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Australian rangelands science – a strategic national asset

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Abstract. Producing, processing and distributing food is the biggest thing that humans do on the planet. In aggregate terms, agriculture has been very successful in ensuring that global food production has more than kept pace with global population growth over recent decades. However, in recent years concerns have intensified about the quality, equity, sustainability and resilience of the food system. Only around one-third of all people on Earth are eating a healthy diet. The food system is the biggest user and polluter of land and water, the biggest driver of habitat and biodiversity loss, and on track to be the biggest emitter of greenhouse gases. The recent emergence of a novel coronavirus and the resultant COVID-19 pandemic has further highlighted the systemic risks to human health from current food production and distribution systems. How to produce more, healthier and safer food, much more efficiently and sustainably, in more difficult climates, and how to share it more equitably, is an existential challenge for humanity. Australian science, and rangeland science in particular, is well-placed to play a leadership role across the Indo-Pacific in this endeavour. The Australian innovation system in agriculture and natural resource management has long had to contend with highly variable climates and extreme weather events, to produce competitive products for global markets with minimal subsidies. The know-how, and associated policies and institutions developed in doing so, are a strategic national asset and an important element of Australian soft power in our region.

Keywords: agricultural production, Australian rangelands, climate variability, desertification, food production, food security, global health crisis, innovation system, land degradation, rangeland science, soft power, sustainable extensification, sustainable land management.

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The challenge

Paradoxically, at a time when global food production and supplies were at their highest point in human history, the COVID-19 pandemic has brought the safety, resilience, sustainability and equity of the global food system into sharp relief. The global health crisis has not yet precipitated a global food crisis, but if current trends continue it may well do so (Sanderson *et al.* 2020), with profound long-term consequences for human health, security, regional stability and economic recovery.

In global aggregate terms, agriculture has done remarkably well since the Green Revolution of the 1960s and '70s. From 1961 to 2003, global population doubled, but aggregate food production increased two and a half times, to 2772 kilocalories per person per day, well above the World Health Organisation suggested minimum basic ration of 2100 kcal/day.

But as we know well in Australian agriculture, climate and ecology, aggregates and averages can be highly misleading. The story is usually in the variance, not the mean.

Although we produce more than enough food overall, the global food system was being questioned well before the novel coronavirus emerged in 2019. Successive global nutrition reports had highlighted major distributional problems masked by the apparent aggregate success: more than 800 million people still suffering from acute hunger, more than two billion people with micronutrient deficiencies, and more than two billion people consuming way too many calories, to the point of being unhealthily overweight or obese. Amazingly, this means that less than one in three people on Earth are eating a healthy diet, despite there being more than enough food to go around (Development Initiatives 2020).

Productivity growth in agriculture in some countries, including Australia, compares well with other economic sectors over recent decades. But in the main, global food production has increased less through productivity increases and more through agriculture expanding and intensifying its footprint: clearing, cultivating and irrigating more lands, extracting more surface and groundwater, using more energy, and applying more agrichemicals. Landmark reports including the EAT-Lancet Commission on Food, Planet, Health (Willett *et al.* 2019), and the Intergovernmental Panel on Climate Change report on Climate Change and Land (IPCC 2019) highlighted the massive, unsustainable environmental impact of the food system.

Globally, agriculture uses 87% of ice-free, non-desert land; it uses around 75% of diverted freshwater; it generates around one-quarter of global greenhouse gas emissions and is on track to be the largest emitting sector; it causes 78% of eutrophication of

rivers and lakes; and it is the main driver of deforestation and associated biodiversity loss (Willett *et al.* 2019).

Producing, processing and distributing food is the biggest thing that humans do on the planet.

Accordingly, fixing the food system is the biggest lever that humans can control, to improve human nutrition and health, to mitigate and adapt to climate change, and to protect and restore the environment.

What is to be done?

Julian Cribb in his book 'The Coming Famine' (Cribb 2010) argued that the world needs a third agricultural revolution. The World Economic Forum (2018) highlighted 12 'transformative technologies' that could accelerate food systems transformation by 2030, in three domains: changing the shape of demand; promoting value-chain linkages; and creating effective production systems. In the latter domain, they highlighted precision agriculture for input optimisation, gene editing for multi-trait seed improvements, microbiome technologies for crop resilience, biological crop protection and soil management, and off-grid renewable energy production.

No doubt these and other technologies have a potential role to play in improving the sustainability and resilience of food systems, especially at cell, plant, field and farm scale. But these and other prescriptive menus of technical 'solutions' tend to ignore or are silent on the wider spatial, temporal, social, institutional and political contexts in which food system transformation occurs.

In the world of international agricultural research where ACIAR[1] operates, we often see projects and programs promoting 'sustainable intensification'. The intensification dimension is usually obvious, but too often the only element that could possibly justify a 'sustainable' label is an increase in resource use efficiency – for example 'more crop per drop'. But increasing efficiency only yields a net environmental dividend if the 'savings' are returned to the environment somehow – for example, through environmental flows in rivers, replenishment of wetlands, or land sparing reserves. Too often, the net environmental pressure is not reduced, but rather more product and more money is made from the same amount of land, often using more inputs. In the long run, this is still unsustainable.

Of course, there are some landscapes that we can manage more intensively, and this can be done well. But for a net improvement in sustainability or resilience, other landscapes or other parts of the same landscape need to be managed less intensively. We also need to promote 'sustainable extensification'. This is where rangeland science has a crucial role to play, and where, in my view, Australia is well-placed to play a leadership role.

Australia's role

Australia has long experienced extreme levels of climate variability compared with other continents. Australian agriculture and pastoralism, especially in the arid zone, is accustomed to long periods of extremely dry weather, occasionally punctuated by flooding rains. The best pastoralists, informed by rangelands science, have developed grazing management systems that anticipate boom-bust cycles, and are able to reduce pressure on the land when necessary.

Other countries are now starting to experience less predictable and reliable monsoons, unexpected and unprecedented periods of drought, and greater frequency and intensity of extreme weather events. Farming systems that have evolved over centuries in regions with reasonably stable and predictable seasonality are increasingly being exposed by more volatile climates. A number of ACIAR projects are now helping partner countries to design more flexibility and responsiveness into farming systems, adapting Australian science to new contexts.

Building resilience and improving sustainability is not just about field- and farm-scale innovation however. It means thinking about whole landscapes, on decadal timeframes and longer. This inevitably entails thinking about the policy and institutional context, including markets, within which food and fibre production operate. Again, Australia has a long tradition of innovative policy and institutional responses to assist land managers to survive on ancient, nutrient depleted landscapes in tough climates.

Campbell Alexandra and Curtis (2017) argue that, at various times and in various places over the last forty years, Australia has designed and tested all the elements of a world-leading framework for growing food and fibre and managing natural resources in variable and warming climates. Innovations that Australia has implemented to varying degrees include:

- Landcare, supporting neighbourhood groups of farmers to work on land degradation problems that cross farm boundaries, which at its peak in the 1990s involved more than one-third of all farm families in Australia, and was acknowledged by Pretty *et al.* (2020) as the largest national initiative in industrialised countries supporting social groups in agriculture;
- farming system research groups, supported by combinations of producer levies and public funding, to deliver farmer-led research and knowledge sharing activities;
- regional natural resource management (NRM) bodies, of which there are 56 covering the entire continent, to support coordinated approaches to NRM at landscape and watershed scales;
- a range of measures to support Indigenous land management, including Indigenous Land Use Agreements, Indigenous Protected Areas, Indigenous ranger programs, and accreditation of Indigenous savanna burning regimes as a legitimate carbon sequestration methodology, creating tradable carbon credits for Indigenous communities;
- a rich diversity of citizen science programs, including WaterWatch (http://www.waterwatch.org.au/), SaltWatch (http://www.vic.waterwatch.org.au/cb_pages/saltwatch.php), FrogID (https://www.frogid.net.au/), BioCollect (https://www.ala.org.au/biocollect/) and many others, designed to involve the wider community in monitoring environmental health, often linked to complementary programs in schools;
- Urban Landcare, encouraging city dwellers to get involved in environmental restoration activities, with complementary programs through Landcare Australia Ltd to facilitate corporate sponsorship for rural and urban landcare projects;
- a suite of incentives measures to encourage stewardship and conservation activities on private lands, including payment for environmental services through market-based instruments such as Bush Tender, taxation reform and local government rating systems;

- creation of markets for water and changing property rights to facilitate water trading in regulated irrigation systems, enabling water to flow to its highest value use;
- strategic purchase of water property rights to create environmental water reserves, managed by dedicated environmental water managers for specific objectives such as fish or bird breeding events, or returning water to parched wetlands; and
- pricing of carbon and establishment of carbon farming initiatives to reward farmers for measuring, building and storing more carbon on their lands and in their soils.

This list is far from exhaustive. These innovations have been complemented, informed, supported and in some cases implemented by an institutional ecosystem that itself has (or had) innovative elements, including:

- Rural Research and Development Corporations, investing public and producer levy funds in applied research programs closely linked to rural industries;
- Cooperative Research Centres, bringing industry and academia together in mission-driven applied research collaborations with a strong emphasis on building research capability in priority areas;
- The National Climate Change Adaptation Research Facility, facilitating sectoral communities of practice in climate change adaptation, informed by targeted applied research;
- collaborative research infrastructure platforms, to facilitate national coordination around critical areas such as data, collections and observing systems;
- not-for-profit organisations purchasing large areas of relatively intact lands and managing them (often very professionally) for long-term environmental benefits; and
- independent, statutory, technically competent auditing bodies, such as the National Water Commission and the Clean Energy Regulator.

The compilation album of Australia's greatest hits in sustainable natural resource management should be an international best-seller. But as lamented by Campbell *et al.* (2017) and Campbell (2016), bright points of Australian innovation have tended to offer ephemeral illumination in a gloomy context of institutional 'ad hockery' and 'systemic amnesia'. Good initiatives have rarely been sustained or monitored well enough for long enough (ANAO 2008) to realise their potential for durable transformation within ecological processes that tend to operate on decadal timeframes. High-performing institutions and collaborations have been repeatedly restructured or abolished for short-term budget 'savings', at enormous long-term opportunity cost. On the whole, Australia has failed to deploy all the best tools in its NRM toolkit together, at sufficient scale, for long enough, to make a real difference on our biggest sustainability and resilience challenges.

It often seems like we are trying to build a tall building by constructing each new level partly using bricks and timber removed from the lower floors, or even the foundations. The consequences are reflected in the condition and trends of our landscapes, ecosystems, biota and rural communities.

Australian expertise in sustainable agriculture, pastoralism and natural resource management is nevertheless highly valued internationally. Over more than 35 years, ACIAR-funded programs have been brokering research partnerships between Australian scientists and their counterparts across our region, in many challenging contexts (ACIAR 2019). This small sample illustrates the diversity:

- grasslands management and payment for environmental services on the Mongolian steppes and the Tibetan plateau;
- Landcare in post-conflict and conflict-vulnerable communities in southern Mindanao, The Philippines;
- innovation platforms for sustainable irrigation in eastern and southern Africa, informed by farmer-driven monitoring of crop water needs and soil moisture using the CSIRO-invented Full Stop wetting front detector and Chameleon soil moisture sensor;
- conservation agriculture in the Eastern Gangetic Plain of India, Bangladesh and Nepal, using Australian-designed small-scale mechanisation to save water, soil, labour and energy, improving yields and air quality through reducing stubble burning;
- community forestry programs using Landcare principles that have involved around 40% of Nepalese households in re-establishing community-owned and managed forests across the middle hills of Nepal;
- designing fishways in the Mekong region, where fish comprise 40–60% of all protein consumed by humans, but fish populations are threatened by both small-scale irrigation structures and large-scale hydroelectric schemes that block their annual upstream migration for spawning;
- developing livelihood options for peatland communities in Indonesia that could radically reduce peatland burning; and
- developing innovative coral spawning and reef restoration techniques that can be deployed at scale relatively cheaply to restore blast-damaged reefs in the Philippines, now being trialled on the Great Barrier Reef.

Whether we recognise it or not, our know-how is a strategic national asset. This is already the case in the resources sector, where Australia plays a dominant role in knowledge-based goods and services. The METS (Mining Equipment, Technology and Services) sector is the fourth most valuable resources export, behind iron ore, coal and gold, with 2015 exports worth around $15 billion (Department of Industry Innovation and Science 2019). Australian expertise in sustainable agriculture, rangelands science and NRM should be seen as equally valuable. Climate change is forcing a growing number of countries to confront how to improve food system resilience across whole landscapes over long timeframes, in increasingly variable and volatile climates. COVID-19 has added food system safety and the resilience of food value chains to that equation. Scientific leadership in this endeavour could be a distinctive element of Australian soft power in our region.

We have all the pixels we need for a compelling big picture, but we have yet to bring them together strategically, then let them work together, adaptively. If we could realise that at home, while sharing that know-how abroad, then Australian landscapes, Australian industries and Australian communities, especially rural communities, would be in better health and better equipped to manage the tough decades ahead.

Conflicts of interest

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