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Commonwealth Department of Agriculture
Online submission via: https://haveyoursay.agriculture.gov.au/future-drought-fund/survey_tools/future-drought-fund-survey

The University of Sydney is pleased to make a submission in response to the Department of Agriculture's draft *Drought Resilience Funding Plan*.

The Australian environment is a challenging one for agricultural production and regional communities, with climate change and drought demanding new – evidence-based – approaches if we are to maintain and increase the value of our agricultural output over the coming decades.

As an education and research institution with proven disciplinary and multidisciplinary strengths, and long-standing partnerships with stakeholders across the agriculture and food sectors, we are confident that Australia can tackle drought as an agricultural and social problem by adapting management, production and financial systems to operate in drought-prone environments.

Our submission highlights the following 11 domains (in R&D, education and research training) as focus areas where we believe the Future Drought Fund can have the most impact in building resilience to drought across the country:

Plant breeding	Digital information
Native species	Use of private data
Soil water and ground cover (biomass)	Federation of research farms
Agricultural product insurance	Capacity building
Stock and animal welfare, health and biosecurity	Role of connectedness and networks
Soil regeneration	

Thank you again for the opportunity to contribute to the Government's development of this important plan. We look forward to working with the Department as it finalises its plan and looks to implement initiatives under the fund.

Should you require further information from the University of Sydney, in the first instance please do not hesitate to contact Professor Alex McBratney, Director, Sydney Institute of Agriculture on alex.mcbratney@sydney.edu.au or 02 8627 1130.

Yours sincerely,

(signature removed)

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The University of Sydney's submission to the Department of Agriculture's draft *Drought Resilience Funding Plan*, December 2019

The University of Sydney Institute of Agriculture (https://sydney.edu.au/agriculture/)

The University of Sydney is confident that Australia can tackle drought as an agricultural and social problem by adapting management, production and financial systems to operate in drought-prone environments. The ability to forecast and prepare for potential future risks, shocks and disruptions to agricultural systems and to build economic resilience will rely on strong scientific and evidence-based research. There will also be a need to strengthen our capacity for multidisciplinary research to be targeted towards building individual and community preparedness and resilience for future droughts.

We will need to understand the probabilities of rainfall over a specific time period everywhere in the country, to be able to predict the environmental conditions across the continent. We will also need to adapt new management practices (i.e. crops, grazing, stocking) to the rainfall probabilities, thereby managing risk and increasing economic, environmental and social resilience. New financial instruments will be required, for example, crop insurance. Most importantly, research will be required to derive the probabilities and design the new practices and financial instruments.

The University of Sydney is well placed to contribute towards this research. The Sydney Institute of Agriculture's attached industry capabilities statement on **Drought and Risk Management** summarises our key relevant capabilities and provides details for some of our leading experts.

Strategic priority no. 1
ECONOMIC RESILIENCE FOR AN INNOVATIVE AND PROFITABLE AGRICULTURAL SECTOR

1. Plant breeding

Drought is a constant variable that Australian plant breeders must address in their screening and selection programs – consequently, our plant breeding and production research collective focuses on the more water-use efficient plant varieties, as crops and for animal feed.

Under drought stress, plant growth and yield are often compromised. Our research strengths over many decades have been in breeding for heat and drought tolerance in cereals and pulses using combined field and laboratory-based approaches. Improved plant varieties that can continue to grow when soil water is restricted are now being selected and transitioned to breeding populations for commercial release.

In conjunction with germplasm improvement, our field-based innovations involving conservative agricultural practices (no-till farming and land management) and increasing use of digital and robotic technologies are extending our ability to continue producing plants and plant products exposed to drought and heat.

Addressing the challenges of drought will continue to guide our research attention to expanding discovery and identifying solutions to help support farmers and plant-linked industries across Australia.

2. Native species

Native species, especially from semi-arid environments, are evolutionarily adapted to be water-use efficient – a key drought mitigation approach. Traits may be transferable to other species. The native species themselves can be a target for improvement and commercialisation. Our research supports incorporating alternative native plant and grass species (e.g. yams and native millet) adapted to low rainfall environments into more mainstream production; along with genetic improvement. This work is considering the economic, environmental and cultural (particularly Aboriginal cultural) implications of food production from drought-tolerant native grassland species in modern farms and food markets. Research has found that there is both demand for the grain/yams in food markets e.g. organic, gluten free, ancient grains, plus the impetus from farmers, Aboriginal people and environmental scientists to establish native grassland production areas, particularly in areas not suited to high-value cropping.

3. Soil water and ground cover (biomass)

Nowcasting and forecasting soil moisture and groundcover in non-irrigated situations use different data streams. This requires moving beyond seasonal weather forecasts to properties directly related to management decisions, e.g. whether to sow and determining stocking rates. The predictions are made on a daily time step at the sub-hectare resolution and for different depths in the soil profile; there is a need to join up projects funded by various Research and Development Corporations (RDC), for example, Meat & Livestock Australia and the Grains RDC.

4. Agricultural product insurance

The University has pioneered agricultural product insurance and is currently funding a project on crop insurance. The project lead is Professor Eddie Anderson from our Business School, who is an expert on supply chains, particularly in relation to contracts and risk. The legal and business principles of crop insurance can be extended to any agricultural product.

5. Stock and animal welfare, health and biosecurity

Maximising stock welfare requires a data-driven model that integrates data from climate, satellite, government records, industry organisations and individual farms to better predict animal welfare risks due to lack of water and/or reduced feed availability due to drought. A prerequisite is the ability to forecast and nowcast soil water and groundcover (see point 3 above) which has flow-on effects to stock welfare.

Further work could also focus on maximising stock productivity/feedbase, water-use efficiency and nutrient-use efficiency in irrigated areas to minimise the need for feed from rainfed areas during drought. This will increase drought resilience across the entire agricultural sector in Australia. For example, our FutureDairy research has shown a potential to increase milk production per litre of water used by a factor of almost five compared to the output of irrigation regions like northern Victoria.

Animal health and biosecurity concerns in relation to drought include the movement and displacement of animals to access water or feed or to escape fires which may lead to transmission of infectious diseases Drought may affect the presence and prevalence of pests and pathogens that impact on livestock health, as exemplified by the increase in number of buffalo and bush flies due to the effect of drought on dung beetles. Similarly, soil displacement resulting from drought, including dust storms, may lead to exposure and movement of pathogens including, for example, anthrax spores, Coxiella (causative agent of Q-fever) and parasite eggs. Expertise in animal infectious diseases and epidemiology within the Sydney Institute of Agriculture and the Sydney School of Veterinary Science can be deployed to track changes in the spread of disease under extreme climate conditions which can impact the livestock industry economically as well as the welfare of animals.

Drought conditions impact the health, productivity and reproduction of animals due to heat and nutritional stresses. Improving the general capacity of the immune response to such non-infectious stressors has the potential to improve livestock resilience to drought. With the expertise in veterinary immunology at the University of Sydney, there is potential for research into capacity for mitigating these stresses by enabling resilience of livestock to drought through supplemental feeding of immunostimulants.

Strategic priority no. 2
ENVIRONMENTAL RESILIENCE FOR SUSTAINABLE FARMING LANDSCAPES

The Future Drought Fund should support the principle of turning data into decisions. Fundamental to this is the ability to forecast future states of the system. Research projects around how data and technology can improve decision-making, e.g. soil probe data infrastructure, should be supported. Priority should also be given to options where the Fund adds value or leverages off investment already being actioned in this area, especially in relation to soil carbon and soil water.

6. Soil regeneration

Consideration should be given to the regeneration of soil (a key strategy of the National Soils Advocate, https://www.pmc.gov.au/domestic-policy/national-soils-advocate) as a sustainable cost-efficient widespread alternative to dams. In addition to increasing water storage (i.e. via more carbon) and improving the level of water accessible to plants, other benefits include improving production constraints, reducing compaction and amelioration of the ecosystem. Strategies for increasing carbon should be investigated and methods developed to forecast soil hydrological improvements from soil carbon increases. The University of Sydney has ongoing work in these areas.

7. Digital information

Current drought management zones and regional assessment of drought are too coarse. There is a need to use digitally-sensed information to disaggregate farms and catchments into drought hazard zones and manage accordingly.

8. Use of private data

Although the Government’s investment in soil survey formally ended in the 1990s, there is a wealth of grower-collected data about their farming systems, particularly their soil nutrients and soil moisture probes. While there are privacy issues at present, the potential use of privately held data does provide the opportunity for developing the modelling capabilities described above (at points 3, 6 & 7).

9. Federation of research farms

National-scale operational and research infrastructure (i.e. the Terrestrial Ecosystem Research Network and the Bureau of Meteorology) is too spatially coarse in its predictive capability use in agriculture and in many cases situated in natural ecosystems. The importance of agriculture merits the creation of more datasets from agricultural landscapes to be able to develop and validate models. This is particularly true for cropping regions. One issue with the agriculture sector is data privacy, however, some universities and state governments have invested significantly in research farms that are authentic representations of real agricultural systems.

Many of these research farms have extensive long-term datasets and have recently invested significantly in sensor and digital infrastructure, e.g. in New South Wales, the:

- University of Sydney has four large farms representing cropping and grazing in southern and northern NSW (around 11,000 hectares);
- NSW Department of Primary Industries has 25 research sites and 13,000 hectares of trial farms;
- University of New England has a Smart Farm; and
- CSIRO has a new farm in southern NSW.

Across Australia collectively, publicly-funded farms represent a large piece of research infrastructure which is yet to be collectively harnessed for national-scale efforts such as drought research.

Investment in these research farms to make data and modelling capabilities open and useable by the agriculture sector would lead to greater innovation. These farms could also be the site of training hubs for professional development (see below).

Strategic priority no. 3
SOCIAL RESILIENCE FOR RESOURCEFUL AND ADAPTABLE COMMUNITIES

10. Capacity building

We strongly support capacity building in terms of education and training in agriculture, with a particular emphasis on high tech agriculture. We see this as encompassing a whole mosaic from pre-university vocational education, through undergraduate and higher degrees by research, to professional training. We note here that our Narrabri campus is a training hub for professional development.

We believe that the Future Drought Fund should support scholarships for undergraduate and higher degrees by research students, with an unequivocal focus on supporting the education, training, upskilling and retraining of people from farming regions. These communities could be further encouraged during these difficult drought years, with preferential access to the higher education loans program and income support payments to help meet living expenses while studying.

Three discrete and practical ideas which the Fund could support are:

- professional drought resilience education in agriculture technology for farmers;
- scholarships for PhD students to undertake research in areas related to drought resilience and agricultural technology;
- targeted funding to support farmers exiting agriculture because of drought to retrain for alternative careers.

Possible projects which the University is well-placed to provide expertise on, could link sensor/drone deep tech innovators from Cicada Innovations with researchers in the Australian Centre for Field Robotics (within our Faculty of Engineering) and the Sydney Institute of Agriculture to develop better use of the water we do have, using targeted irrigation from smart systems. This would be an ideal industry-ag sector-regional doctoral thesis. We have found that embedding PhD students into research programs is ideal; having these based in the field and connected directly to local drought affected communities.

11. Role of connectedness and networks

We also support consideration of research projects related to the psycho-social preparation of drought affected communities and the ongoing drought response. This should be a priority area for research and the development of counselling support programs targeted at rural communities dealing with drought and associated environmental disasters like bushfires. Our Brain and Mind Centre is a global leader in research and treatment, with a focus on conditions that affect child development, youth mental health and brain ageing. The Centre's work extends beyond laboratories and clinics to our strong partnerships with industry, government, communities, other healthcare providers and researchers. With funding support, there is great potential to extend the Centre's work into drought affected communities building on the successful headspace youth mental health clinic and emerging virtual technologies, which are also being developed by our researchers and clinical psychologists.

Other ideas which the Fund could support are:

- funding in the form of grants or tax boost / offset, to encourage farmers to 'upskill' with data literacy, technology and other innovations that might assist them to prepare for and deal with drought;
- funding to enable institutions like the University of Sydney and other research-intensive universities to develop and host conferences in rural, regional and remote areas and cover the costs of travel and accommodation for delegates;
- dedicated funding for scholarships for people from regional areas to undertake studies in Agriculture at the pre-university, bachelor and postgraduate level, including funding support for collaborative proposals between TAFE/VET providers, industry and universities to develop innovative pathways and online delivery offerings for farmers; and
- funding opportunities for looking at small-scale economies, to sustain regional and local economies to carry farmers through drought.

THE UNIVERSITY OF SYDNEY

Sydney Institute of Agriculture

AgTech and Food: Industry Capabilities

Drought and Risk Management

Embedding world-leading research on farms and in communities

Expertise

The Sydney Institute of Agriculture has significant experience in improving crop species for drought tolerance and water-use-efficiency for major crops globally - like wheat and legumes.

The Plant Breeding Institute has significant capacity and experience in the genetic improvement of crop species for water-use-efficiency and drought tolerance. Drought adaptive traits are identified, characterized and validated from extensive germplasm collections that include adapted cultivars and wild crop relatives. These traits are pyramided in agronomically superior backgrounds using integrated molecular genetics, plant physiology, high throughput phenotyping and optimized data management. The products are evaluated nationally using genomic estimated breeding values and associated environmental covariates to identify sub-groups of genotypes based on their predicted performance in other grain growing regions of Australia.

A resilient agricultural system builds capacity across a wide range of areas to ensure the ongoing, sustainable and smooth growth of the agricultural sector, to manage risk and withstand the shocks and disruption that often occur. Building economic resilience is critical. Finding ways to improve farm gate returns is a key policy goal of the Australian government. Increasing the profitability of agriculture is often a precursor to improving resilience in other areas. The ability to forecast and prepare for potential future risks, shocks and disruptions to agriculture and to build economic resilience will rely on strong scientific and evidence-based research.

The University of Sydney operates farms in different climatic regions across New South Wales which are used for field-based research to develop technologies at operational scales right up to commercial levels.

Tools and methodologies used

Our researchers use technologies and methods such as:

- plant breeding
- profitability analysis
- farming systems research and analysis
- risk analysis
- seasonal forecasting
- digital technologies
- integrated bio-physical and economic modelling
- drought forecasting and monitoring.
- understanding drought legacies with a combination of field observations in the rangelands, remotely-sensed data on vegetation greenness fraction, manipulative experiments reducing rainfall inputs, and innovative modelling approaches to build ecosystem forecasts under future altered environments.
- evaluation of economic efficiency of irrigated agricultural enterprises, including environmental effects from irrigation such as drought contributing water depletion and salinity.
- market-based instruments for environmental water recovery and the role of the water market in drought mitigation.
- integrated bio-physical and economic modelling of irrigated agricultural enterprises under alternative water availability conditions.

AgTech and Food: Industry Capabilities

Embedding world-leading research on farms and in communities

Case studies

Improving heat tolerance in wheat and chickpeas: Our heat tolerance work is now approaching the stage where germplasm and associated genetic knowledge is incorpoated into plant breeding.

Hybrid wheat for food security:
We are researching hybrid wheat – both the methods to produce hybrids, and also the genetics required so that the hybrids will be successful in commerce.

Integrated genetic solutions to crown rot in wheat: We have produced new wheat genetics, combining many sources of resistance by molecular marker assisted breeding and advanced phenotyping. This trait is now in high-yielding lines.
These lines, and the marker knowledge are being used by commercial breeders for their product development.

Soil moisture nowcasting and forecasting: This approach uses different data streams relates to soil moisture and combine these with process models, geospatial data and data analytics to predict the current and future status of soil moisture. The predictions are made on a daily time step at the sub-hectare resolution and for different depths in the soil profile. The predictions can be used to vary management season to season based on risks associated with drought.

Site-specific crop management and are investigating management zones for drought tolerance: All fields/paddocks can be divided into management zones. We are working on ranking these zone's resistance to drought or alternatively the risk of crop failure under drought conditions. Under this approach by predicting the dry season, it can be determined if a whole paddock or part of a paddock should be sown.

Our experts

Associate Professor Daniel Tan (Research Capability Coordinator): crop agronomy, specialising in crop abiotic stress and farming systems. His specific interests within crop abiotic stress are in physiology, especially high temperature tolerance.

Dr Kedar Adhikari: leads the faba bean breeding program for northern New South Wales and southern Queensland to provide alternative crops to wheat in rotation.

Associate Professor Tiho Ancev: agricultural, environmental and resource economics, economics of precision agriculture, integrated biophysical and economic modelling, productivity and efficiency analysis.

Professor Eddie Anderson: research on supply chains, particularly in relation to contracts and risk.

Dr Helen Bramley: plant physiologist working with plant geneticists/breeders to help uncover the basis of stress tolerance and water use efficiency, and to develop rapid screening methods for these traits.

Associate Professor Thomas Bishop: modelling and predicting the variation of environmental properties in space and time with an emphasis on applying this to soil and water science.

Dr Philip Davies: both a pathologist and plant geneticist and an expert on the root diseases of cereal crops, the impact of which is exacerbated by drought.

Associate Professor Feike Dijkstra: uses ecosystem simulation models to better understand the importance of plant-microbial interactions for carbon and nutrient cycling in ecosystems affected by global change.

Professor Brent Kaiser: expert in pulse legumes, and nitrogen fixation and distribution in these and other crops.

Dr Angela Pattison: researches drought and heat tolerance in cereals and methods plants use to maintain growth during water-stress, with the aim of releasing high yielding lines which cope well in both drought and average seasons.

Associate Professor Guy Roth: research on crop agronomy, plant stress, irrigation, water use efficiency, biodiversity and soil health.

Dr Rebecca Thistlethwaite: key wheat heat tolerance researcher, developing screening methods, and advanced genetic materials.

Professor Richard Trethowan: interested in developing crop cultivars that use water more efficiently and better adapt to increasingly hostile production conditions. Genetic variation for stress tolerance can be introduced into commercial cultivars from ancestral forms of the world's most important food crops.

Dr Floris van Ogtrop: focuses on identifying links between water quality and human, animal and plant health. Also interested in applied statistics for seasonal climate forecasting, hydrological prediction and environmental modelling.

Associate Professor Willem Vervoort: complex models to characterise key landscape, climate and water relationships and to support experimental work.

Professor Glenda Wardle: Expert in long-term monitoring of arid ecosystems and how changing environmental conditions of drought, flooding rains, fire and ferals interact to drive booms and busts in plant and animal populations.

Associate Professor Brett Whelan: improving the efficiency of crop management in terms of input and water use within fields and farms by understanding the natural variability in crop production and identifying site-specific management responses.

For further enquiries contact:

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