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Developing the north: learning from the past to guide future plans and policies

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Abstract. The development of northern Australia has been a policy ambition for over a century and the desire to do so continues unabated. Attempts to develop the north, especially for more intensive forms of agriculture are not new. In this paper we explore past agricultural developments, including some that persist today and those that have failed, to determine critical factors in success or failure. This was done with the aim of identifying where most effort should focus in supporting contemporary agricultural developments. Although climatic and environmental constraints, including pests and diseases, remain a challenge for agricultural development in these largely tropical rangelands, it is mainly factors associated with finances and investment planning, land tenure and property rights, management, skills, and supply chains, which provide the critical challenges. In particular, the desire to scale-up too rapidly and the associated failure to invest sufficient time and resources in management to learn how to develop appropriate farming systems that are sustainable and economically viable is a recurrent theme through the case study assessment. Scaling up in a more measured way, with a staged approach to the investment in physical capital, should better allow for the inevitable set-backs and the unexpected costs in developing tropical rangelands for agriculture. There are two notable differences from the historical mandate to develop. First is the acknowledgement that development should not disadvantage Indigenous people, that Indigenous people have strong interests and rights in land and water resources and that these resources will be deployed to further Indigenous economic development. Second, assessing environmental impacts of more intensive development is more rigorous than in the past and the resources and timeframes required for these processes are often underestimated.

Additional keywords: development, economics, intensive agriculture, management.

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Introduction

The development of northern Australia (for this Special Issue broadly defined as the area north of the Tropic of Capricorn, ~350 million ha) has been a policy ambition for over a century. Reasons for development in the past have included habitation of the 'empty north' for economic and defence reasons (Cook 2009). More recently, drivers for renewed interest in developing the north include the Millennium drought in the main irrigation areas of southern Australia, opportunities for Australia to contribute to global food security challenges, especially in the context of Asia (Commonwealth of Australia 2012), and broader national policy goals surrounding regional development and increasingly, a vision in which '. . . *native title holders can fully participate in developing the north.*' (p.19, Commonwealth of Australia 2015).

This Special Issue focuses on the challenges and opportunities associated with realising these policy goals in the northern rangelands and savannas. Over the last century, the potential for agricultural development has received most attention in terms of policy initiatives and public discourse. However, the evidence shows that the mining industry has been the economic success story of development in the north. Although most of the profits from mining flow out of the regions, the industry has provided benefits to local regions either directly through infrastructure, services and employment in regional communities or indirectly through programs such as Royalties for Regions in Western Australia, which has invested $6.1 billion in regional development, using mining and onshore petroleum royalties. In addition to agriculture and mining as sectors, there has also been increasing interest in development opportunities for Indigenous communities and businesses, particularly as it relates to land and sea management.

Given the broad expanse of rangelands and savannas across northern Australia, there is an emphasis in this Special Issue on development that involves significant areas of land and the people that live within the region. Agriculture and livelihoods from ecosystems are therefore the focus of the papers that follow. This includes the underpinning climate and resources that support agriculture and ecosystems, governance challenges in facilitating development and natural resource management, agricultural and pastoral opportunities for development including Indigenous communities, supply chain constraints and regional economic drivers.

This introductory paper focuses on how we can use lessons of the past to guide decision-making and management in the future development of northern Australia, using agricultural development as a case study. There has been a long history of agricultural research and development in northern Australia, producing a mix of successes and failures from which several insights can be drawn.

Context for agricultural development in northern Australia

Intensifying agricultural production in northern Australia has its challenges and its opportunities. Outside of the wet tropics along the east coast of Queensland, the landscapes are predominantly either tropical savannas or more arid rangelands. More than 80% of rainfall occurs during the months from November to April and it is highly variable from year to year (Ash *et al*. 1997). The variability in annual rainfall in at least some parts of the north is known to be ~30% higher than areas of similar mean rainfall in other 'wet–dry' tropical regions of the world (Petheram *et al.* 2008*a*). Maximum temperatures across northern Australia commonly exceed 35°C from October to May and annual pan evaporation is greater than 2000 mm in much of the area. In considering future development, it is highly likely temperatures will increase under climate change as will rainfall variability (Mathew *et al*. 2018, this issue). Whether rainfall will increase or decrease is uncertain (Moise *et al*. 2015).

The soils are mostly highly weathered and infertile, with smaller pockets of higher-fertility soils with good water-holding capacity. One estimate suggests the amount of arable soils in an area including the northern draining basins are possibly as much as 5 million to 17 million ha (Wilson *et al.* 2009), although lack of fine-scale data for northern Australia means that there are large uncertainties associated with this estimate. A more recent detailed analysis of the Flinders and Gilbert catchments in north Queensland found that there were 8 million ha of potentially irrigable agricultural soils in those two catchments alone (Petheram *et al.* 2013*a*, 2013*b*).

The major rivers can deliver large quantities of water suitable for irrigation but the flows are strongly seasonal and interannual variability in surface water runoff is higher than that of rainfall (Petheram *et al*. 2008*a*), so that mean flows for many rivers are much higher than median flows. Additionally, the water is not always available in the best locations for intensive agriculture. The largest flows are typically in lower parts of the catchments that are of low relief (hence unsuitable for dams) and prone to seasonal flooding and secondary salinisation. In upper reaches of the catchments rainfall is usually lower and opportunities for impoundments that are capable of storing large volumes of water are constrained by less of the catchment being upstream of any potential dam site. So in terms of surface water, large-scale irrigated developments will be limited to relatively few locations. Petheram *et al.* (2018, this issue) provide evidence that when the whole of northern Australia is considered, ~1.4 million ha of land could be irrigated from surface water storages although such a large area is unlikely given the constraints inherent in this estimate and would require the building of 83 large dams. This is a larger area than the whole of the Murray–Darling Basin, which accounts for 1.2 million ha of irrigation. The 1.4 million ha does not include groundwater, which can also provide reliable water in various locations across northern Australia with current estimates suggesting 100 000–150 000 ha of irrigation might be possible through groundwater sources (Petheram *et al*. 2018, this issue), especially where there is regular and reliable recharge of the aquifers.

In addition to abiotic constraints to agricultural production of climate, soils and water, the role of pests and diseases can be significant. The tropical climate provides fewer natural breaks to life cycles of many pests and diseases. This was a key reason for cotton not succeeding as a crop in the early stages of development in the Ord region (Yeates *et al*. 2014). More recently, disease outbreaks have caused significant restrictions to the horticultural industries in the Northern Territory with the arrival of cucumber green mottle mosaic virus affecting melons (Tesoriero *et al*. 2016) and banana freckle and Panama Tropical Race 4 diseases severely affecting the banana industry (Cook *et al*. 2015; McMaster *et al*. 2015).

Apart from biophysical constraints, a range of market, policy, socioeconomic and environmental factors will influence future opportunities for more intensive agricultural development of Australia's tropical savannas and rangelands. The profitability of the largest agricultural industry in northern Australia, extensive beef production, is over a longer time frame marginal for many operations (Sangha and Russell-Smith 2018, this issue), who question whether longer-term financial viability can be achieved for new agricultural developments. To some extent this view that development will not necessarily lead to improved economic outcomes for the beef sector is supported by the analysis undertaken by MacLeod *et al*. (2018, this issue). They found that irrigated forages can increase animal productivity (e.g. average turnoff weight of sale animals), but the projected economic advantage ranged from negative to moderately positive across three regional case studies. Where there was an attractive return on the investment in irrigation, this only occurred under the more buoyant beef prices that have existed in the last three years. There may be more opportunities to convert rangeland to more intensive crop production and the opportunities for that type of agricultural development have been examined at various intervals over the last 70 years (e.g. Chapman *et al*. 1996; Petheram *et al*. 2016), but such development at scale remains elusive.

Supply chains and associated transport logistics and infrastructure such as roads and ports, processing facilities and power are all significant challenges for establishing a larger-scale agricultural sector in northern Australia, especially west of the Great Dividing Range (Ash *et al*. 2017; Higgins *et al*. 2018, this issue). New developments require a raft of approvals that can include permits to clear and other environmental requirements, such as considerations under the *Environment*, *Protection and Biodiversity Conservation Act 1999* (Cth), changes to tenure, native title and Indigenous land-use agreements, water licences, etc. These can add considerable cost and time to developments. The governance arrangements associated with development are complex and can be frustrating for proponents (Brisbin 2018; Dale 2018, this issue).

Any expansion in agriculture needs to consider the impacts on Indigenous livelihoods. Disruption to streamflow caused by water extraction may disadvantage both immediate and downstream communities. However, there may be opportunities for improved livelihoods for Indigenous communities associated with agricultural development that go beyond jobs for the existing communities and allow resettlement of depopulated traditional lands (Barber 2018, this issue). Capitalising on these opportunities is not a certainty. Stoeckl *et al*. (2013) found there can be little flow-on benefit to Indigenous communities from agricultural development, pointing to the need for a more proactive approach to Indigenous livelihoods. Opportunities for Indigenous communities in northern Australia as part of a broader development policy agenda can extend beyond agriculture to include natural resource management (Jarvis *et al*. 2018; Sangha and Russell-Smith 2018, this issue).

Although, the tropical savannas and rangelands are relatively intact, and more intensive agricultural development will not likely be broadscale in nature, there are environmental risks. These occur onsite in terms of loss of tree cover and biodiversity at the local scale, as well as the potential for offsite impacts. For example, the impact of sediments and nutrients from agricultural catchments on high-value marine ecosystems such as the Great Barrier Reef have been well documented (Brodie and Mitchell 2005).

Direct challenges facing expanded agricultural development in northern Australia include:

- accessing suitable land and water resources to underpin expanded agricultural production;
- navigating the various approval processes associated with land tenure, Native Title, water resource allocation, environmental impact;
- acquiring support from local communities and in effect, a social licence to operate;
- sourcing the significant capital investment required to support the high cost of 'greenfields' agricultural development is in the order of \$10 000 to \$40 000 per ha. Going forward, the cost of water infrastructure development is expected to be borne by private sector investment rather than government investment, as was typically the case in the past;
- providing genuine opportunities for Indigenous economic development;
- cost-effectively, reliably and sustainably growing agricultural products in the variable climate and environment and getting them to market via efficient supply chains;
- establishing new and viable export markets for high-value, perishable fruit and vegetable products with high seasonality of supplies; and
- maintaining the ecological values of northern Australia.

Successfully addressing these challenges is critical to establishing the value proposition for northern agricultural expansion. However, increasing the scale and intensity of agriculture in northern Australia is not a blank canvas. There is a rich history of development initiatives from which we can learn.

There were several ambitious developments that occurred in the 30 or so years following World War II and these had mixed success (Bauer 1977). Associated with these early post-war developments were assessments that the economic case for development was not strong (Davidson 1965; Courtenay 1978). Although some of those factors from decades past remain relatively unchanged (e.g. climate, challenging markets and supply chain costs), in other areas technology improvements have been made (e.g. agronomic technologies, farming equipment, communications).

To date most of the analysis of past agricultural developments has been descriptive, with a few notable exceptions – for example, Fisher *et al*. (1977) and Chapman *et al*. (1996). We aim to synthesise these past and more recent analyses (Ash *et al.* 2014) for several past and current agricultural developments, to determine the critical factors in success or failure of agricultural developments in northern Australia. This is done with the aim of identifying where most effort should focus in supporting contemporary agricultural developments.

Analytical approach

Eleven agricultural developments in northern Australia were analysed, drawing on an earlier study for the Commonwealth by Ash *et al*. (2014). These included both dryland and irrigated development schemes. For each of these 11 development case studies, historical records and published accounts were assessed for scale of development, crop yields (expected vs actual), investment, and key factors affecting success or failure of the development. These key factors were (a) climate, (b) soils and agronomy, (c) pests and diseases, (d) management and farm operations, and (e) supply chains and markets. For each of these factors a rating of 0 to 4 was assigned, with:

0 = No constraint;
1 = Minor constraint – intermittent and can be managed;
2 = Moderate constraint – either more persistent constraint that needs ongoing active management or an intermittent constraint that has a noticeable impact on production, operations or revenue (or any combination of these three);
3 = Severe constraint – either persistent constraint or regularly occurring interruption that significantly impacts on production, operations or revenue (or any combination of these three); and
4 = Critical constraint – ultimately results in enterprise failure.

These ratings were assigned on the basis of written descriptions, available records and some personal accounts. This included journal publications, government reports, articles written at the time of the developments, and monographs.

To interpret these interacting factors in what has driven success or failure in agricultural development in northern Australia we have used the sustainable rural livelihoods framework (Ellis 2000), adapted by Nelson *et al*. (2010), as it provides a pragmatic approach to assessing the adaptive capacity of individuals and industries to adopt, change and reinvent in response to external pressures. It has been applied successfully in Australian agriculture at a national scale (Nelson *et al*. 2010) and to examine specific challenges within an industry (e.g. crop protection in sugar; Hunt *et al*. 2012). Adaptive capacity was assessed via five broadly defined types of capital or assets (adapted from Nelson *et al*. 2010), including:

(a) natural capital – the climate and soils that determine the productivity of land, as well as the environmental resources from which rural livelihoods are derived;

(b) human capital – the knowledge, skills and education of individuals that contribute to the productivity of labour and capacity to manage land;
(c) physical capital – infrastructure (e.g. dams, channels), equipment and improvements in genetic resources (crops suited to the northern Australian tropical environment) and well connected supply chains;
(d) financial capital – the level, patience and persistence of income sources, and access to other financial resources (e.g. investment) and markets; and
(e) social capital – relationships and the close social bonds that facilitate cooperative action and sharing of ideas and resources.

Results

A brief summary of the various schemes and their fate is provided below and the qualitative analysis of the key factors influencing success or failure is described in Table 1.

Territory Rice Limited, The Northern Territory

The potential for rice production in the Top End was first raised in earnest after World War II (Poggendorff 1949; Agricultural Section 1954). This led to the establishment of a Rice Advisory Committee to facilitate development proposals (Mollah 1982).

At the same time, commercial interest had been stimulated and Territory Rice Ltd was established and capitalised with an initial \$5 million (33% Australia, 67% United States). The company entered into an agreement with the Commonwealth to lease 300 000 ha of land over 30 years in exchange for developing 200 000 ha of land and providing the agronomic advances to establish a rice industry in northern Australia. Pilot operations commenced in 1954, reaching just over 2000 ha before being abandoned in 1960 with significant losses and the company being placed in receivership.

Ord River Irrigation Area 1960–1980, Western Australia

The Ord River Irrigation Area was initiated and implemented by the Western Australian and Australian governments in the late 1950s. The Diversion Dam at Kununurra was completed in 1963 and the Ord River Dam, (which produced Lake Argyle) was completed in 1972. Commercial farmers were first offered land in the irrigation scheme in 1963. Considerable agronomic research had been conducted at the Kimberley Research Station from 1946 to determine which crops and agronomic methods would be suitable for the climate and soils of the Kimberley region. Although this research underpinned agricultural development it did not in itself guarantee success of the commercial agricultural ventures.

The Australian Government had expressed reservations about the viability of the scheme during the planning stages:

> 'If we were spending the money ourselves and of our own choice, we would, I think, like to have a good deal more information as to the problems of transport and marketing. It is one thing to feel reasonably satisfied that certain commodities can be grown under irrigation. It is, of course, quite another to determine whether they can be profitably grown.' (RG Menzies, Prime Minister of Australia 1959).

Table 1. Summary of the 11 agricultural developments and factors that affected their success or failure

E = Expected area and A = Actual area cropped. The expected area for the Ord 1960–1980 represents all areas proposed for development at the time and includes land shown as expected for the Ord 1980-present. Scores described in the section, Analytical approach, are bolded

Initiative, location and years of operation	Planned and actual scale (ha)	Crop	Expected and actual yield	Climate	Soils and agronomy	Pests and diseases	Management and farm operations	Supply chain and markets
1. Territory Rice Ltd Humpty Doo, Adelaide and Alligator Rivers (1955–1961)	E – 200 000 A – 2250	Irrigated rice	E – 2.5 t/ha A – 1.3 t/ha	**3** Trafficability problems during monsoonal wets	**4** Poorly adapted varieties; salt at depth; germination failures	**1** Magpie geese a minor problem	**4** Lack of capital; lack of water at planting; poor levelling of soils	**1** Small amount of rice was sold but no clear strategy for full production
2. Ord River Irrigation Area Kununurra, WA (1960–1980)	E – 70 000 A – 14 000	Cotton + other crops	E – 800 kg/ha A – 700 kg/ha (lint)	**1** Humidity and temperatures favoured pests and diseases	**2** Reasonably well adapted varieties; lint of low quality	**4** Severely affected by cotton boll worm	**2** Good farming operations on 250-ha farms; high input costs	**4** Cotton subsidies that were removed by 1972, so not competitive
3. Ord River Irrigation Area Kununurra, WA (1980 – present)	E – 45 000 A – 5000	Sandalwood, melons, chia, maize, cotton, pulse crops	Most crops achieve yields within 10% of other regions	**1** Very high temperature and evaporation in the late dry season	**2** Agronomy of crops sufficient; wet season cropping limited by trafficability	**2** Pests such as aphids a persistent risk for some horticultural crops	**1** Well organised farm operations; reliant on backpacker labour	**3** High transport costs to southern ports; limited sea transport to export markets

4. Tipperary Land Corporation, NT	E – 79 000 A – 6900	Dryland sorghum	E – 3.3 t/ha A – 1.7 t/ha	**2** Short season gave a narrow planting window	**2** Soil constraints known, limited by well adapted varieties	**1** Minor weed and pest problems	**4** Inappropriate cultivation; poor seedbed preparation	**4** No proper storage facilities on farm or at port
5. Camballin Irrigation Area, WA	E – 25 000 A – 1930	Dryland and irrigated sorghum	E – 3.5 t/ha A – 3.5 t/ha	**2** Flood risk from Fitzroy River	**1** Nutrient requirements well known	**0** None reported	**4** Insufficient capital; challenges with approvals	**3** Export contracts not fulfilled; storage facility built in Broome
6. Northern Agricultural Development Corporation, NT	E – 25 000 A – 10 000	Dryland sorghum	E – 2.5 t/ha A – 1.8 t/ha	**3** Short growing season not sufficient for reliable yields	**2** Hard setting and erodible soils	**0** None reported, though galahs anticipated as a risk	**4** Poor seedbed preparation; too much capital in equipment	**3** Rudimentary storage, poor marketing
7. Burdekin River Irrigation Area, Qld	E – 90 000 A – 90 000	Sugarcane + some other minor crops	E – 150 t/ha A – 120 t/ha	**1** High solar radiation favourable for crops; cyclone risk	**2** Salinity in the delta region; soils generally well suited to sugarcane	**1** Cane grub can be an issue but can be controlled	**2** Sugar yield decline due to soil run-down; need for tailwater recycling	**1** Well developed processing infrastructure; now more market competition
8. Lakeland Downs, Qld	E – 6000 A – 6000	Sorghum and maize	E – 3–4 t/ha A – 1.8 t/ha	**3** First 2 years extremely dry. Second dam destroyed by high rainfall	**2** Used suitable varieties; employed agronomists	**2** Pests (midge, armyworm) and diseases	**4** Poor land clearing and cultivation; insufficient equipment	**2** Developed storage facilities and markets; beef collapse in mid-1970s
9. Peanut Co. of Australia, NT	E – 4000 A – 2000	Peanuts, maize and hay	E – 4–5 t/ha A – 3 t/ha	**1** Reliable but short wet season; good plans needed for wet season planting	**2** Longer maturing peanut varieties not well suited to double cropping	**2** Many pests but well managed	**3** Challenges in scaling up; high costs of production in Katherine	**3** Drying plants in Katherine but processing plant in Qld meant transport costs were high
10. Mareeba-Dimbulah Irrigation Area	E – 20 000 A – 12 000	Mixed crops (sugarcane, mangoes, bananas, etc.)	Sugarcane E – 100 t/ha A – 90 t/ha	**1** Fairly reliable wet season, moderate cyclone risk	**0** Mostly fertile, volcanic soils + sandy soils	**1** Well planned pest programs manages most issues	**1** Many properties small scale as a legacy of tobacco days	**2** Long distance to markets for horticulture; local processing for peanuts, grains, sugar
11. Katherine mangoes	E – 5000 A – 2000	Mangoes + some melons	KP mangoes E – 10 t/ha A – 5 t/ha	**1** High minimum temperatures can affect flowering	**2** Deep sandy soils ideal for mangoes; red soils prone to scalding	**1** Low pest pressure	**2** Variable flowering poses issues for consistent yields	**2** Market timing advantage, variable production and high transport costs

Nevertheless, the Australian Government financially supported the development of both the Diversion Dam and the Ord River Dam. The optimism at the opening of Lake Kununurra in 1963 was not borne out in commercial production, with the quality of cotton and pests becoming major constraints. Cotton production had effectively ceased by the mid-1970s, and in the mid to late 1970s future prospects for the Ord Scheme were being reviewed as the transition phase post-cotton was proving to be challenging both for farmers and government. Both the Western Australian and Australian governments remained committed and by 1980 the area under irrigation was greater (12 000 ha) than during the cotton phase, with a range of crops being grown. There was growing private interest in acquiring irrigation land and the Ord River Irrigation Area entered a new phase.

Ord River Irrigation Area 1980-present, Western Australia

The renewed phase of development commencing in the early 1980s signalled a move away from broadacre crops to a wide range of high-value field and horticultural crops (pulse crops, curcurbits, mangoes and bananas). Farmers tested and trialled new farming approaches in trying to adapt these crops to the environment often with the aim of being able to supply crops for southern markets out of season or very early in the season.

In addition to the emerging successes with higher-value crops, broadacre agriculture made a return to the Ord in the mid-1990s with the introduction of sugarcane and the establishment of a small mill. Sugar was grown on ~4000 ha at its peak, producing 55 000 t/year of sugar that was trucked to Wyndham port for export. The small scale of the mill and amount of land in production led eventually to the industry not being viable, and production ceased in 2007.

Managed Investment Schemes found their way to the Ord River in the early part of the 21st century, with the establishment of Indian sandalwood (principally), African mahogany and mango plantations. By 2012, sandalwood was grown on around half of the 14 000 ha of irrigated land available. Through all this period horticultural crops and field crops such as chickpeas, beans, pumpkins and melons were being successfully grown, with the main issues being distance from markets, highly variable market prices and transport costs. New field crops such as chia were being successfully grown by farmers in the region and a new vertically integrated industry established which allowed value adding of the broadacre crop.

With the Ord Stage 2 development and other areas along or near the Ord River (e.g. Carlton Hill station) being planned for development the total area of irrigation could increase to over 45 000 ha. The Western Australian Government committed $334 million to this expansion between 2010 and 2013, the Australian Government contributed $195 million for a building program (Office of the Auditor General Western Australia 2016) with a private company developing the new farmland. The Ord Final Indigenous Land Use Agreement between the State of Western Australia and the Miriuwung Gajerrong Traditional Owners was critical to the expansion of land available for irrigation by negotiating native title future act provisions and addressing compensation liabilities.

Tipperary Land Corporation, The Northern Territory

The Tipperary Land Corporation development was part of the post-World War II effort towards agricultural development in The Northern Territory. Investigations into crops and agronomic practices suitable for dryland farming systems for the Katherine region laid the ground work for development, which drew on a major land systems survey by CSIRO in the Katherine–Darwin region published in 1953, initiated by the Northern Australia Development Committee (McGregor 2013). This large-scale commercial development came closer to realisation when Tipperary Station was purchased in 1967 by a group of Texan investors, who established the Tipperary Land Corporation (Mollah 1980). They aimed to establish very large areas of sorghum production and cattle fattening on this 400 000 ha pastoral lease. It was envisaged that full-scale development would require US$20 million; over US$7 million had been raised for the initial phases by late 1967.

However, the corporation's prospectus was overly optimistic in its yield estimates, suggesting that trial yields were lower than could be achieved commercially. After only 3 years of growing grain sorghum, cash flow constraints essentially ended cropping at Tipperary, and the property was sold in 1973.

Camballin Irrigation Area, Western Australia

The Camballin irrigation project commenced in the Fitzroy River floodplain in the West Kimberley region of Western Australia in the 1950s. It was initiated by private enterprise and did not receive the same attention as the Ord River irrigation developments, also in the Kimberley region.

Northern Developments Pty Ltd began small-scale rice production from 1952 to ~1969. Based on promising production, the Western Australian Government agreed to support some irrigation development activities through the construction of a modest dam and the erection of a barrage across the Fitzroy River. In return, Northern Development agreed to crop 8000 ha of land with rice. The Western Australian Government also established the town of Camballin, gazetted 1959, to service the irrigation scheme and granted nearly 5000 ha of freehold.

In 1969 the Australian Land and Cattle Co. (ALCCO) took over the former Northern Development Pty Ltd holdings and had plans for considerable expansion, including a 17-km levee bank to prevent flooding of the expanded cropping area. This was a large cropping and grazing production enterprise but the company struggled with investment and government approvals and went into receivership in 1982 (Fletcher 2008). The levee bank failed in a large flood in 1983, causing significant damage to machinery and infrastructure, which effectively ended operations at Camballin.

Northern Agricultural Development Corporation, The Northern Territory

The Northern Agricultural Development Corporation was formed in 1971 with the aim of developing the 585 000 ha Willeroo Station from a low-input, extensive pastoral lease to a high productivity crop and cattle fattening operation. This involved plans of clearing 80 000 ha for improved pasture (Stylosanthes legume) and 25 000 ha for grain sorghum, and establishing a feedlot to fatten cattle (Fisher *et al.* 1977). Close to 50 000 ha was cleared in total. About 18 000 ha was sown to Stylo and 10 000 ha cultivated for sorghum production. The clearing and planting was undertaken in a short timeframe and some of the more arable soils were left uncleared in favour of less suitable soils. Little was invested in infrastructure, with grain storage occurring in the open and suffering damage. The Corporation went into receivership in September 1974.

Lower Burdekin Irrigation Area, Queensland

The Burdekin Haughton Water Supply Scheme is the largest irrigated agricultural development in northern Australia, with ~90 000 ha of land used to grow a range of crops in the lower Burdekin region, though sugarcane by far dominates the area cropped. The delta region of the lower Burdekin was established in the 1860s, relying mostly on groundwater, although it is today supplemented by surface irrigation water. The Burdekin Falls Dam was completed in 1987 and the reservoir (Lake Dalrymple) filled to capacity in 1988.

Unlike other new cropping schemes across the north, there was already an established sugar industry and associated infrastructure at the time of development of the Burdekin Falls Dam. Four sugar mills service the Lower Burdekin. Contractual arrangements were put in place with growers to supply cane to mills for several years, to guarantee the mills a certain quota of sugarcane and ensure the longer-term viability of mills. Other crops grown in the Lower Burdekin include various pulses (soybean, mungbean, chickpea) that are often used in rotation with sugarcane, horticultural crops such as melons, and small amounts of cotton and rice, though there is renewed interest and investment in these two broadacre crops.

Lakeland Downs, Queensland

At the time of purchase in 1968, Lakeland Downs was a cattle property (Butcher's Hill) located 80 km south-west of Cooktown in far north Queensland. It was purchased with the goal of establishing a significant dryland and irrigated grain production system integrated with cattle production.

Two dams were constructed to provide irrigation for dry-season cropping. The second dam, constructed on the Laura River, was destroyed in the 1970–71 wet season before it could be used. Considerable capital investment went into irrigation infrastructure but only ~500 ha was used for irrigation.

A grain storage facility and wharf were constructed at Archer Point, from which grain was loaded on to light vessels that ferried the grain to a ship moored further out to sea. The scale of development led to the establishment of a small town, named Lakeland Downs, which had a population of ~200, 60 of whom were employed in the agricultural development enterprise (Wallace 2002).

Grain production reached a peak in the 1970–71 wet season but the cropping operation ceased by 1974. Crop yields did not provide sufficient returns, nor did the cattle operation, and the company went into liquidation in 1974.

Subsequent ownership and management focussed on a wide range of crops including peanuts, rice, sorghum, maize, bananas, pawpaw, passionfruit and coffee. Around 1980, the farms were sold as smallholder farming operations, averaging 400 ha. Cropping at Lakeland Downs continues today, with a range of crops still being produced in dryland production or with largely supplemental irrigation from small dams and groundwater. Most recently, bananas have expanded at Lakeland Downs as a diversification strategy for banana growers hard hit by cyclones in the Innisfail–Tully region in 2006 and 2011.

Peanut Co. of Australia, The Northern Territory

The Peanut Co. of Australia purchased a small area of land in the Katherine region in 2002–03 to determine whether peanuts could be commercially grown in winter under irrigation (PCA 2003). In response to ongoing drought in southern Queensland, the company decided to expand its operations in Katherine by moving from small-scale testing of a few hundred hectares to full-scale commercial production of thousands of hectares. This involved the purchase in June 2007 of an 11 700-ha property in Katherine with access to irrigation water. The expectation was to have 4000 ha under cropping and 3200 ha being irrigated, growing rain-fed wet-season crops (peanuts, corn, hay) and dry-season irrigated crops.

Although yields were commercially viable, the Peanut Co. of Australia made a decision in 2010 to divest its Katherine operations (PCA 2010) due to a strategic decision to invest more effort in the core operations of processing, the high operating costs at Katherine, some uncertainty over longer-term water allocations and the need for ongoing capital to scale-up to full operations. The properties in Katherine were disposed of in 2012 and the major agricultural use shifted to sandalwood plantations.

Mareeba-Dimbulah Water Supply Scheme, Queensland

Construction of the Tinaroo Falls Dam commenced in 1953 and was completed in 1958. This large dam was the foundation for the Mareeba–Dimbulah Irrigation Area (now MDWSS), which was created largely to support the tobacco industry. The total area serviced by the irrigation scheme was 11 800 ha, which spanned the Walsh, Barron and Mitchell rivers. Farms were small in size because tobacco production was intensive, requiring a minimum of 40 ha. In addition to tobacco, a range of other crops and irrigated pastures were grown.

With the deregulation of the tobacco industry in 1995, attention turned to other crops and sugarcane is now the dominant crop. A sugar mill was constructed at Arriga, west of Mareeba, in 1997–1998. Other major crops include mangoes and bananas, with smaller areas of pawpaw, avocado, lychee, macadamia, citrus, pongamia and coffee. The area under bananas has increased significantly in recent years as growers in the Tully–Innisfail area looked to spread their climate risk as a result of severe cyclones in the Innisfail and Tully areas.

Katherine Mangoes, The Northern Territory

The mango industry started in the Northern Territory in the early 1980s in the Katherine and Darwin rural areas. Manbulloo Mangoes was a large investment in 1982 of 300 ha that failed financially after 7 years, but following a change in corporate ownership and management it became a profitable business. The Northern Territory Government supported development in the Katherine region through the 1995 release of 3000 ha of land with roads, power and water licences for farming, with the land sold at commercial valuations. Much of this is planted to mangoes and the industry is now worth around $45 million/year from 2000 ha, based on irrigation from the Katherine River or from bores. There is a defined competitive market advantage supplying out-of-season mangoes to southern markets before Queensland production.

The future opportunities remain positive because of the strong market demand. However, current productivity is constrained by variable yields and poor flowering, especially in traditional varieties such as Kensington Pride. These low and variable yields combined with a low percentage of Class 1 mangoes, which are demanded by major domestic and export markets, provide ongoing challenges. Newer varieties protected by Plant Variety Rights, provide higher and more reliable yields.

Current status of developments

Of the 11 case studies of agricultural development, four successfully continue to operate at a regionally relevant scale – the Ord River Irrigation Area, the lower Burdekin, the Mareeba–Dimbulah Water Supply Scheme and the Katherine mango industry. The Lakeland Downs development also continues though it could not be categorised as regionally significant. Elements of the Camballin Irrigation Area are being used to grow hay and other crops, but at a relatively small scale.

All three of the continuing large-scale (>10 000 ha) irrigation schemes (Ord, Burdekin, Mareeba-Dimbulah) have received significant government investment, in the order of hundreds of millions of dollars each in core dam infrastructure, with a mixture of state and Australian government funds supporting the construction of the dams and associated channel infrastructure. This has leveraged significant private sector investment. Government investment has provided other benefits, for example, development of townships such as Kununurra and the infrastructure and services that provides in support of other sectors such as tourism and mining industries. Current water charges largely reflect the costs of supplying water and maintaining the assets and do not include capital costs of development.

With the exception of Katherine and Lakeland Downs, all of the private agricultural development schemes that had little or no direct government investment, particularly in infrastructure, have not persisted.

It is worth noting that development plans continue to be put forward and in some cases are being implemented. Large-scale developments (mostly dryland) are underway in the Northern Gulf region of Queensland, and in these cases the development plans are yet to be fully realised. In the Ord, new agricultural land is being developed although at this stage only ~7000 ha are being cropped of the over 30 000 ha planned in addition to the nearly 15 000 ha of Ord Stage I.

Key factors that have influenced the fate of agricultural developments in northern Australia

Many factors come into play in determining the success or failure of large-scale agricultural developments. In this analysis we have focussed on the important biophysical factors of climate, soils, pests and diseases, as well as the key agronomic, management, financial, and market and supply chain factors.

Natural capital

Key factors affecting natural capital in northern agricultural developments are climate, land resources, water and pests and diseases.

Climate

The climate of northern Australia provides a comparative advantage for the production of some horticultural crops, providing fruit to markets when other regions cannot do so (e.g. early season mangoes, melon production in the middle of the year). It is a harsh climate, with high temperatures and evaporation, and highly seasonal rainfall. However, it was a direct and significant constraint on success in only 4 of the 11 case studies. Three of these were dryland farming systems: the short growing season with a sudden onset of the wet season left a small planting window at Willeroo and Tipperary in the Northern Territory; and two very dry years (decile 10) at the start of the Lakeland Downs development. These issues associated with climate, as well as others such as high-intensity rainfall events on bare soils at time of planting or high temperatures at the soil surface at the time of planting and germination, have been well recognised (Chapman *et al*. 1996) and considerable research effort has been expended in developing farming system strategies to manage them. However, for most areas in northern Australia, the short growing season, even if it is reliable, will constrain most grain crops. There will be more opportunity for shorter season pulse crops such as mungbean.

Territory Rice Ltd at Humpty Doo was the only case study from the irrigated developments that was severely constrained by climatic factors in farm operations. It was particularly affected by a combination of the monsoonal rains and clay soils, which made it difficult to cultivate the land in the wet season.

Climate played an interacting role in disrupting production, harvest or transport in several other developments. In the Tipperary and Northern Australian Development Corporation's dryland cropping operations, grain was stored in the open and its quality was affected by unseasonal rainfall. At Lakeland Downs, the first 2 years were particularly dry (ironic given that one of the dams was destroyed in the 1970–1971 wet season, even before it was used) and highlights an important issue of the run of years experienced at the time the development commences and how that interacts with financial viability. This is particularly relevant to dryland developments solely reliant on rainfall or in irrigation developments where storages have relatively low reliability because of high interannual variability in rainfall. If cash flow projections are based on average years, then major developments can run into trouble if a run of poor seasons or extreme events are experienced in the early years of operation (Ash *et al*. 2017). One solution for irrigation developments where reliability is affected by interannual variability is to ensure water is not overallocated and that those who have access to water can have higher certainty in its use. This is particularly the case should the enterprise-type require substantial fixed costs such as a mill or packing shed or other processing facility.

Even where the variability in rainfall is overcome through reliable irrigation storages, extreme weather events can be an important disruption to production. For example, at Camballin in Western Australia, a large rainfall event washed away the levee bank protecting the cropping area, inundating much of the plant and equipment. By that stage the company was already in receivership but if it was in full production, it would have been catastrophic.

Soils

Growing crop varieties that were well adapted to the available soils provided some challenges in nearly all of the agricultural developments. Although in several the developments specific soils information was lacking (Cameron and Hooper 1985), the soil constraints were well enough identified through previous land resource assessments and/or location specific analysis (e.g. erodible soils, surface sealing after disturbance, trafficability in the wet season) before implementation. In some cases these constraints were addressed but in others they were ignored or time pressures to get the development underway meant that suboptimal practices were put in place. However, some soils risks were not considered or even ignored at the time, for example, rising watertables from irrigation with risk of secondary salinisation (Petheram *et al*. 2008*b*).

Pests and diseases

The tropical climate provided a range of pest problems to crops in several the developments. However, with the exception of cotton in the Ord River Irrigation Area, they did not suppress yields sufficiently to put in jeopardy the viability of the development. In many of the developments the lifespan of cropping was only a few years, which may have not provided sufficient time for pest loads to build up.

In the Ord River Irrigation Area, pest loads on the cotton crop were a significant issue. The crop was planted in the late wet season and provided an oasis of green forage as the native grasses hayed off in the early dry season. A wide range of insect pests attacked the cotton but cotton boll worm (*Helicoverpa armigera*) became the dominant pest problem and could only be controlled with regular spraying with DDT and/or organophosphate insecticides. Apart from the practicalities and environmental consequences of applying an insecticide up to 30 times during a crop cycle, the costs of production rose dramatically, making cotton growing unviable.

More recent disease outbreaks in melon and banana crops have proved to be locally devastating, not so much from the direct impact on crop yield, but the quarantine and market restrictions placed on affected properties.

Human capital

Skills and experience in farming in northern Australia were in limited supply in many of these developments. Although in some of the regions there had been significant investment in research at a small scale, there had been relatively little effort in understanding the practical challenges of commercial-scale farming. The learning-by-doing approach, combined with the speed at which many of the developments occurred, meant that on-farm management did not fully consider all the available soils and agronomic information, leading at times to costly mistakes in land preparation and planting and management of crops. Exacerbating these issues was that many of the larger-scale developments were being overseen by head office management and centralised decision-making that were remote from the actual development and often without good communications or appreciation of issues unfolding on the ground. This low level of human capital was on the whole more important in the failure of agricultural developments than climatic or agronomic constraints and played a significant role in 7 of the 11 case studies. The same constraints are now being recognised among graziers who are looking to develop their land for irrigation (McKellar *et al*. 2015).

Physical capital

All of the developments were based on creating new areas of land for agriculture and were all 'greenfield'. This required the physical capital to be provided in the form of dams and associated support infrastructure (channels, roads, etc.), land preparation, farm equipment, cold stores, and packing sheds. Appropriate capital was often not set aside for equipment that was required to match the environment and the lack of supporting local mechanical and agribusiness services. When machinery broke down it often needed to be sent to southern Australia for repair or skilled labour had to be flown in. This led to significant down time and missing of critical crop sowing or harvesting windows. Capital plans did not often account for the need for back-up equipment and as a consequence, several developments were severely capital constrained. This was particularly an issue for schemes that were ambitious in scale from the outset. In contrast to this 'get big quickly' approach that characterised some of the early agricultural initiatives, the development of the mango industry in the Katherine region proceeded more steadily and so provided an opportunity to solve problems as the industry grew. Capital investment occurred through a mixture of local entrepreneurs and Managed Investment Schemes and provided the infrastructure to support the growing industry.

An important aspect of physical capital is having suitable crop varieties and genetic resources. For most of the early developments, crop varieties to suit the climatic conditions had not been specifically developed. In most situations this was recognised and varieties were chosen that were best aligned to the environment. At times this still caused issues – for example, Territory Rice Ltd had access to rice varieties that were poorly suited to the daylength of the Top End and the mechanised farming practices, and the peanut varieties used in the Peanut Co. of Australia development at Katherine took five months to reach maturity from time of planting. This put pressure on planting right at the end of the wet season to fit the peanut crop into the dry season so there was enough time to plant a wet-season crop.

The physical capital associated with supply chains, especially a lack of infrastructure to transport, store or process the agricultural product, was a significant impediment in 6 of the 11 study developments. There were exceptions, such as in the Lakeland Downs development, where considerable thought had been given to export markets, with a Japanese investor involved and under licence to buy the grain produced. Grain storage facilities were built near Lakeland Downs at Archer Point and a wharf was constructed to take the grain out to ships anchored in deeper water.

Financial capital and reliable markets

A common factor across many of the developments that were not successful was that the time required to expand to full scale was underestimated and not enough market analysis was undertaken. Little allowance was made for the time required to get to know the new environment and adapt farming practices. In parallel, financial plans tended to overestimate early production, returns on capital and economies of scale, leading to cash flow problems. As a consequence, the areas of development actually achieved were usually much less than the original expectations (Fig. 1). Exceptions to this are the Burdekin and Lakeland Downs developments where the area of planned irrigation was fully developed. In the Burdekin this can be attributed to having a well established industry already in existence, with sugar mills, transport networks, agribusiness and government support services, and investors well established in the region. At Lakeland Downs, only a modest area (6000 ha) was originally expected for development and it has gone through various phases of activity over the last few decades.

In addition to on-farm finances, the need to have well connected markets was assessed to be a key success factor from the analysis of the case studies. Markets that were supported or guaranteed were important drivers in two of the developments, namely cotton in the Ord River Irrigation Area and tobacco in the Mareeba-Dimbulah Water Supply Scheme. The cotton subsidy was gradually removed between 1969 and 1972 and, combined with the high costs of production in the Ord associated with pest control, led to the cessation of cotton growing in that region. In response to growing public health concerns about tobacco and the increased questioning of government support being provided to tobacco growers through guaranteed levels of Australian tobacco leaf and assigned quotas on production, the Australian Government removed the regulatory framework in 1995 (Griggs 2002), which ended the guaranteed market for tobacco growers in north Queensland.

In the case of Katherine mangoes, its northern location gives it a distinct advantage in terms of markets and was a main driver for its development. Mangoes grown in this region are ready for market before the main Queensland mango crop and so its main competitor is the mango industry in the Kimberley region. Its close proximity to the Stuart Highway that connects to southern markets is also an advantage.

In larger companies with a diverse portfolio of agricultural investments beyond northern Australia, or investments outside agriculture, priorities can change rapidly in response to financial pressures, shifts in strategic direction or changes in senior management. This was a key factor in the Peanut Co. of Australia withdrawing from its Katherine operations (Jakku *et al*. 2016), although there were also some production challenges.

Social capital

Most of the historical developments commenced with almost no social capital. There was usually no history of agricultural development and so there was little in the way of a community of practitioners from which experiences could be shared. Many of the large-scale projects were directed from head offices a long distance from the farm operations, which added complexity and transaction costs and did not foster an environment where social capital could be built. In the agricultural developments that continue today that situation has changed. For example, in the Ord region, the Ord River District Co-operative has been in existence since 1963 and provides support, advice and direct services and inputs to farmers in the region. It has, over the years, become a vital institution for the farming community. Similarly, for those agricultural developments that have been in operation for more than 30 years, a second generation of farmers is

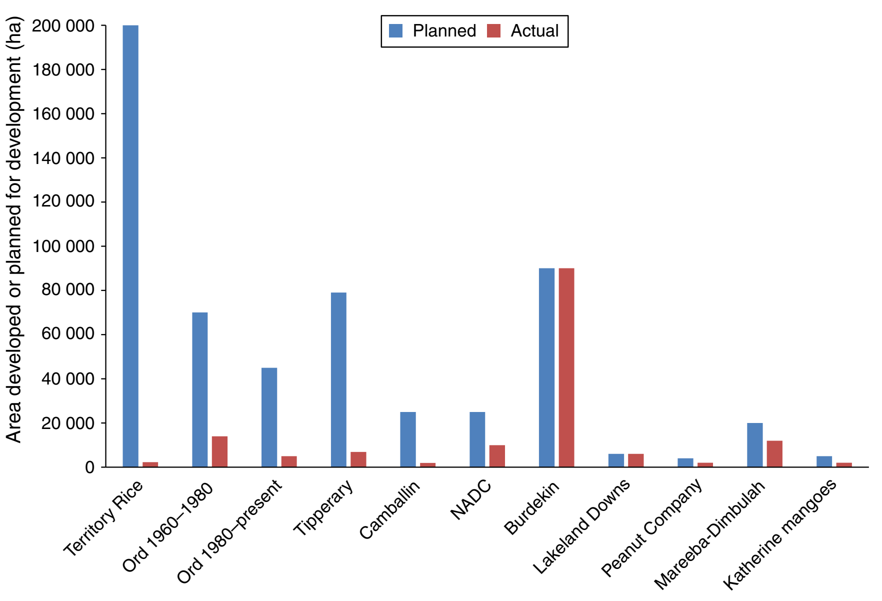

Fig. 1. Areas (ha) of land planned for development, or expected to be developed, and actually developed in the 11 case studies. The planned area for the Ord 1960–1980 represents all areas proposed for development at the time and includes land shown as planned for the Ord 1980-present.

emerging, providing additional social capital. The time required to build this social capital should not be underestimated, and it needs to be actively fostered in the development of new agricultural precincts and developments. Where existing graziers are looking to invest in irrigated agriculture, it is understood that considerable social learning is required and there is a key role for knowledge brokers and farmer groups (McKellar *et al*. 2015).

Social capital beyond the farm gate is also important. Towns such as Kununurra, Katherine, Mareeba and Ayr provide a level of services such as health, transport and education for those associated with the agricultural developments (and their families) that was not available in other areas.

Lessons for future agricultural developments

There are lessons that can be learned from these past large-scale agricultural developments. The climatic and soils constraints remain but are now much better understood, and there are now crop varieties better suited to the environment in northern Australia. That does not mean that the agronomic challenges in northern Australia have been overcome but rather experience gained over many decades, coupled with technology advances, means they are more manageable. It is much easier with today's technology to pre-determine soil risks whether they be risk of erosion or areas that are a much higher risk of salinisation (Petheram *et al*. 2008*b*).

Similarly, much more is known about pests and diseases and there are now tools to match different pests and weeds to specific climates (Sutherst and Maywald 1985) that are commercially available (e.g. CLIMEX, Hearne Scientific Software). In addition to tools that can assist with risk mapping, significant advances have been made with pest management of some crops (e.g. genetically modified cotton) that make it easier to grow in northern Australia (Yeates 2009).

Unexpected pests and diseases will inevitably occur so some diversity in crops and cropping practices will be needed to manage such outbreaks. For example, the recent return of rice to the Ord River Irrigation Area was affected by rice blast. The industry had not re-established itself to a sufficiently strong position so the disease set back the return of rice as a crop in the Ord region. Rice varieties with greater tolerance to rice blast are available though they need testing locally to determine their agronomic fit.

For those large-scale developments that did not persist, it was issues associated with management, planning and finances, and supply chains and markets that contributed most to their demise. In particular, there was a recurring pattern of attempting to rapidly scale-up operations in new environments where there was a lack of agricultural experience in climate, soils and agronomy and their interaction with farm operations. This can be generally attributed to financial pressures from the outset of the development that dictated the need to achieve returns on capital within a few years of start-up. A more realistic assessment of the environmental and operational constraints in the development and implementation phase is probably needed in the business case for any new investment. This 'learning phase' needs to be factored in to development and investment plans and this issue was clearly identified in the study of Jakku *et al*. (2016), where a detailed exploration of decision drivers was undertaken for the Peanut Co. of Australia development at Katherine.

Supply chain issues remain a significant challenge. For example, opening up new areas to a crop that requires processing facilities, such as a sugar mill or cotton gin, requires both a large scale of cropping and the financial investment to support the processing infrastructure. The high capital required for these investments demands that water reliability needs to be close to 100%. Aligning these two objectives in time and space can be difficult to achieve, given the significant risks for both growers and processors.

In addition, the distance to market or to a port is a critical factor in the viability of large-scale developments that are producing bulk commodities or commodities that need to reach the market within a short period (e.g. horticultural produce). Significant thought and planning on the logistics and transport to markets is required because transport is a significant component of costs of production in many of these prospective regions. Some of the supply chain constraints (such as flood-proofing roads, port facilities) require large capital investments that could only be justified by multiple industries and users, or over longer timeframes or as deliberate investment strategies by government to develop certain regions.

Finally, the products have to be sold and the changing nature of markets remains an issue. Indeed, if anything, competition for markets has become stronger and small advantages or disadvantages in production and supply chains can make the difference between profit and loss. Broadacre crops feed into a world market so the amount of production from northern Australia is not a factor affecting prices received. However, for high-value horticultural crops such as mangoes, melons and pumpkins, the main market is domestic consumption and the price received is sensitive to the overall production and seasonality of that production because of the ease of saturating the domestic market. The future for significant expansion of these high-value commodities lies in export markets rather than domestic markets, yet for many of these high-value horticultural products, export protocols are not in place for many of the prospective countries nor are there transport logistics in place for rapid transport to overseas markets of high-value produce.

Development in the 21st Century should also include stronger and deeper Indigenous involvement in water and land planning processes. The Ord Final Agreement is an example of the benefits that may flow to Indigenous people in return for development. Contrary to a widely-held view otherwise, the Ord Final Agreement showed that Traditional Owners may agree to development if they are satisfied that there are economic and social benefits to their communities. Barber (2018, this issue) reports on a study in north Queensland in which he shows that Indigenous participants identified significant risks in development, but also recognised that development could lead to employment-related resettlement of depopulated traditional lands. Barber (2018, this issue) also noted that any benefits to Traditional Owners in the immediate development zone may further disadvantage Indigenous people downstream of the development.

Additionally, as Jarvis *et al*. (2018, this issue) show, Indigenous economic development may also slowly build as Indigenous people benefit from agricultural investment or other forms of economic activity. Jarvis and colleagues also highlight out that this is not an easy or certain outcome. Economic policy descriptions designed within the context of urbanised western economies do not easily translate into economic advancement of remote Indigenous economies in northern Australia.

Complex and lengthy approval processes and institutional uncertainty remain a major impediment to development in northern Australia (Stokes *et al*. 2017) and this is an area where policy reform can make a significant difference. For example, pastoral lease conditions have historically restricted land use activities to those closely aligned to pastoral production. In recent years, the Northern Territory Government has made changes to the Pastoral Land Act so that non-pastoral use permits can be obtained to pursue activities that can generate alternative revenue streams (agriculture, horticulture, aquaculture, tourism, forestry) to pastoral production. Changes introduced by the Northern Territory Government include permits approved for a 30-year period, permits registered to the lease rather than the individual so that they can be transferred, and assistance with business planning and assistance with ensuring compliance to the *Native Title Act*.

New approaches to assessing impacts of development on biodiversity have been proposed (Whitehead *et al*. 2017) to make more effective use of strategic assessments under the *Environment Protection Biodiversity and Conservation Act 1999*. This can offer a means of reducing regulatory risk for developers by providing at the outset an indication of which areas can be developed with low risk to biodiversity. Achieving a more harmonised approach to policy and governance within and across jurisdictions and developing policy and plans that more actively engage stakeholders and help them to navigate the range of issues they will face are seen as two critical elements for progressing development more effectively and efficiently (Dale 2018; Brisbin 2018, this issue).

The ambition to develop northern Australia will continue. However, history tells us that successful development of Australia's tropical rangelands and savannas is more likely to be realised by taking a long-term, steady growth pathway rather than some of the 'get big quickly' schemes of the past. There are several ways development might proceed, such as a series of high-technology small-scale mosaic irrigation projects (Chilcott 2009) or a few larger-scale schemes that are implemented gradually over decades rather than years. Regardless of the pathways of development, all initiatives will need to: accommodate the social and human learning required; fully understand the constraints and opportunities imposed by the climate, soils and ecosystems; work with local communities and seek opportunities for Indigenous economic development; proactively plan the way to navigate the approvals processes required to undertake the development; and take a staged approach to the investment in physical capital and have patient expectations of that capital. Even with these steps in place uncertainties remain but by taking a measured, evidence-based and socially inclusive approach, agricultural developments in the future will have the best chance of success.

Conflicts of Interest

The authors declare no conflicts of interest.

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