systems. A new engineering facility at the University's Springfield campus is supporting the expansion of these facilities with state-of-the-art fire testing laboratories.

Equipment in these facilities includes:

- Cone Calorimeter
- Vertical Burning Tester
- Oxygen Index Tester
- Smoke Chamber
- Pyrolysis Gas Chromatography Mass Spectrometry.





Research Projects Inscreasing the safety and resilience of buildings

Professor Hao Wang is participating in the Australian Research Council Training Centre for Fire Retardant Materials and Safety Technologies led by the University of NSW. This centre accelerates the transformation of Australia's industries in producing new fire-retardant materials, high value products and engineering services and improves the fire safety of lightweight structures and fire protection systems.

Professor Pingan Song, an expert in bionano polymers, has been awarded an Australian Research Council Future Fellowship for the project Development of Flame Retardant Thermal Insulation Materials for Buildings.

Worldwide, almost all building thermal insulation materials are made from polymer foams, such as polyurethane and polystyrene foams, which are intrinsically flammable and pose a high fire risk. This project is developing next-generation fire-retardant rigid polymer foams (RPF)-based thermal insulation materials for buildings and will bring significant benefits to Australia by reducing energy costs and economic losses associated with building fires.



Fire resilient wind farms

Professors Pingan Song and Xuesen Zeng have received funding from the Australian Research Council's Linkage Program for a research project which is developing advanced fire-retardant composite resins for manufacturing bushfire-safe wind farm infrastructure. The innovation of the project is the development of a new class of lowcost, novel, highly effective fire retardants and their value-added fire-retardant composite resins with well-preserved physical properties. This is achieved by understanding the composition-property relationship of fire retardants and optimising their synthetic parameters. The outcomes of this project will position Australia's advanced composite manufacturing at the forefront of fire-retardant technology and will accelerate Australia's energy transition to renewables by improving the resilience of wind farm infrastructure.

Queensland Connects: Disaster Resilience Program

Dr Venkata Chevali, a Senior Research Fellow and Materials Engineer, is part of a Queensland Connects team, a regional entrepreneurship acceleration program for Disaster Resilience. The team is exploring innovative solutions to the highest priority and most complex natural disasters facing Queensland to not only enhance the resilience and sustainability of infrastructure, but also to create new high value jobs and global commercial opportunities in the longer term. The Queensland Connects program is part of the Queensland Government's Advance Queensland Regional Futures Initiative.

Flame-retardant polymer resins

Dr Siqi Huo, has received a Discovery Early Career Research Award fellowship from the Australian Research Council to support his research in producing high-performance flame-retardant polymer resins, which are environmentally benign, flameretardant oligomers.

These resins mitigate fire hazards, thereby protecting lives, property, and the environment by replacing current flammable epoxy resins used in electrical, construction and transportation.

Critical Infrastructure Resilience

Researchers from the Centre for Future Materials are strengthening the resilience of critical civil infrastructure, such as electricity assets and road structures, by focussing on the development of fireretardant materials including coatings for electrical cables and wires.

Centre researchers Professor Karu Karunasena and Associate Professor Weena Lokuge have expertise in flood modelling, bushfire modelling, and assessing the resilience of road structures under natural hazards such as flooding and bushfire.

Research Projects

Enhancing resilience of critical road infrastructure: bridges, culverts and flood ways

Road networks and critical road structures such as bridges, culverts and flood ways play a vital role before, during and after extreme events to reduce the vulnerability of the community. The University participated in a project led by RMIT and funded by the Bushfire and Natural Hazards Cooperative Research Centre which aimed to:

- Advance the understanding of the factors required for quantifying the impact of hazards on road structures; and
- Understand failure mechanisms under different hazards and vulnerable structural forms, with structures grouped according to vulnerability.

Numerical investigation into the behaviour of floodways during extreme flood events

The Bushfire and Natural Hazards Cooperative Research Centre a University-led project project, which aimed to improve the resilience of floodway structures during extreme flood events. The research involves three-dimensional modelling of floodway structures under different extreme loading conditions, with outcomes contributing to the development of a structural design method to compliment the hydraulic design approaches utilised in current Australian design guidelines.

Key Contact Professor Xuesen Zeng

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Sustainable, safe and healthy landscapes

The Centre for Sustainable Agricultural Systems conducts research and engagement that enhances the management of agricultural enterprises as complex and embedded systems, maximising production and conservation outcomes.

The Centre's research assists decision-makers to diagnose system constraints and make informed, sciencebased decisions that improve productivity, profitability and environmental sustainability; and analyse, develop and implement policies, practices and designs for sustainable agricultural systems.

Key research themes include:

- Spatial diagnosis and management of system constraints:
- Maximising ecosystem services in agricultural and silvicultural systems;
- Managing human-wildlife interactions;
- Soil-plant-water integrated system dynamics;
- Soil security;
- Analysis and modelling of agricultural systems and catchments:
- Assessing economic feasibility and benefits of adopting high-grade organic fertilizers; and
- Value chain analysis of agriculture and forest products.

The Centre has expertise relevant to disaster resilience in the areas of biophysical, statistical and economic modelling approaches to better manage agricultural systems in a changing and increasingly variable climate, natural resource management, and soil and water management.

Research Projects

Associate Professor Keith Pembleton worked with grain growers in North Western Queensland to manage short term irrigation water shortages and with North Queensland rice growers to replant after their crops were destroyed in the 2019 floods. Professor Tek Maraseni has worked with the South Burnett Reginal Council on savanna burning and published a review that provided a number of suggestions to develop a new methodologyfor the Australian Government's Emissions Reduction Funds. Professor Tek Maraseni is also engaged in the development of soil certification products and conducting research to evaluate the economic viability of organic fertilizers.

Other areas of research focus include:

- Soil erosion, sediment, water quality, modelling, monitoring;
- Pre and post bushfire landscape analysis for soil erosion, sediment control, and water quality;
- Developing modelling capabilities to manage post bushfire impacts on downstream water resources; and
- Developing management frameworks to mitigate bushfire impacts on land and water resources.

Key Contact Professor Robbie Girling

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Restoring health to fire-affected soils

For millions of years, wildfires have helped to maintain nature's ecological balance, cleaning out leaf litter and helping to return nutrients into the soil. However, this process is complex, with each plant species and soil type reacting differently to being burnt. Working alongside a national team of researchers and industry experts, University ecologist Dr Christina Birnbaum is studying the impact of wildfires on the health of Tasmania's alpine plant species and their associated soils. Findings from this experiment will be used to assist future ecological restoration programs in areas affected by wildfires.

Emerging research suggests that there are temporal changes in soil fungal communities, with high fire frequencies increasing soil fungal plant pathogens and lowering the abundance of symbiotic, plant beneficial, soil fungal communities. It is hoped that

the School of Agriculture and Environmental Science explores the link between wildfires, communities to inform ecological restoration.



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natural soil microbial processes may help to facilitate natural recovery and germination of plant species, making alpine restoration more cost-effective and applicable to more areas to speed up recovery.

Dr Birnbaum is planting alpine seeds into different soils under controlled conditions to observe how well the plants germinate and grow in the glasshouse and if there is a difference in growth in historically burnt soils compared to more recently burnt soils against control treatments. A study of the below-ground effects; the presence of bacteria and fungi in the soil, and whether there is any difference between the plant samples in how they respond to different soils will inform our understanding of how to restore these ecosystems after a wildfire.

Operational response and innovation

During natural disasters, such as bushfire and floods, there are extremely high numbers of calls to emergency services. Artificial Intelligence technology developed by the University of Southern Queensland is helping to prioritise the response and identify fake calls.

Professor Rajib Rana, from the University's School of Mathematics, Physics and Computing, and his team are developing algorithms to determine the level of risk associated with individual calls to emergency services by measuring distress levels in real-time phone calls. This research is supported by funding from the Advance Queensland Industry Research Fellowship scheme.

The algorithms can be integrated into any call centre system as a cloud-based service. This technology will enable operators at emergency services call centres to assess the level of risk for each call and prioritise their response accordingly, while also identifying timewasting hoax calls.

Distress causes physiological changes affecting speech production. Professor Rana's team are developing algorithms underpinning Artificial Intelligence to analyse and assess these changes in real-time.



Community engagement and preparedness

University researchers work collaboratively to enhance community engagement and disaster preparation.

Dr Barbara Ryan's research focuses on disaster response communication and community engagement for disaster preparedness and recovery and community engagement measurement and evaluation. Dr Ryan's recent research focuses on the experiences of people affected by the extreme floods in New South Wales and Queensland in 2022 and is providing vital insights into preparedness, response and the early stages of flood recovery to help reduce future flood risk.

This research informed the development of a report which was presented at the 2023 Natural Hazards Research Forum that provides vital information to assist emergency management organisations, government departments, local councils, community organisations and community members to better manage the complexities of community responses before, during and after severe weather.

This project was conducted in collaboration with Natural Hazards Research Australia, the University of Southern Queensland, Macquarie University and the Queensland University of Technology.



Dr Ryan currently leads a project with Toowoomba Regional Council on bushfire preparedness funded through the 'Get Ready' grant administered by the Queensland Reconstruction Authority. In the 2020 bushfires, 34 people died, and more than 18.6 million hectares of bush, forest and parks burned in the nation's worst bushfire season in history. In the Toowoomba region, homes were under threat and neighbourhoods filled with hazardous smoke.

The project is a multidisciplinary effort, with research contributions from Professor Karu Karunasena (civil engineering and construction), Ms Esther Anderson (anthropology and environmental humanities), Associate Professor Rachel King (statistics), Associate Professor Weena Lokuge (civil engineering) and Dr Ryan (disaster behaviour). The project is providing insights into bushfire mitigation including engineering, systems and community behaviour and determining how well-prepared communities are in the Toowoomba and Lockyer regions.

> Dr Barbara Ryan works with Natural Hazards Research Australia and is the current chair of Emergency Media and Public Affairs, a national organisation for emergency communicators and engagement practitioners.

Research Projects

The Southern Queensland and Northern New South Wales Innovation Hub

Extension and community engagement experts from the University of Southern Queensland are leading the Southern Queensland and Northern New South Wales (SQNNSW) Innovation Hub to build a drought-proof Australia and help Australian farmers to thrive into the future.

The SQNNSW Innovation Hub is one of eight national Drought Resilience and Adoption and Innovation Hubs, a flagship of the multi-billion-dollar Future Drought Fund led by the Australian Government. Headquartered at the University's Toowoomba campus, the Hub's regional reach covers from Longreach in Queensland to Dubbo in New South Wales, and from the east cost to the Southern Australian and Nothern Territory borders in the west. Australian farmers live with the reality of a changing climate with sometimes devastating impacts on production and profit. The Hub is applying proven drought-resilience research on the ground to improve innovation and adoption across agriculture, industry and the community. Through extensive consultation, the SQNNSW Innovation Hub has identified four key regional priorities:

- Data and Decision-making: data access, interpretation and application, decision-making support, tools, processes and capacity.
- Wellbeing and Employability: recognising the connection between support for wellbeing and personal capacity in skills and confidence as business managers, employees and community members.
- Environmental Commodities: understanding opportunities and risks in engaging in emerging environmental markets.
- Best Practice Agriculture and Preparing for Drought: techniques, tools, processes and approaches that support holistic, sustainable, productive, profitable management of natural resources within extreme variable climate conditions.

University of Southern Queensland School of Law and Justice researchers have the expertise to advise on legal and regulatory frameworks, for example new burn regimes and the use of Federal Government powers in disaster situations. Professor Noeleen McNamara's expertise in environmental and natural resources law includes the relationship between Australian legislation and traditional land management practices. Professor Anthony Gray is currently investigating the Australian Federal Government's constitutional powers in response to emergencies caused by natural disasters or pandemics.



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Community Recovery

The University's Centre for Health Research and Centre for Heritage and Culture are working together to develop interventions that boost community resilience and support their recovery from the impact and trauma of natural disasters.

Professor Sonja March is the Director of the Centre for Health Research and is the Mental Health Program Theme Lead. Professor March's research focuses on the use of digital technology to improve access to evidence-based psychosocial interventions and tools, particularly for vulnerable populations such as children and adolescents, and geographically isolated communities. Professor March successfully co-led the translation of BRAVE (an online, psychological program for the treatment of childhood and adolescent anxiety developed by researchers from University of Southern Queensland, The University of Queensland and Griffith University), into a public health service, providing a digital platform free-ofcharge, to all young Australians. The program has had significant impact, with more than 50,000 registered users. BRAVE has also been disseminated in New Zealand for to provide support for young people following the Christchurch Earthquakes. In 2019, the University received a \$5 million grant from the Federal Government's Medical Research Future Fund, through the Million Minds program to Professor March's team to build on the BRAVE program to develop a more comprehensive online platform that integrates detection, assessment and tailored interventions.

Professor March co-developed and disseminated a training package for teachers and guidance officers as part of the Queensland 2011 Natural Disaster Response. This resource has now been disseminated across Queensland, has been utilised following the New Zealand Christchurch earthquakes and has been translated for use in Japan, with the team training over 800 Japanese professionals. Professor March recently consulted with the Emerging Minds Network to develop an online format to provide a disaster toolkit for first responders, educators and health service providers. This toolkit is available on the Emerging Minds Network and won a national award for impact in 2019. Following COVID-19, registrations to the BRAVE program increased by 30%, highlighting the demand for, and impact of this service. Currently Professor March and her team are involved in two major studies focused on COVID-19 and child mental health. They are working with an international group of researchers from Oxford University to examine how children across the world are managing the pandemic.

In 2023, the international research consortium came together for a five-day workshop held at the Lorentz Centre in Leiden, Netherlands, to develop international consensus statements and guidelines about the impact of the pandemic on children's mental health, and the required response to improve children's mental health globally. They are also involved in a new study to understand exactly what is happening for young Australians during and after the crisis, working alongside Griffith University and University of Queensland.

Key Contact

Professor Sonja March

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A multidisciplinary research consortium with representation from the Centre for Heritage and Culture, Centre for Health Research, School of Humanities and Communication, School of Education, School of Creative Arts and the School of Psychology and Counselling, convened by Professor Jessica Gildersleeve, have expertise in the application of creative arts and narrative therapy for trauma management and recovery in children. Most recently this group worked on projects related to the COVID-19 pandemic.

Researchers from the School of Creative Arts have formed a Creative Recoveries Research Team, which explores creative and cultural responses to natural disasters, climate change impacts and pandemics with a focus on community resilience and recovery. The team creates opportunities for communities to recover and build resilience through communitybased creative and cultural engagement programs leading to positive social, cultural and well-being. The Arts can provide a pathway for communities to make sense of and cope with disaster by conveying emotions and experiences that are difficult to express through words. The Arts can bring a community together and is inclusive to everyone including people with disabilities, older people, youth and those who are financially disadvantaged.

Key Contact

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