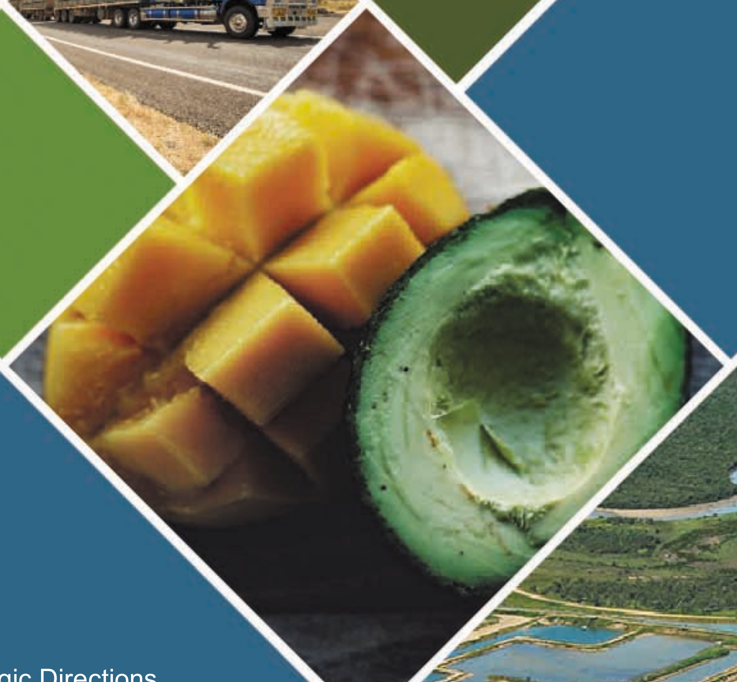
NORTHERN HEALTH SERVICE DELIVERY

TRADITIONAL OWNER–LED DEVELOPMENT

AGRICULTURE & FOOD



Northern Australian broadacre cropping situational analysis

ST Strategic Services and Pivotal Point Strategic Directions

July 2020

CRCNA DEVELOPING NORTHERN AUSTRALIA

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Project Participants

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Disclaimer

Peer review statement

The CRCNA recognises the value of knowledge exchange and the importance of objective peer review. It is committed to encouraging and supporting its research teams in this regard.

The authors confirm this document has been reviewed and approved by the project's steering committee and by its program leader. These reviewers evaluated its originality, methodology, rigour, compliance with ethical guidelines, conclusions against results, conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2018), and they provided constructive feedback which was considered and addressed by the authors.

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Acronyms

ABARES - Australian Bureau of Agricultural and Resource Economics and Sciences
CRCNA - Cooperative Research Centre for Developing Northern Australia
CRDC – Cotton Research and Development Corporation
CSIRO – Commonwealth Scientific and Industrial Research Organisation
DAF - Queensland Department of Agriculture and Fisheries
DAFWA – Department of Food and Agriculture WA (predecessor to DPIRD)
DAWA – Department of Agriculture WA (predecessor to DPIRD)
DPIRD – Department of Primary Industries and Regional Development (WA)
DPIR - Department of Primary Industry and Resources (NT)
GRDC – Grains Research and Development Corporation
HIAL – Horticulture Innovation Australia Ltd
KPCA - Kimberley Pilbara Cattlemen's Association
MLA – Meat and Livestock Australia Ltd
NACRA - Northern Australia Crop Research Alliance
NSWDPI – NSW Department of Primary Industries
NTF - Northern Territory Farmers Association
ORIA - Ord River Irrigation Area
PHADI – Pilbara Hinterland Agricultural Development Initiative
PMAV - Property Maps of Assessable Vegetation
RDC – Rural R&D Corporation
QAAFI - Queensland Alliance for Agriculture and Food Innovation

EXECUTIVE SUMMARY

The primary finding of this situational analysis is that broadacre cropping in the north of Australia can be an important part of a farming business but most value is realised when broadacre cropping is integrated with other enterprises, particularly beef production. The capacity to grow a range of crops in the north is clear but due to the barriers, costs and risks of broadacre cropping in the tropics, farmers in the north need to leverage crop production as part of a broader business value proposition to promote sustainability and business profitability.

Previous research suggests the possibility of a single broadacre crop generating a positive return from greenfield irrigation development is marginal, yet there are operations currently investing significant resources into the development of furrow and pressurised irrigation systems. Dryland cropping is viewed as opportunistic given the variability in rainfall yet, at least in NW Queensland, there are growers that have been successfully producing dryland crops for a number of years. The disparity between modelled research and commercial data should not be unexpected due to the difficulty in modelling outcomes for every assumption, environment, business model or mix of enterprises that might exist and this needs to be considered.

Accordingly, R&D focussed on the production of specific crops without an understanding of the fit within a broader business model will not be optimal. For example, a single irrigated farming system could involve melons, hay, cotton, mungbean and maize servicing domestic and export markets. The optimal integration for production of the various commodities is complicated and cannot be understood through a single lens. R&D supporting a whole of business approach differs from traditional R&D programs that have typically focussed on maximising production of specific commodities. Part of this is driven by the way that funding is provided through commodity specific Rural R&D Corporations (RDCs). The opportunity exists to facilitate co-investment across a range of RDCs (GRDC, HIAL, CRDC, MLA and AgriFutures) to solve particular constraints in a range of business models that include their respective commodities.

The business model incorporating realistic commercial analysis of markets and supply chains along with production systems is intrinsic to any cropping R&D investment. For example, one of the fundamental issues raised by northern Australian growers is the regulatory constraints on accessing land and water to enable a viable production volume. Focussing on the agronomics of a particular crop is an important aspect of production but the effectiveness of the investment is compromised if land and water constraints limit the probability of minimum scale being achieved. This is particularly evident when substantial investment is required not only for production but also for first stage processing (e.g. establishment of a cotton gin or pulse packaging infrastructure).

The second main finding is that incremental learning at local and regional scales is essential in the north. The extraordinarily vast physical area of “the north”, crossing the jurisdictions of Western Australia (WA), the Northern Territory (NT) and Queensland (Qld) over 4,000km east to west and 1500km north to south, means that the significant variability and complexity across and within farming regions cannot be underestimated. R&D undertaken in one location can have minimal application just kilometres away but contrarily can provide meaningful insights on the other side of the country. Going ‘all in’ with a large scale development requires knowledge of, and confidence in, a business model and farming system which likely has not been proven for that region.

A practical response of growers to this variability has been the establishment of mosaic agriculture, where optimal combinations of soil, water and environment are targeted in land parcels for cropping development to lower risk and allow incremental growth (albeit, typically requiring the purchase of massive pastoral stations to gain land access). Large-scale, capital intensive developments are harder to establish but continue to be explored, particularly in Queensland and are the subject of a range of reviews and current activity. Regardless of development approach, incremental learnings built through seasons and market cycles are imperative to successful cropping production. This is in stark contrast to some of the large scale, rapidly established ventures of the last century which did little in the way of building long term sustainable industries as capital diminished and they were abandoned.

In assisting the establishment of successful, sustainable and profitable cropping industries in northern Australia, the CRCNA could:

- Assist stakeholders across the regions of northern Australia to align and communicate their agriculture vision

- Facilitate the formation and coordination of Landholder Advisory Groups to provide input on required RD&E, land and water constraints and other planning activities
- Contribute to the development of improved Land and Water access processes
- Empirically validate assumptions of key R&D models that have influenced both grower confidence and government policy settings
- Build regional and local R&D and extension capacity to support a participatory approach to generating knowledge that growers value and adopt.
- Encourage research that is integrated across and within enterprises. In particular, the potential to integrate cropping production with the established beef industry and the ability to produce two crops in a single year
- Assist in access to commercial broadacre cropping support including agronomy, mechanics, irrigation specialists etc.
- Participate in and influence Federal Government initiatives that support labour access for northern Australia
- Facilitate research into and cooperation with Storage and Handling Supply Chains relevant to a region
- Assist with value chain analysis and marketing structures to support delivery of crop products into domestic and international markets.

For the purpose of this analysis, and consistent with the CRCNA, “the north” is defined as those areas north of the Tropic of Capricorn but including all the Northern Territory. The analysis does not extend to central Queensland, where broadacre cropping is already well developed, supported by public and private investment in R&D, and has established supply chains for grain and cotton.

The scope was focussed on a situational review (where are we now and where have we been?) with an eye to the future.

BROADACRE CROPPING SWOT

STRENGTHS

- Vast areas with potentially arable soils suitable for a wide range of crops.
- Existing congruent operations ranging from pastoral through to sugarcane and intensive horticulture production.
- Significant investment and research conducted over decades.
- Potential to crop in both the wet season with available moisture advantages and dry season with trafficability and crop quality advantages.
- Cattle feed demand for crops is large, valuable and proximate.
- Landholders willing to invest substantial capital and time in development of cropping, including in infrastructure and R&D.

WEAKNESSES

- Land tenure, land use and water access processes are complex, difficult, slow, costly and different in each jurisdiction (State and Commonwealth).
- Variable rainfall and high evaporation rates make water storage and soil moisture retention ephemeral.
- Vast distances between cropping areas making shared capacity, labour and experience difficult.
- Most export and domestic markets are distant involving significant freight costs and development of regional supply chain infrastructure.
- Variable rainfall increases the risk of dryland crops and introduces issues of trafficability and timing of critical farm operations.
- Northern cropping is still developing requiring significant capital inputs.
- Lack of action previously has reduced landholder willingness to engage in public processes.

OPPORTUNITIES

- Integrated farming systems with the focus on profitable business models rather than an individual commodity.
- Post farm gate processing development linked to integrated farm enterprises e.g regional cotton ginning supplying seed to cattle enterprises.
- Coordinated, participatory RD&E focussed on constraints defined by producers.
- Coordination of commodity led research functions to identify synergies and reduce producer fatigue.
- Development of flexible cropping options to assist agile management in response to variable rainfall.
- Improved efficiency in gaining access to land and water to build scale.
- Critical first stage processing infrastructure for potential base crops such as cotton or oilseeds.

THREATS

- Australia's southern oriented political focus and mindset disrupting northern opportunities.
- Lack of clarity on land and water access principles and process further undermining investor confidence.
- Lack of patient capital - investors require returns on timescales that limit the capacity for early trial and error with attendant increase in overall investment risk.
- New cropping ventures impacted by serious unknown environmental constraints (e.g rising water tables, salinity etc).
- Market volatility negatively impacting early stage cropping developments.
- Cropping expansion and development not being accepted by northern communities.

INTRODUCTION

As defined by the CRCNA brief for this paper, cropping includes broadacre production of fodder, pasture, cereals, pulses, oilseeds, and cotton; but not rice or sugar. Production can be irrigated or dryland (rainfed) and does not include self-seeding, wild or native pasture.

In the context of supply chains and markets, the products of broadacre cropping are: the seeds of cereals, pulses and oilseeds, which are generically referred to as grain and used for human food or animal feed; fibre, most commonly in reference to cotton lint for clothing; and hay/silage for ruminant animal feed. Pasture or forage has *in situ* value for ruminant animal feed within operations but cannot be transported as part of a supply chain.

The Importance of the Business Model

The CRCNA cropping situational analysis has been formed through an understanding of current and potential business models starting with the customer. R&D that removes constraints to these business models is of the highest value to growers in the medium term and, in turn, provides a platform for identifying longer term R&D investment needs.

This paper has been compiled, using available information, to assist in identifying the constraints and opportunities to developing current and potential viable business models for cropping in northern Australia including the impacts of Crop Genetics, Environment, Market and Value Chain and Farm Input, Capacity and Infrastructure that could potentially be the focus of R&D supported by CRCNA.

"Businessmen, as opposed to visionaries, focus on low hanging fruit first, since early success helps sustain long term risk, and remove constraints on business growth or those that increase risk."

Graham Laitt 2014
Former owner of Liverigna Station, the site with an extensive history of cropping located near the Fitzroy in WA.

Figure 1 displays the method used for the basis of assessing constraints across Broadacre Cropping in the north.

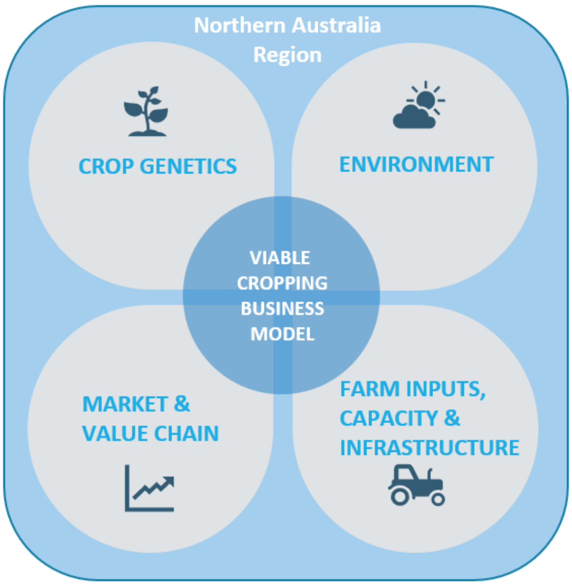

Figure 1 Broadacre cropping constraint model

COMMON CONSTRAINTS

Several constraints to the successful integration of cropping in farming businesses across the north of Australia are common and are highlighted below.

Crop Genetics

A very wide range of broadacre crops can be grown in northern Australia presenting a range of opportunities but also a number of risks. Plot trials, and more importantly farm-scale trials, can and are being undertaken with the aim to identify those crops with the most potential for commercial viability. However, there is the temptation to focus on crops that, with some genetic improvement, could be competitive. This may be a legitimate long-term goal, but it is not suitable for the short-term development of broad acre cropping options. Genetic improvement, even at the simplest level is time consuming and expensive. The relatively small size of the current northern production system does not warrant the devotion of large amounts of resources for even simple genetic improvement in crops that are not in demand elsewhere in Australia or internationally. While the application of genetic improvement in the short term will be limited, there are a number of crops that have dedicated breeding programs in either the public or private sector that can support at least some genetic improvement and generate varieties that, while targeted at a broader production base, are suitable for the north. The following is a brief outline of current breeding efforts for the main crops of interest to growers in the north.

- **Sorghum** – grain sorghum improvement is underpinned by a pre-breeding program at the Queensland Alliance for Agriculture and Food Innovation (QAAFI) and funded by the Queensland Government and the GRDC. Lines from the QAAFI program are used by several private companies to generate commercial hybrid varieties. Private companies producing sorghum hybrids include Advanta/Pacific Seeds, Pioneer/Gentech Seeds, NuSeed, Radicle Seeds, Elders and Barenburg/Heritage Seeds. A number of these programs have material being trialled in the north either as part of the CRCNA program[1] or separately. The companies offer a range of varieties for grain and forage production. The potential for dual purpose types that can be carried to grain or cut early for hay or silage is an attractive proposition for growers.
- **Maize** – grain and forage maize varieties are offered by a number of private companies that include Advanta/Pacific Seeds, Pioneer/Gentech Seeds, Radicle Seeds, HSR Seeds and Barenburg/Heritage Seeds. Some companies are offering dual purpose types.
- **Cotton** – Initial cotton production in northern Australia targeted wet season production in the Ord River Irrigation Area (ORIA) but suffered issues of quality and pest impacts such that commercial production ceased by the mid-1970s (Ash and Watson, 2018). Dry season cropping (established February and harvest October) has been the focus of more recent R&D and commercial scale trials with significant potential being identified. Dry season cotton production has the advantage of avoiding some of the main insect pests, in particular *Spodoptera* cluster caterpillars and pink bollworm that were significant in the failure of initial attempts at cotton production in the ORIA (Yeates *et al*., 2013).

  The development of transgenic cotton expressing Bt genes that provide protection against the main insect pests (cotton bollworm and native budworm) has dramatically changed the nature of the Australian cotton industry. Insecticide use has fallen significantly, and integrated pest management has been embraced as part of a wider best management program for sustainable cotton production. Many of these improvements are applicable to cotton production in the north. In particular, the release of Bollgard III varieties (containing the VIP protein) are likely to provide some protection to *Spodoptera*[2] although the need to control mirids and aphids in an integrated program remains.

  Cotton genetic improvement in Australia is undertaken by CSIRO in a joint program with Cotton Seed Distributors Ltd. accessing biotechnology traits (currently herbicide tolerance and insect resistance) from Bayer. To date, most commercially available, Australian bred varieties seem to be adaptable and perform across a wide range of environments[3] although selection for shorter season varieties would be a

1 https://crcna.com.au/research/projects/de-risking-broadacre-cropping-options-northern-queensland

2 S. Yeates – *Pers. Comm.*

3 P. Graham – Cottonseed Distributors *Pers. Comm.*

priority for the north in future. All the current partners of cotton variety development are supportive of providing varieties that can be grown in northern Australia. New traits to limit the damage by mirids and thrips are undergoing field trials in the USA and development continues Bollgard IV type traits for lepidoptera control as well as flexible herbicide options[4].

- **Chickpeas** – The national chickpea breeding program is situated at Tamworth, NSW and jointly funded by the NSW Government and the GRDC. The program breeds both kabuli and desi types and has released varieties suitable for central Queensland. DAF has participated in collaborative trials in the past, but the recent restructure of the program will see this activity coordinated in-house. The main focus of the program remains *Ascochyta* blight resistance, but the program also targets *Phytophthora* resistance that is likely to be important in the north. The program maintains active trials in central Queensland and has recently released the variety PBA Drummond⊕ for the central production area. The variety has significantly higher grain yield than all other varieties in central Queensland, improved resistance to *Ascochyta* blight in comparison to some other varieties (although still rated as susceptible) but is susceptible to *Phytophthora*[5]. The program has recently completed a major restructure that should see significantly improved genetic gain resulting in the release of superior varieties over the next 10 years. The WA Department of Agriculture historically also bred varieties that are still grown in the north, particularly the ORIA.
- **Mungbeans** – The national mungbean breeding program is funded by DAF and GRDC and has seen significant success in the last 10 years with the release of the variety Jade⊕. Jade⊕ is a large seeded shiny green mungbean with superior yield that is suitable for both spring and summer plantings. It remains susceptible to the important diseases, tan spot, powdery mildew and halo blight[6] and the breeding program is currently working on varieties with improved levels of resistance. The program targets high yield and disease resistance while maintaining the appearance traits required for market access. Trials are conducted across Queensland and northern NSW and have included investigating short duration lines to minimise production risk (spring and autumn crops) and longer phenology to maximise yield potential under irrigation in north Queensland[7]. All varieties from the program are marketed through the Australian Mungbean Association.
- **Peanuts** – The majority of peanut breeding in Australia is conducted by PCA Pty Ltd in conjunction with GRDC. The program focusses on two maturity groups, longer season types that mature in 140-150 days and early types that mature in 110-120 days. Key selection traits are yield, hi oleic oil content and disease resistance. Trials are undertaken on an extensive basis. Taabinga⊕ is the latest early maturity release to replace Redvale⊕ and has very broad adaptation making it suitable for growth in southern and northern Queensland. Taabinga⊕ has improved disease resistance and superior yield[8].
- **Sesame** – Sesame varieties in Australia are provided by two companies Agriventis and Equinom. Equinom is an Israel-based start-up company specialising in enhanced varieties without biotechnology traits and has just completed a $10m series B funding round of which a major investor was BASF[9]. Equinom has released a shatter-resistant white variety allowing for mechanical harvesting that would otherwise result in substantial yield penalties[10]. Equinom varieties are included in several current CRCNA trials[11]. Agriventis is an Australian company with black sesame offerings. Agriventis has been working with Central Queensland University and has material in CRCNA trials. Initial yields of sesame in all trials are encouraging.
- **Safflower** - Safflower improvement is being conducted by GO Resources in a joint project with the Victorian Government using genomic selection and accelerated generations to maximise genetic gain. Trials are conducted from the Ord across to north Queensland and down to the high rainfall zone of western Victoria. The program is targeting yield and oil content for both dryland and irrigated production

4 L.A. Burzio – Bayer Crop Science – Australian Cottongrower Cotton Yearbook 2018. https://issuu.com/greenmountpress/docs/cotton_yearbook_2018

5 https://www.seednet.com.au/sites/seednet/files/2018-09/documents/PBA-Drummond-chickpea-factsheet.pdf

6 http://www.mungbean.org.au/assets/2013_vmp_jade-au.pdf

7 http://era.daf.qld.gov.au/id/eprint/7049/1/2019%20Summary%20Report%20to%20DAF%20for%20RDE%20Investments.pdf

8 https://groundcover.grdc.com.au/story/6301045/best-traits-combined-in-new-peanut-release/

9 https://agfundernews.com/breaking-pea-power-israeli-seed-breeder-equinom-closes-10m-series-b.html

10 https://www.queenslandcountrylife.com.au/story/6284107/new-sesame-shatters-old-problem/

11 https://crcna.com.au/research/projects/developing-oilseed-industry-northern-australia

and has three lines approaching commercial release with significant yield increases (up to 30%)[12]. Traditional breeding programs have developed safflower seed with oleic acid levels in the range of 75–85%. However, like other oilseeds, the remaining linoleic acid component, at 12-18%, is not desirable for industrial use because it is unstable and difficult to remove during oil processing. Therefore, it is desirable to develop a safflower seed that accumulates high oleic acid (C18:1) but contains very low linoleic acid (C18:2) and zero linolenic (C18:3) content (Wood *et al*., 2018). CSIRO has produced safflower seed oil containing a minimum of 90% oleic content and less than 1.5% polyunsaturates and 4% saturates. Due to the high level of oleic content, the oil derived is referred to as Super High Oleic (SHO).

All super high oleic (SHO) safflower varieties are genetically modified and subject to regulation by the Commonwealth Office of the Gene Technology Regulator. The Queensland Government did not to enact marketing and trade regulations of GMOs when GM canola was approved for commercial production in the early 2000s and production of GM safflower, at least in Queensland, is therefore not expected to be problematic.

- **Soybean** - Soybean has a public genetic improvement program funded by GRDC, CSIRO and NSWDPI with a focus on high-value culinary types for the higher rainfall eastern coastal areas and Murrumbidgee Irrigation Area (although more recently soybean has largely been displaced by cotton in the MIA). All soybean varieties in production in Australia are non-GMO. Recent releases are expected to be attractive in north Queensland and are expected to be accessible for the 2020 season. Kuranda⌽ is adaptable to the coastal regions from the south to the far north while Mossman⌽ is expected to perform well as a break crop in rotation with sugarcane or as a forage crop and to provide a winter season option in the Burdekin[13]. A shift to crushing types to meet Indonesian feed industry demand for full fat soybeans to combine with feed wheat in livestock rations[14] would see Australia in direct competition with much larger producers in the Northern Hemisphere and consequently would be a far less attractive option. There has been interest in the NT for Indonesian varieties of soybean suitable for 'natto' (culinary). Importing these soybean genetics to the NT is complicated by plant quarantine processes.

Environmental

Water

Water access is a major limitation to expanded broadacre cropping in northern Australia. The ongoing drought in the south has driven some growers to seek production capacity further north. It has also re-ignited the debate on the value of water, its cultural, environmental and amenity importance, and its central role in supporting a wide range of agricultural production and the regional industries and the towns that rely on agriculture and their associated businesses. This has driven a reluctance for Governments to make allocations that may contribute to future overallocation. If water is overallocated it is economically, financially, socially and politically difficult to reduce allocations in the future (Philip *et al*., 2018). In a joint submission to the Australia Parliamentary inquiry into Development of Northern Australia, Australians for Northern Development and Economic Vision propose that water is underutilised due to issues with allocation and power[15]. There is a widely held belief that water allocations are significantly hindered by an overly conservative approach to water releases – potentially driven by anticipated community concerns.

Discussion relating to dams for irrigation is regularly raised across the north due to significant river systems that flow ephemerally, but with enormous volumes of water through the wet season. A common viewpoint is that this water is 'wasted' as it runs out to the sea. However, the contrary assessment is that water, even in flood, contributes to the unique river plain ecosystems and there is considerable wariness of repeating the mistakes perceived to have been made in the Murray-Darling irrigation areas. As such, large scale dams present significant challenges and gaining water access for even small scale on-farm catchments can be difficult.

12 D. Hudson – Manager R&D GO Resources *Pers. Comm.*

13 http://australianoilseeds.com/soy_australia/licensed_varieties

14 https://ussoy.org/indonesia-poised-to-continue-soybean-demand-growth/

15 https://www.etheridge.qld.gov.au/downloads/file/346/http-1-pdf

Mosaic irrigation, involving on-farm water storage or ground water may allow better matching of natural resources in a region to irrigated production while minimising unwanted environmental impacts (Cook *et al*., 2008). The approach involves the construction of shallower water storages that potentially are subject to relatively greater levels of evaporative loss. However, given that most water for irrigated broadacre cropping would be used prior to the months of maximum evaporative losses, this impact may not be as significant as initial examination might suggest.

The literature does provide some modelling of potential costs and benefits and is summarised below for the purpose of informing and stimulating discussion regarding irrigation in northern Australia. The information comprises general statements based on scientific research and is not suitable for the development of individual business plans. Individual developers will need to undertake their own detailed analysis of costs and potential returns. The costs and benefits of on-farm water storage and irrigation infrastructure are likely to be highly variable depending on site, access to equipment, design, pumping rate, irrigation type and soil as well as expected returns to name but a few variables.

Ash *et al*., (2017) calculated potential gross margin returns of a range of crops using simulation modelling under different cropping scenarios in northern Australia. The analysis was based on a starting level of debt of $8000/ha and $12,000/ha, representing typical investment to develop land from undisturbed savanna or the purchase of developed land. Ash *et al*., (2017) quote a gross margin of at least $3,000-$4,000/ha required to break even on irrigation developments with capital costs of $10,000/ ha. Baker and Vivian (2017) estimate that the capital cost of a greenfield surface water storage and furrow irrigation development in the Northern Territory at approximately $10,900/ha or approximately $6,900/ha for water storage and furrow irrigation on an existing farm. They further estimated that a greenfield sprinkler system using groundwater in the Northern Territory would have capital costs of approximately $27,650/ha or $11,500/ha - $14,000/ha for development on an existing farm. Ham (2018) through trials in the Pilbara associated with the Northern Beef Futures project (DPIRD and MLA Donor Company) estimated that, including approvals and infrastructure, a 40-hectare centre pivot could cost as much as $1.25m ($31,000/ha) and take at least seven years to see a return on investment - the cited ballpark return being $3,500/ha every year. Some growers estimate much lower establishment costs and therefore required returns, reflective of the highly variable nature of such developments.

While the north receives large amounts of rainfall in the wet season, the amount of rain and its timing both within years and interannually is amongst the most variable in the world (Petheram and Yang, 2013). In addition, evaporation in the dry season far exceeds rainfall. Combine this with soils of variable nature and fertility and broadacre cropping in the north presents some challenges. Dryland cropping production and risk differs with total rainfall, timing of rainfall, plant available water (determined by a range of factors including soil type, constraints, stubble management etc), plant genetics and the capacity to undertake critical production activities (e.g. planting, weed control, pest control etc) in a timely manner. As with other agricultural production areas of Australia, these factors vary by region and location down to variations at the individual paddock scale.

The viability of irrigated broadacre cropping, and the necessary returns required to cover required investment, are affected by a large range of variables and associated assumptions that have a significant impact on modelled outcomes at the regional, local and farm level. On the ground validation of both irrigation and dryland production is required to assist informed discussion of the potential for broadacre cropping in northern Australia.

Despite these challenges, a substantial number of local landholders, as well as growers from further south recognise the potential for combined dryland and irrigated broadacre cropping and are willing to expend time, effort and resources to develop a broadacre cropping industry if afforded the opportunity to do so.

Biosecurity

The development of broadacre cropping in northern Australia is not without risk. The potential for year-round crop production introduces the possibility of establishing a green bridge across seasons that could promote the incursion of pests and diseases that subsequently may migrate further south into the more established cropping areas. The recent discovery of fall armyworm in crops in the north could be interpreted in this manner but, given the distribution of fall armyworm across the world, it was highly likely that it would have migrated to Australia at some point. Indeed, its discovery in crops to the north may even have provided an early warning to growers further south to increase monitoring vigilance and control. Despite this, there is a risk of further incursions given the proximity of northern Australia to our Asian neighbours. Both cotton[16] and grains[17] have biosecurity plans developed with Plant Health Australia. In addition, the Federal Government has committed significant funding to strengthen biosecurity surveillance and analysis under the Agricultural Competitiveness[18] program. The Northern Agricultural Quarantine Strategy was developed in 1989 and remains in place some 30 years later[19].

Some pests, weeds and diseases will differ in the north in comparison to the south, for example the potential impact of *Alternaria* on cotton (Yeates *et al*., 2013). This will require ongoing efforts in integrated weed, pest and disease management as part of efforts to expand broadacre cropping.

Trials in the north are routinely enclosed with exclusion fencing to prevent feral and native animal damage. Exclusion fencing for commercial production is unlikely to be feasible and although the risk may be diluted over larger cropping areas, reliance on co-ordinated pest control will still be important. Preliminary feedback is that coordinated efforts have been effective in managing feral pigs and weeds such as rubber vine at least in the Gilbert Catchment. One distinct element in the north is its heterogeneity through State and Territory policy and regulation. Both the NT and WA have restrictions on the transfer of seed/grain across borders to prevent weed and pest incursions and this can mean value is lost in accessing proximate markets or infrastructure. This will prove to be a particularly important consideration in the potential location of a cotton gin.

Climate

Dry season cropping in the northern Australia is characterised by day lengths and temperature patterns that are the opposite of temperate production further south. There is lower overall photosynthetic capacity in northern environments that is compensated for somewhat by cooler temperatures during the dry season growing period. By way of example, with respect to cotton, this results in development occurring over a longer period producing higher yield potential than would otherwise be expected (Yeates *et al*., 2010a; Yeates *et al*., 2010b). The difference in growing climate means that, while many agronomic practices can be adapted from production system further south, some aspects of crop agronomy will require new knowledge to be developed and applied. Production in the north will not be as simple as transposing skills and knowledge from the south.

Market and Value Chain

Northern Australia's population comprises approximately 1.4m people spread across 40% of Australia's land mass. Distribution is sparse with the single largest centre being Townsville with approximately 12% of the total population[20]. The reality of this population base is that, as a domestic market for produce, it has little to no impact on cropping demand.

The most proximal significant markets for human food and fibre produced in the north of Australia, are in South East Asia which, with a population of 650m, is 26 times Australia's population. Markets in SE Asia are also more proximal than many other domestic markets. Darwin is 2,700km from Indonesia's capital, Jakarta, compared to 3,100km from Sydney (by air).

Notwithstanding this, large scale commodity crop markets compete globally, and supply chain cost is critical for market and therefore crop viability. Many crops that could agronomically be grown in the North of Australia are practically capped by a mixture of lower cost production and supply from competing nations. For example, soybean as an oilseed is in high demand in Indonesia (domestic consumption approx. 3mt pa) but as a very cost sensitive market, northern Australia is unlikely to compete with the large scale efficient production capabilities of North and South America.

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16 https://www.planthealthaustralia.com.au/industries/cotton/

17 https://www.planthealthaustralia.com.au/national-programs/grains-farm-biosecurity-program/

18 https://www.agriculture.gov.au/biosecurity/australia/northern-biosecurity

19 https://www.agriculture.gov.au/biosecurity/australia/naqs

20 https://naif.gov.au/wp-content/uploads/2016/08/Economic-Note-Northern-Australia-September-2016.pdf

Export markets are also dependent on export infrastructure. Small volumes or 'non-bulk' product such as cotton lint require container packing which is currently only available at Darwin, Gladstone, Mackay and Townsville. Bulk export of grains is possible in Wyndham, Darwin, Mc and possibly Townsville, but with varying levels of infrastructure mostly constructed for non-grains purposes.

Australia's southern markets, mostly on the eastern seaboard, also represent a potential domestic demand for products that might otherwise be imported. Typically, this has been a proven market strategy for horticultural crops which are agronomically unsuited to production in the south (e.g. banana) or counter cyclical (e.g. melon in winter). For broadacre cropping, fewer examples exist though there has been some production of niche grains for the southern domestic markets such as sesame, quinoa, out of season peanuts, chia, and tropical pulses especially for high value culinary purposes such as soybean and mungbean. Niche premium markets, whether domestic or export are, by their nature, limited in size and when supply exceeds demand, the premium falls. This was recently experienced with chia where the market became less viable for northern producers as cheaper South American production expanded.

While niche markets will continue to be a valuable aspect of potential broadacre cropping in the north, three specific commodities with potential application across most of the north are:

- animal feed
- cotton
- peanuts.

Animal Feed

The most material domestic market for northern Australian broadacre cropping is animal feed. Northern Australia's population of cattle is over 11 million and would consume roughly 24 million tonnes of forage/fodder per annum[21]. Native/wild rain fed pasture is the lowest cost feed option and satisfies most of the cattle feed demand through the wet season. However, the quality of the native feed base at the end of the dry season is poor and nutritionally inadequate requiring supplementary feeding supported by hay and other feed often transported from further south and/or by transport of livestock to different properties. These additional costs can have a significant impact on enterprise and whole of farm profitability. The shortfalls in available 'natural' forage along with improved cattle values has seen the demand for cropped forage and fodder increase. The main economic advantages to beef enterprises of irrigated fodder production (Brennan-McKellar *et al*., 2013) accrues from;

- longer fattening periods and improved daily weight gains (avoidance of dry season 'protein drought' in cattle feed cycle) resulting in higher turnoff weights that attract a higher price per head and creates an efficient annual breeder production cycle preparing weaners for market;
- reduced need for supplementary feed, such as grain and purchased hay, during the dry season; and
- potential direct sale of fodder as a source of revenue.

The key to the fodder market business model is freight. Fodder value is effectively limited by the cost of freighting fodder, such as oaten hay, from competing locations, whether from within Australia or imported. Production of fodder near to terminal demand improves the viability of fodder producing models which has driven the interest for northern broadacre production and underpins many of the systems discussed in this paper. A fundamental challenge is proving to be the optimisation of the volume of fodder production with the quality required to finish cattle for domestic and export markets.

Cotton

The drought and low or zero water allocations in the south resulted in a 50% reduction in cotton plantings in 2019[22] albeit from above average plantings in 2018. The 30-year average cotton production is approximately 600,000t of lint and 840,000t of cottonseed with predicted production in 2019/20 to fall by as much as 82% to 61,000 ha producing around 135,000t of lint and 191,000t of seed (ABARES, 2020). The pressures on southern cotton production have seen several businesses expand into the north in search of cheaper, available water for irrigation or to expand their businesses in dryland production systems. Apart from the direct value of cotton lint, one of the advantages of cotton production is the potential use of cottonseed as a high value feed supplement for local and regional cattle production. The cotton industry has detailed, up to

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21 https://www.mla.com.au/globalassets/mla-corporate/prices--markets/documents/trends--analysis/fast-facts--maps/cattle-numbers-map-2019-june-2018-1.pdf

22 https://www.abc.net.au/news/rural/2019-06-04/drought-and-low-water-allocation-impacts-cotton-harvest/11172966

date (2019/20 season) gross margin analysis for a range of production types[23] (**Table 1**).

Table 1 Cotton Gross Margin analysis

Production	Yield	Price (at gin)		Variable Costs	Gross Margin
		Lint	Seed		
Dryland	3.6 bales/ha	$597/bale*	$100/bale	$1,212	$939/ha
Furrow Irrigated	12 bales/ha	$597/bale	$100/bale	$3,815	$4,549/ha
Furrow Irrigated (all operations outsourced)	12 bales/ha	$597/bale	$100/bale	$4,728	$3,636/ha
Overhead	12 bales/ha	$597/bale	$100/bale	$3,994/ha	$4,370/ha
Semi Irrigated	7 bales/ha	$597/bale*	$100/bale	$2,208/ha	$2,671/ha

* Note: price assumptions may change if dryland fibre quality is sub-standard to irrigated quality.

These figures suggest that cotton has the potential to be an important component of a broadacre production system in northern Australia. A similar observation was made by Baker and Vivian (2017). It is important to note that the gross margins of irrigated cotton above are calculated on 12 bales/ha. Advice from the cotton industry[24] is to be realistic about initial yields, in the last 10 years average yields have varied from 5.5 -12 bales/ha on irrigated sites with about 10% of crops abandoned completely. As observed on numerous occasions, it will be important to start small, applying new learnings in each successive season.

The transport costs of cotton are relatively high in comparison to grain or livestock due the large percentage of non-lint material (seed and trash) and the low bulk density of the product. Cartage costs in the gross margins above are estimated at $12.47/lint bale on the assumption of production being within 50km of a gin. Recent analysis of the transport costs from Kununurra and Katherine estimate transport costs of approximately $110 (ex Katherine) to $160 (ex Kununurra) per lint bale using backloading rates that the authors suggest are unsustainable[25]. Assuming transport costs are $80/lint bale would have the effect of decreasing gross margin for irrigated cotton by approximately $800/ha and dryland cotton by $240/ha.

It is estimated that a minimum of 7500ha of cotton yielding 9 bales/ha is required to sustain a commercially viable gin (Ash and Gleeson, 2014), that is the equivalent of 67,500 bales. Assuming a dryland average production of 4 bales/ha a minimum of approximately 17,000ha could produce that quantum. However, it is generally agreed that dryland cotton production could be feasible, dependent on rainfall and price, once or twice in a five-year rotation[26], therefore a minimal annual dryland production area would need to be in the order of 45,000ha of which 17,000ha was planted to cotton each year to maintain continuity of supply. A lower yield would require larger areas and the figures do not account for seasons where variable rainfall either suppresses yields or causes entire crop failure.

A potential aspect of dryland production relating to the potential for water stress to negatively impact fibre quality (shorter and less fine) resulting in market price penalties, needs to be understood further. Given the estimated $30-40m required to establish a gin (Stokes *et al*., 2017), seasons of short supply would be expected to cause significant financial pressure on gin operators. Despite this, the enthusiasm for cotton production is significant and a number of landholders are undertaking commercial scale production trials.

23 https://www.cottoninfo.com.au/publications/australian-cotton-industry-gross-margin-budgets

24 Tropical cotton production: Considerations for northern cotton growers. https://www.cottoninfo.com.au/publications/tropical-cotton-production

25 NT Farmers' Association – Business case for the construction of a cotton gin in the Northern Territory (2019)

26 P. Graham – Cottonseed Distributors Pers. Comm.

Peanuts

Australia consumes around 50,000t of peanuts (on a kernel basis), mostly for peanut butter and the snack food market. Imports have increased significantly over the last 15 years from a low base to around 25,000t that would require around 6,000-8,000ha of additional peanut production in Australia just for import replacement (Baker and Vivian, 2017).

Previous research by the Peanut Company of Australia Pty Ltd (PCA) has demonstrated that peanuts are relatively drought-tolerant, but irrigation is required to maximise yields needed to generate acceptable returns given relatively high variable input costs. Preliminary discussion indicates that a production area of 500ha could justify a dedicated peanut thresher. Around 1,000ha (yielding 5t/ha) would be required for a viable shelling plant with kernels transported to Kingaroy for processing[27] The crop uses between two and six ML of water / ha depending on rainfall and soil type[28].

Newer, short season varieties have been developed with excellent disease resistance in types that retain leaf making them suitable as dual purpose or even pure hay varieties[29]. Varieties that can produce 10-12 tonnes of high-quality hay in 100-120 days in the tropics have been developed with hay likely to sell for around $400/t, generating gross revenue up to $4,800/ha. In some regions it may be possible to plant and harvest two fodder crops over the dry season, with an optional wet season grain crop on lighter soils (Baker and Vivian, 2017). The potential to grow dual purpose varieties harvested at high moisture content followed immediately by baling of hay and drying of pods is an exciting opportunity to generate two products from a single crop but requires further investigation and potentially an engineering solution to the harvest operation and post-harvest handling.

There is significant potential for expanded peanut production in the Ord, Northern Territory and the Gilbert catchment. Expansion needs to be underpinned by agronomy R&D but the potential in north Queensland has already resulted in PCA employing three new agronomists across Queensland[30].

Farm Inputs, Capacity and Infrastructure

Access to dedicated farm machinery, and the mechanics required to service it, is an initial issue in many areas[31] although some of the larger enterprises will acquire and redesign machinery as required. Cotton and peanut production require access to specialist picking equipment with the cost of a cotton picker estimated at approximately $1.25m per unit. Contract harvesters and pickers may be an option, but the hectares planted and available for harvest need to be enough to warrant the diversion of resources from larger areas further south. If the likely harvest is small, contract work will most probably attract a healthy premium.

Access to skilled labour is an issue across regional Australia and is as difficult if not more difficult to attract in northern Australia. In the broadacre cropping sector, the ongoing move toward precision agriculture will require ongoing access to labour with the skills required not only to utilise precision technologies but to make decisions in a timely manner when unexpected circumstances arise. These skills are in demand across the broadacre cropping industry and are unlikely to be met by seasonal workers on an *ad hoc* basis. Landholders recognise that a certain and secure workforce with the requisite qualifications and seasonal availability are critical to the success of agriculture in the north. A number of broadacre producers from the south regularly utilise exchange programs with growers in the Northern Hemisphere that provide access to skills while also promoting the exchange of ideas and learning. This may provide a useful model in the north at least initially.

Practically, farm input application will also be impacted in the wet in some areas when the cracking clays present trafficability issues that may cause delays to crucial farm operations, especially crop monitoring and chemical application.

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27 G. Wright PCA *Pers.Comm.*

28 http://www.pca.com.au/wp-content/uploads/2017/12/Peanut-Production-Guide-2017.pdf

29 G. Wright PCA *Pers.Comm*

30 G. Wright PCA *Pers.Comm*

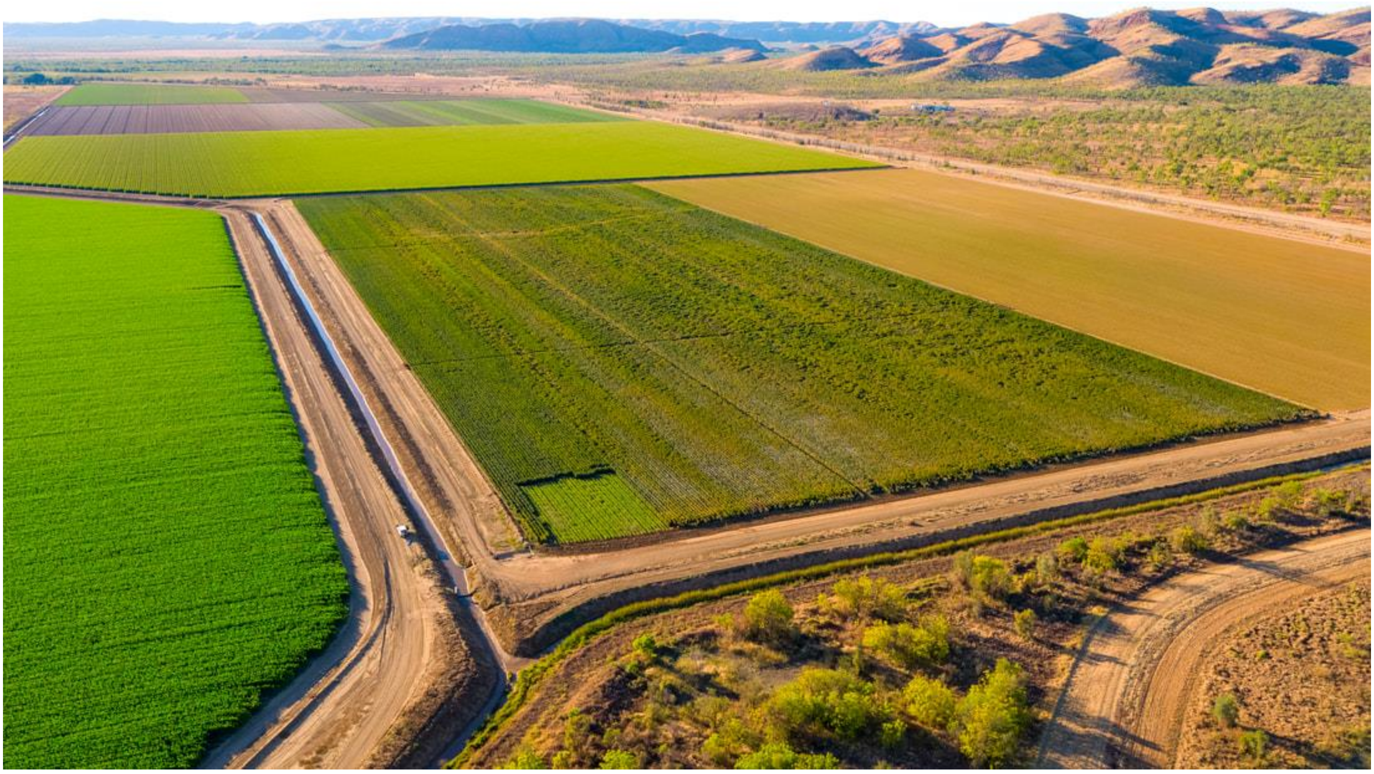
31 https://www.northqueenslandregister.com.au/story/6414364/monsoon-disaster-yields-opportunity-chickpea-crop/

REGIONAL ANALYSIS

Due to the disparity of cropping opportunities across the north of Australia, analysis has, in most cases, been broken down into logical regions across the two States and the Territory making up Australia's north as follows:

- West Kimberley/Pilbara Pastoral
- Ord Irrigation Area (ORIA)
- Northern Territory 'Big River' area
- Flinders Catchment
- Gilbert Catchment
- Mitchell/Atherton Tablelands
- Burdekin

(Although there is potential for cropping outside these areas, they are either already currently serviced by relevant RDCs (e.g. Central Queensland) or the current and historical scale is not material to form significant learnings for this situational analysis (e.g. the central desert region of the Northern Territory, which currently has only small scale irrigated fodder production and potential for peanuts).



Cropping Kununurra, WA. Source: NACRA

WESTERN AUSTRALIA - West Kimberley and Pilbara Pastoral Operations

Introduction

The vast pastoral operations of the Pilbara and Kimberley have been tested for their cropping potential for over fifty years. The nature of the Pilbara and Kimberley means that irrigated cropping is opportunistically placed at the intersection of arable land and water access, resulting in a mosaic irrigation layout. It is estimated there are at least 80 centre pivots, covering about 3,200 ha of land[32], installed across the north of WA and other than the Ord Irrigation Scheme, this is the only material cropping country currently in production in north WA. Industry participants speculate that the potential for expansion ranges from 5,000 to 10,000 ha in the medium term noting that the final number is highly dependent on Government regulation impacts on land and water access. The Kimberley Pilbara Cattleman's Association (KPCA) is the primary industry development and advocacy body representing pastoralists active in advancing cropping. The Pastoralists and Graziers Association (PGA) has also represented participants with respect to policy issues.

Overarching Business Model Elements

The Market and Value Chain

The major market for northern WA cropping is increasingly cattle feed across pastoral stations in the Pilbara and Kimberley. The only viable current supply of supplementary cattle feed is from south Western Australia in the form of pellets or hay which typically have a transport fee of $150 to $200/t[33] and face demand competition from southern dairy, feedlot and international export markets. Transporting fodder from the Northern Territory is prevented by the *Biosecurity and Agriculture Management Act* making WA a closed market.

The cattle feed market in WA has been increasing for the following reasons:

- the export market moving from smaller liveweight cattle to heavier (450kg +) cattle,
- the opening of Yeeda's Kimberley Meat Company Abattoir in 2016 building a market for locally finished cattle,
- the innovative production of premium beef (e.g. Wagyu) in the tropics as opposed to the traditional *Bos indicus* lines,
- the increased interest in de-risking operations where drought or fire can severely impact native pastoral grasses, and
- an interest in supplying markets outside of traditional demand cycles.

The cost of adding a kilo of liveweight gain through irrigated cropping in the Pilbara has been calculated in DPIRD's Economics of Irrigated Crops paper at between $2.80 to $3.20/ kg liveweight[34] . It is important to note however, that the commercial viability of fodder is not incremental. The marginal cost to produce an extra kilogram of liveweight may be more than the attainable liveweight price per kilogram but when taken as a whole, the provision of cropped feed may allow access to a market whereby the whole animal is more profitable than if the additional weight was not accumulated. Complexity increases further when considering animal health and behavioural responses to feed, such as fecundity, over the course of an animal's lifespan.

The cost of production risk also needs to be considered as northern WA properties are exposed to cyclonic conditions with exposure and flooding that results in high cattle mortality a greater risk than damage to infrastructure. Such devastation was evident in the mass cattle death caused by flooding in Qld's gulf country in 2019.[35]

The ultimate value of fodder driven through the supply chain is via the sale of cattle into domestic or export markets. The primary market for the Pilbara/Kimberley is the export of live cattle through Wyndham, Broome or Port Hedland ports. The Yeeda abattoir near Broome provides a local processing option (approx. 35,000 head) and further processing is undertaken in WA's south-west in addition to backgrounding and finishing. All

32 https://www.abc.net.au/news/rural/2019-11-17/wa-pastoralists-attempt-to-drought-proof-using-centre-pivots/11663698

33 https://futurebeef.com.au/wp-content/uploads/2019/05/Why-would-a-pastoralist-invest-in-irrigation-PDF-3.0MB.pdf

34 https://www.agric.wa.gov.au/sites/gateway/files/PHADI%20FS3_Economics%20of%20irrigated%20crops_single%20page.pdf

35 https://www.abc.net.au/news/rural/2019-04-16/cattle-deaths-tallied-in-north-west-queensland/11002938

markets are supported by road freight. An audit of northern beef infrastructure was conducted in 2016 by ACIL Allen on behalf of DAFWA. [36]

Export numbers for northern Australia for the year of 2019 (2018 numbers in brackets) are below (**Figure 2**).

1. Darwin 373,836 (416,942)
2. Townsville 364,046 (257,751)
3. Portland 170,506 (140,521)
4. Fremantle 155,003 (145,557)
5. Broome 110,987 (85,317)
6. Port Alma 45,835 (2199)
7. Brisbane 14,710 (12,716)
8. Wyndham 13,795 (15,114)
9. Geraldton 12,219 (14,525)
10. Port Hedland 6,447 (2,714)

Figure 2 Live cattle export numbers by port. Source: Dept Agriculture, Water and Environment

Crop Genetics

Numerous crops have been trialled as fodder and forage in the Kimberley/Pilbara including:

- C4 perennial tropical grasses such Rhodes and Panic
- C4 grain crops such as Maize and Sorghum
- temperate crops such as Oats and Lucerne
- tropical legumes such as Cowpea and Blue Pea.

Work to date conducted by DPIRD [37] has indicated that only perennial grass and fodder sorghum production can achieve the yield threshold to reach the pay-off investment of $3500 pa, per hectare for irrigated cropping. Rhodes grass is currently proving the most viable and is the common commercially produced fodder crop throughout the region. Rhodes grass is perennial and is known for its ability to rapidly grow biomass but suffers lower nutrient value as it matures. The green leaf is the most nutritionally beneficial part of the plant, but the greatest biomass is produced in the stem as the grass grows. Accordingly, the grass must be cut or grazed at the optimal time to maintain nutritional levels through maximising leaf growth and minimising stem growth (**Figure 3**). Growth is variable due to environmental conditions and yields can vary significantly whereby the optimal time between cuts may be from 21 days to 48 days. Active management is therefore required to assess when the grass should be cut for hay, particularly if used as forage and growth outstrips grazing.[38] Dry season (cooler) growth is slower or may completely stop in more southern areas. In good conditions, Rhodes grass can produce forage yields in excess of 30t dry matter/ha.[39]

Forage sorghum has also been trialled and commercially produced and can yield about 18t dry matter/ha.[40] There is a willingness to trial other tropical feed and fodder varieties, including those used in the NT and Qld, but State biosecurity laws regarding the introduction of non-native plants onto pastoral leases currently restrict this.[41]

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36 https://www.agric.wa.gov.au/sites/gateway/files/Northern%20Beef%20Infrastructure%20Audit%20-%20Acil%20Allen%2C%202016_0.pdf

37 https://futurebeef.com.au/wp-content/uploads/2019/05/Why-would-a-pastoralist-invest-in-irrigation-PDF-3.0MB.pdf

38 https://www.mla.com.au/news-and-events/industry-news/the-rhode-less-travelled/

39 https://www.csiro.au/en/Research/Major-initiatives/Northern-Australia/Current-work/NAWRA/Fitzroy-report

40 https://www.csiro.au/en/Research/Major-initiatives/Northern-Australia/Current-work/NAWRA/Fitzroy-report

41 https://www.farmonline.com.au/story/6387027/cost-of-production-the-challenge-in-pardoos-vision-for-pilbara-wagyu/

Crop stage	Crop coefficient (K_c) to be applied to ET_o	Number of days in crop stage*
Planting and establishment	0.4	30
Rapid growth	0.9	30
Mid to late growth	1.2	21
Harvest	0.4	4
Average for ongoing cycles of fodder production	0.95	32

*Crop stage length subject to climatic conditions. Stages may be shorter in summer and longer in winter.

Figure 3 Example of a coefficient for establishment of Rhodes grass as pasture for fodder production.

Source: DPIRD Growing Irrigated Crops and Pastures in the Pilbara

Since most of northern WA is under a pastoral lease, a diversification permit from the Pastoral Lands Board (PLB) is required to grow non-indigenous species. The permit approval process requires the PLB to seek advice from DPIRD and Biodiversity, Conservation and Attractions (DBCA) on the 'weediness' of the proposed species.

Accordingly, as part of DPIRD's Northern Beef Development project (in conjunction with the MLA), weed risk assessment trials have been conducted across a number of sites in the West Kimberley and Pilbara to determine the invasiveness, impacts and potential distribution of a number of non-indigenous commercial pasture and fodder grasses and legumes which are widely used in similar environments in the Northern Territory and Queensland.[42]

Environment

Average rainfall in the West Kimberley and Pilbara ranges from 300 to 600mm and is highly variable with cyclonic activity providing intense but infrequent rainfall events. Combined with daytime wet season temperatures averaging over 35 degrees Celsius for most locations and the attendant high evaporation rates, sustained dryland cropping is not commercially realistic. Accordingly, irrigation is fundamental to any cropping development. Irrigation in coastal Western Kimberley and the Pilbara has a short history and is almost exclusively reliant on groundwater.

The State Department of Water and Environmental Regulation (DWER) issues water licences and outlines the various types of licences and permits available and the application process. DWER maintains a water register that gives additional information about water resources. The regulatory approval process has been heavily critiqued by industry including the KPCA[43] and is being reviewed by the joint CRCNA/DPIRD review - Prioritising, de-risking and brokering agricultural development in Western Australia project. [44]

Soils in the Kimberley and Pilbara regions that have been developed to date are mostly pindan type sands. There is also interest in developing the black cracking soils found on flood plains, but this comes with the obvious flood risk and access challenges in the wet season.

Farm Inputs, Capacity and Infrastructure

Kimberley and Pilbara soils are nutrient deficient and require substantial inputs, particularly nitrogen and trace elements. These inputs are usually sourced thousands of kilometres to the south (Geraldton or Kwinana Port facilities) and are freighted by road.

42 https://www.agric.wa.gov.au/pasture-management/northern-beef-development-mosaic-agriculture?page=0%2C3

43 https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Red_Tape/Environment/Submissions

44 https://crcna.com.au/research/projects/prioritising-de-risking-and-brokering-agricultural-development-western-australia

The sandier soils allow equipment access in the wet season, but scale is required to justify specialist equipment associated with specific cropping options – for example, silage production requires different equipment and expertise than stand and graze forage production. Remoteness means contract equipment operation across multiple locations is cost prohibitive.

Due to the need for irrigation, the commercial viability of crop production is dependent on the capital cost of the irrigation equipment and the operating costs of running it. Pivot irrigation is favoured over furrow irrigation due to the avoidance of capital expenditure on gradient groundworks but is associated with higher operating costs. As the irrigated cropping industry in the region is nascent, innovation is continual and is critical in lowering the Return on Investment threshold for production viability. The ability to develop irrigation systems requires investors with ‘deep pockets’ and a good deal of the recent development has been pursued by investors drawing on external funding sources. Stations regularly change hands and two stations with irrigation capacity are on the market at the time of writing.

In addition to infrastructure investment, irrigated cropping requires specialist agronomy advice. Agronomist support over vast distances is challenging. For example, the distance from Broome, where DPIRD offices are located, to Pardoo Station is 460km south-west and to Gogo Station is 370km East (**Figure 4**). Agronomy support from places such as Carnarvon and further south are impractically distant and limited by relevant expertise and experience of Kimberley/Pilbara issues.

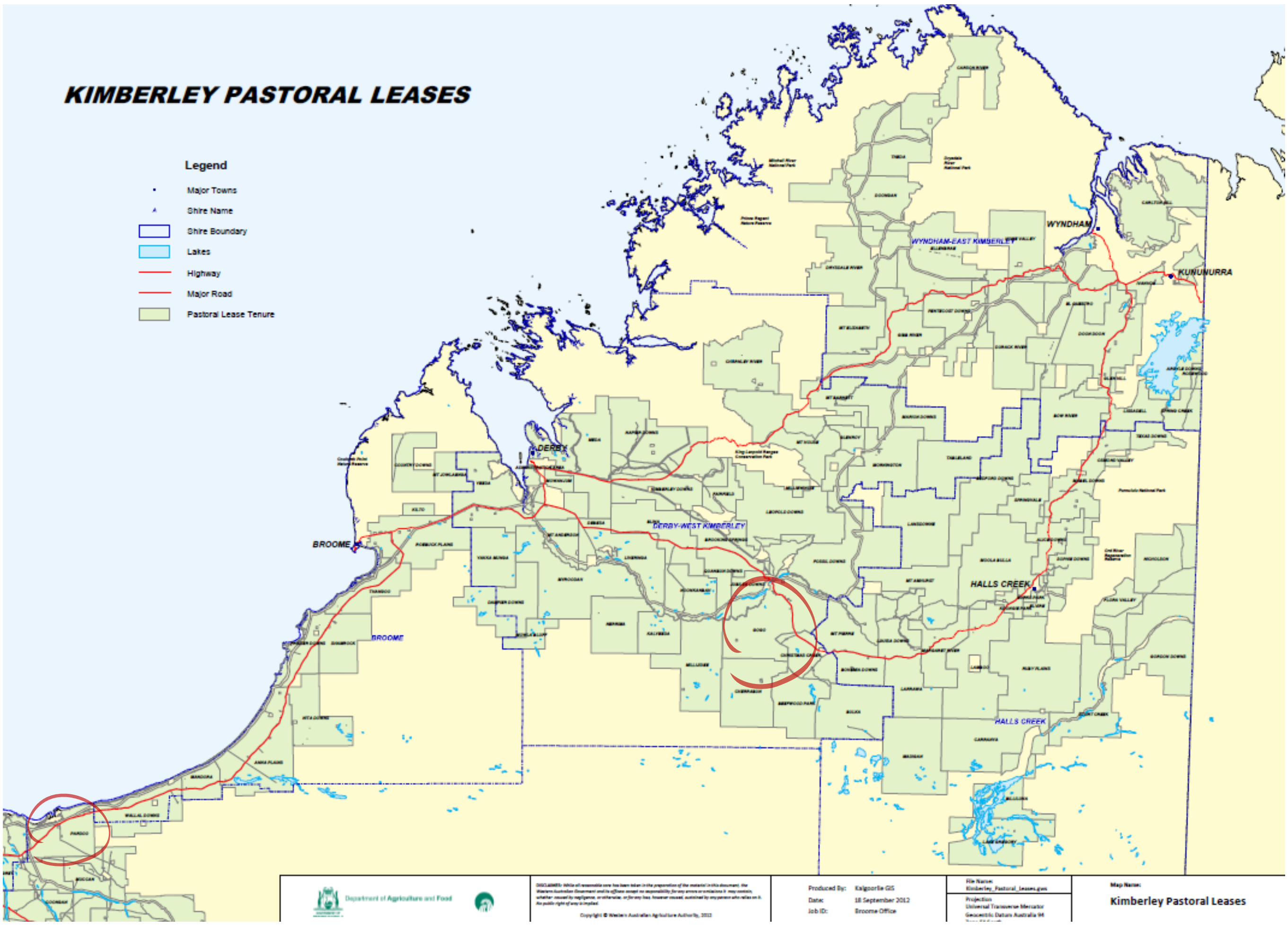

Figure 4 Station locations - Pardoo and Gogo

Source: DAFWA

Current and Potential Business Models

The Fitzroy

The Fitzroy River has been carrying the eroded sediment of the Kimberley for many millennia leaving a fine sedimental and, in places, thick layer of arable material across its floodplains. The vastness of the Fitzroy's arable plains, estimated at over four million hectares, is only matched by the immense 6,600 gigalitres of average water flow (over 12 times the volume of Sydney Harbour) which makes its way into King Sound each year.[45]

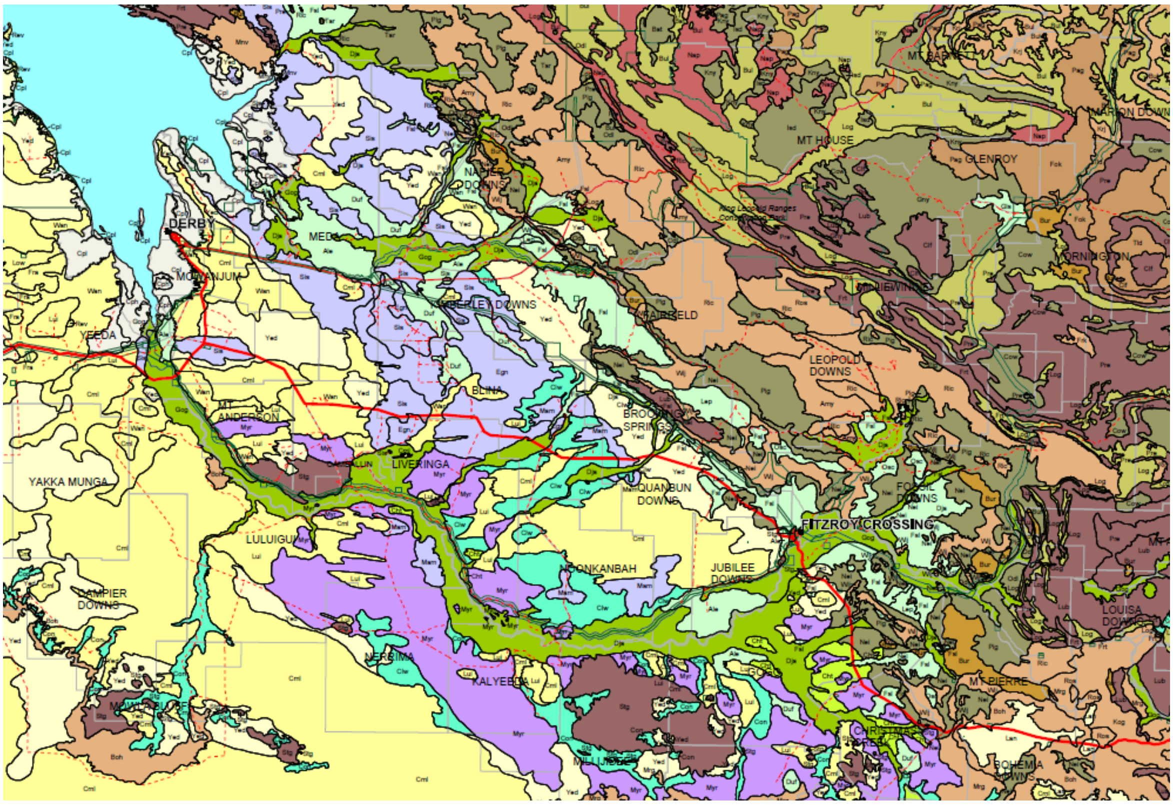

Figure 5 Fitzroy River soil systems

Source: Land Systems of the Kimberley (DAFWA)

Alluvial plains with mixed woodlands/shrublands and mixed grasses

Agl	Angallari	Con	Coonangoody	Stc	Sturt Creek
Clw	Calwynyardah	Mnr	Mannerie		

Alluvial and sandy plains with soft spinifex grasslands

Cht	Chestnut

Alluvial plains with tussock grasslands

Ale	Alexander	Duf	Duffer	Iva	Ivanhoe
Ann	Anna	Fsl	Fossil 2	Lgr	Lake Gregory
Arg	Argyle	Gls	Gladstone	Lep	Leopold
Bnm	Bannerman	Inv	Inverway	Osc	Oscar

Calcrete plains with spinifex grasslands

Spi	Spincrete

River plains with grassy woodlands and tussock grasslands

Dja	Djada	Wof	Wolfe
Gog	Gogo		

Stony plains with spinifex grasslands

Myr	Myroodah	Pda	Parda	Phr	Phire

Plains with low woodlands and spinifex/tussock grasslands

Egn	Egan	Mam	Mamilu
Gia	Gidgia	Sis	Sisters

45 https://www.csiro.au/en/Research/Major-initiatives/Northern-Australia/Current-work/NAWRA/Fitzroy-report

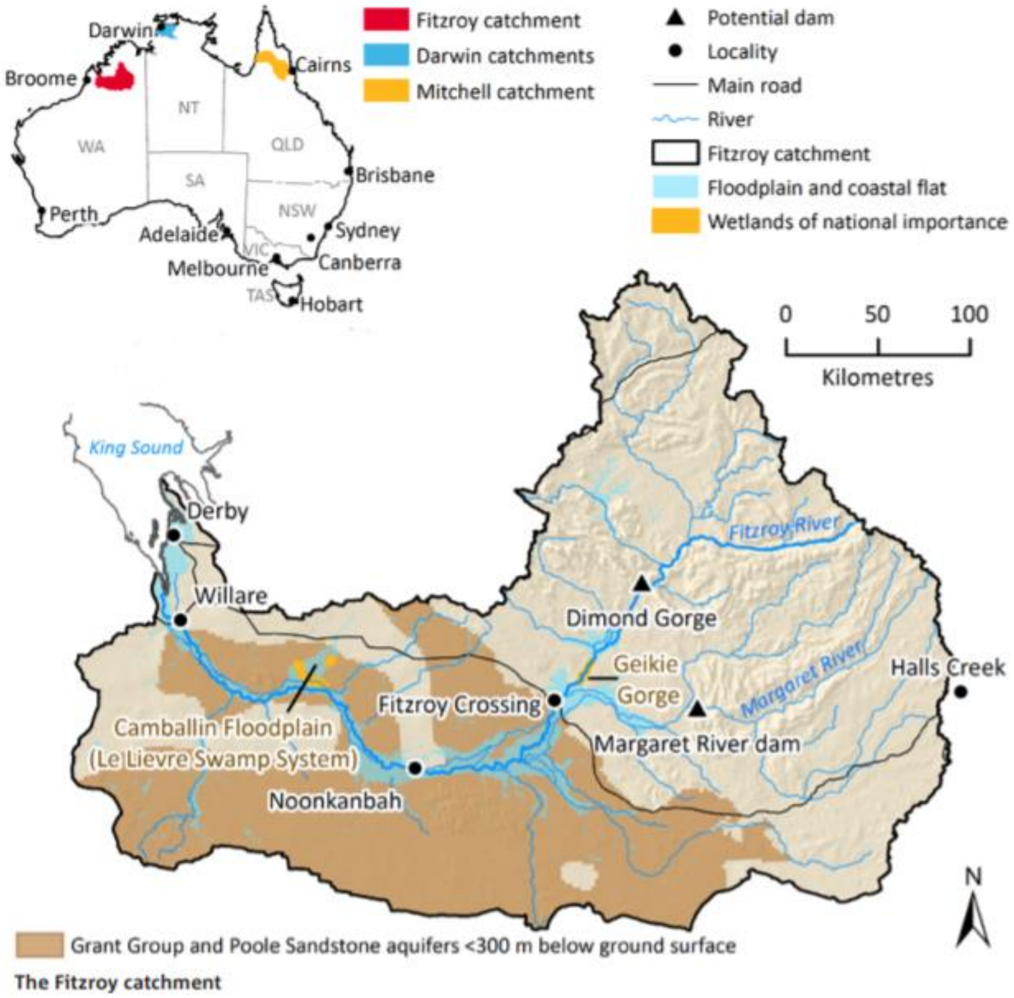

Figure 6 CSIRO Fitzroy catchment

Source: CSIRO Northern Australia Water Assessment- Fitzroy 2018 (CSIRO, 2018a)

The first significant attempt at cropping in the Fitzroy was in 1950s at Camballin/Liverigna Station when Northern Developments attempted to grow rice using irrigation sourced from the purpose built 17-mile dam on the Fitzroy tributary, Urella Creek. Subsequently, from the mid-sixties through to the early eighties, Australian Land and Cattle Company made numerous attempts to crop the same area, starting with fodder and finishing with grain sorghum production. Ultimately, the environmental challenges of too little or too much water spelt the death of the major infrastructure investments made over this time and today little remains of these initial efforts.

In 2014 Hancock Agriculture, Gina Rinehart's agricultural investment company, bought into the Fitzroy through the purchase of Liverigna and Nerrima Stations. This was followed by the acquisition of nearby Fossil Downs in 2015. Hancock has since commenced discussions with the State Government to access 325 gigalitres of surface water from the Fitzroy though no formal application has been made at this time.
It has been reported that the underlying business model for irrigation development is driven by cattle feed demand. The plan is to irrigate 21,200ha producing 330,000 tonnes a year of high-protein fodder crops, including sorghum, hay and maize. The fodder would be used to maintain and improve cattle weight (up to 25 per cent heavier) and decrease cattle loss throughout the year resulting in an additional 20,000 cattle being run year-round on Hancock's Stations.

The State Government has stated that damming the Fitzroy or major tributary would not be considered and Hancock Agriculture has not sought to construct an instream dam but is interested in the construction of off-stream storage capturing flood waters.[46] To that extent, there is common ground between these stakeholders, but multiple other issues need to be worked through along with Traditional Owners, Environmental Groups and neighbouring pastoralists.

Gogo Station, owned by the Harris family, is also located on the Fitzroy. In 2017, Gogo applied for a water entitlement of 50 gigalitres a year from a gravity offtake channel directing flood water from the Margaret River into off-stream storage dams. The stored water would be used to furrow irrigate approximately 5,000 ha to grow broadacre crops.

Concurrently, but independently of the furrow irrigation proposal, Gogo applied for seven centre pivot fields (665ha) accessing five gigalitres of groundwater from limestone aquifers to produce a range of hay and forage crops to improve cattle production on Gogo Station.[47] Currently, Gogo uses two pivots to irrigate fodder crops. Gogo has identified several possible crops in its proposal but has nominated grain sorghum as its initial objective. This grain would be primarily used for intensive feeding of cattle on station.

From an overall capacity perspective, CSIRO's 2018 Water Resource Assessment for the Fitzroy catchment stated that: In the Fitzroy catchment, water harvesting (water pumped into ring tanks) could potentially support 160,000 ha growing one dry-season crop a year in 85% of years. Independent of surface water, groundwater could potentially support up to 30,000 ha of hay production in all years (CSIRO, 2018a).

The Fitzroy is mostly in its natural state and accordingly, is seen by some parties as an environmental bastion. Opponents to development submissions are opposed to any water removal from the Fitzroy and have lodged their concerns with the WA Government. The establishment of a National Park adjoining the Fitzroy and Margaret River is concurrently being considered along with the Hancock and Gogo development applications. The timeline for a decision is 'expected' before the end of 2020 with pastoralists pushing for a decision as soon as possible and opposing groups not wanting to be rushed and requesting a thorough analysis.[48] Ultimately, until this decision is made, there is little advancement possible for Fitzroy cropping outside of small groundwater-based applications akin to the pivots of the Pilbara and Western Kimberley.

Western Kimberley/Pilbara

The first pivot irrigation system was established in 2008 at Minderoo. Currently, Minderoo has approximately 160 ha under irrigation producing Rhodes grass as fodder/forage for cattle [49] (additional capacity has been considered for horticulture).

Minderoo irrigation. Source DPIRD

46 https://www.hancockprospecting.com.au/wp-content/uploads/2017/10/2017-09-07-ABC-News-Fitzroy-River-National-Park-plan-creating-steady-flow-of-concerns-from-Kimberley-cattle-industry.pdf

47 http://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Gogo%20Referral%20Supporting%20information%2030-8-17.pdf

48 https://www.abc.net.au/news/2020-02-04/fitzroy-river-protection-urged-as-wa-election-deadline-looms/11914270

49 https://www.abc.net.au/news/rural/2017-09-07/minderoo-station-andrew-forrest-expands-irrigation-horticulture/8874860

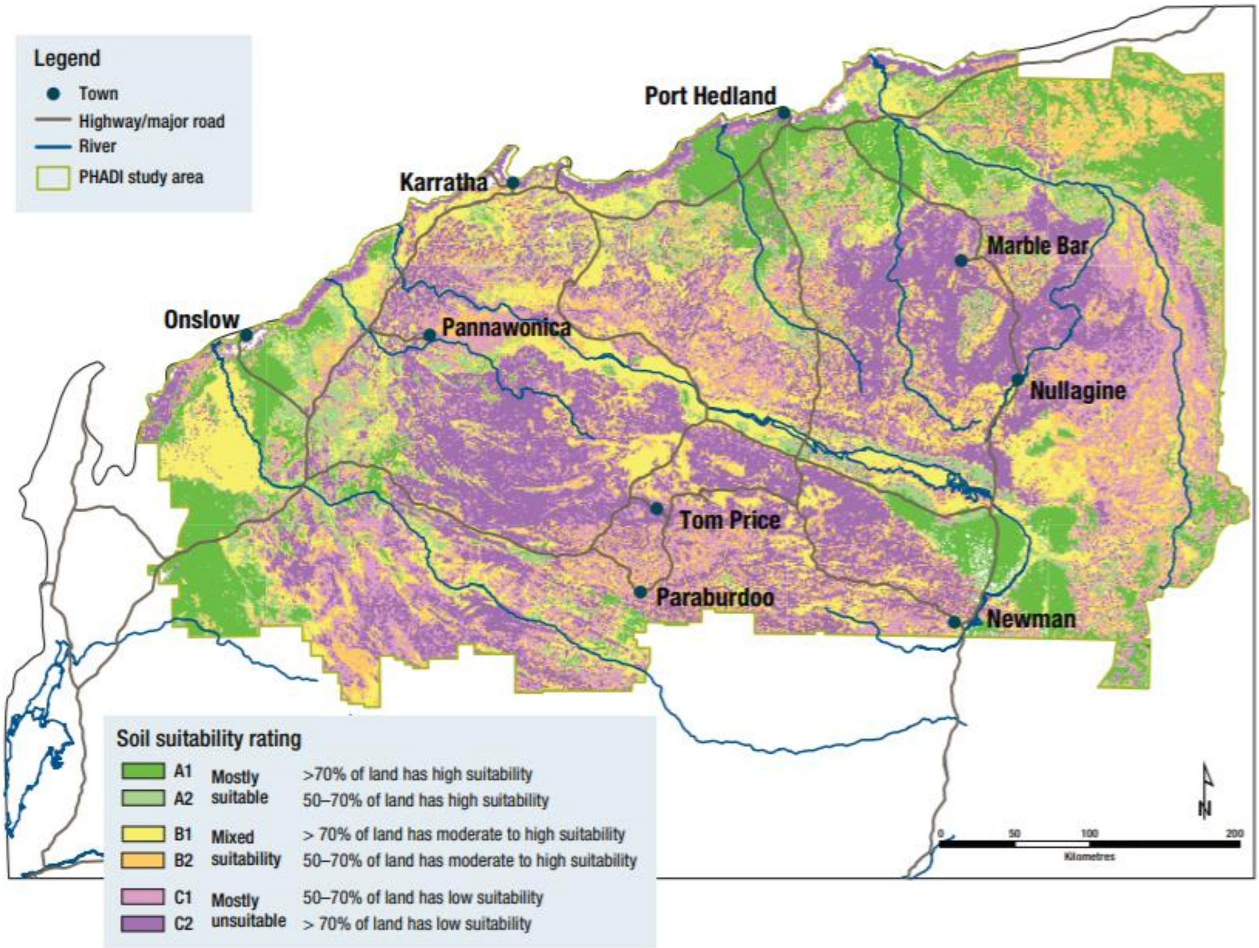

Figure 7 Pilbara soil suitability

Source: DPIRD Growing the Pilbara 2017

The largest single agriculture investment in centre pivot irrigation in the area is at Pardoo Station. Pardoo has twenty pivots providing forage and fodder for its strategic investment in developing Wagyu genetics. Pardoo draws artesian water from the high-pressure Canning-Wallal aquifer which provides wellhead pressure sufficient to enable high-flow supply to two pivot irrigation systems per bore without the need for supplementary pumping. WA's Department of Water granted Pardoo a monitored allocation of 14.8 gigalitres of water a year from this aquifer. Each pivot's area is 40-50 ha providing Pardoo with 900 ha of irrigatable land to supplement its 200,000 ha of pastoral grazing land. The owner of Pardoo, Singaporean Bruce Cheung, has stated the eventual objective is to establish at least 10 more pivots, to support a rotational grazing system with hay production, pasture and a feedlot.[50]

In common with other northern pastoral operations considering cropping, Pardoo's business model is driven by improving reproduction and weight gain, and decreasing mortality, of cattle through the production of high quality feed at a lower cost than purchasing and freighting feed from southern production areas.

Soils in the Pilbara (**Figure 7Error! Reference source not found.**) are nutritionally deficient. Pardoo's pivot system requires substantial inputs in the form of trace elements, regular top-dressing with phosphorus and potassium and about 1,000kg of nitrogen per hectare per annum.[51] As the standard supply chain for inputs is oriented to the southern broadacre markets, considerable freight costs are incurred in transporting fertiliser and chemical to the northern Pilbara. The closest southern port, Geraldton, is 1400km away.

50 https://www.abc.net.au/news/2018-03-11/meet-the-singaporean-businessman-transforming-the-pilbara/9526810

51 https://www.mla.com.au/news-and-events/industry-news/the-rhode-less-travelled/?clean=true

Pardoo's main crop has been Rhodes grass for stand and graze or cutting for hay. They have also trialled lucerne and used maize for silage. According to a 2019 submission to Streamline WA, Pardoo is facing significant challenges to remain viable using the crop species approved on their existing Diversification Permits. They state that it will not be possible to complete the Pardoo Wagyu Project successfully and produce a premium boxed wagyu beef for Asian markets, utilising the crops that are currently approved on existing Diversification Permits, as these crops are not supplying sufficient digestible energy to produce the weight gain required.[52] Pardoo are specifically seeking to gain access to:

- *Megathyrsus maximus* (Panic grass)
- *Cenchrus americanus* (Pearl Millet)
- *Clitoria ternatea* (Butterfly pea)
- *Leucaena leucocephala* (Leucaena)

In conjunction with Pardoo's commercial cattle operation, the Mowanjum Irrigation Trial has been the flagship project of the Water for Food program in the north of WA. The project is underpinned by a partnership agreement between the Government of Western Australia and Mowanjum Aboriginal Corporation executed in November 2014 and concluding in 2018[53].

Anna Plains is the only pastoral station in the north known to be using drip irrigation to grow quantities of Rhodes grass hay. Pastoralist David Stoate said that aside from providing feed for cattle, eliminating high freight costs in remote areas like the Kimberley was a huge financial benefit. "It saves you having to buy in that extra fodder if you can produce it yourself, which is a big advantage," he said. "In the past 12 months it's yielded just under 30 tonnes a hectare; it's probably about 1,500 bales over 28 ha.[54]

Wallal Downs Station owned by Grenleigh Pty Ltd is a station situated 350 kms south of Broome. It sits on top of the artesian Wallal aquifer in the West Canning Basin, where they currently have six pivots covering 285 ha. Wallal has also sought and gained clearing permits for another six pivots.

Argyle Cattle Company, owner of Shamrock Station has proposed 650 ha of clearing for pivot irrigation systems and the installation of up to 12 bores pulling up 9.5 gigalitres of groundwater per year to help feed Argyle's increasing cattle stock. Using 13 centre pivots, it is proposing to develop these 650 hectares of irrigated fodder for a stand-and-graze operation.[55] Other operations with pivot irrigation for fodder include Nita Downs (approved for 250 ha), Kilto (500ha) and Liverigna (300 ha).

Pilbara Mine Dewatering

The Pilbara's primary land based economic activity is iron ore mining with export values over $60B per annum. Massive open cut mines in the Hamersley Ranges that drop below the water table require dewatering processes to allow mining operations to follow the ore body. To carefully balance economic, social and environmental considerations that ensure future access to ore bodies, responsibly managing this water is essential. Water supply from dewatering is variable based on mining operations but has been recorded as exceeding 120GL.[56]

In 2012, Rio Tinto developed the Hamersley Agricultural Project consisting of 16 centre pivots supplied by water from the Marandoo mine irrigating approximately 850 ha. In 2014 the Nammuldi Agricultural Project was developed comprising 19 centre pivots irrigating 900ha. These operations have focussed on providing fodder for cattle on Rio Tinto's own stations and for sale on the open market.

The $12.5m Royalties for Regions Pilbara Hinterland Agricultural Development Initiative (PHADI) explored the future of irrigated agriculture development in the Pilbara with a dewatering project based at the East

52 https://www.wa.gov.au/sites/default/files/2019-11/Pardoo%20Beef%20submission_6%20September%202019_1.pdf

53 https://www.agric.wa.gov.au/waterforfood/mowanjum-irrigation-trial

54 https://www.abc.net.au/news/rural/2019-11-17/wa-pastoralists-attempt-to-drought-proof-using-centre-pivots/11663698

55 http://www.epa.wa.gov.au/proposals/shamrock-station-irrigation-project

56 https://www.agric.wa.gov.au/sites/gateway/files/DPIRD_Growing%20the%20Pilbara.pdf

Pilbara Woodie Woodie mine growing sorghum, perennial grasses, lucerne and tropical legumes. However, the Woodie Woodie mine was placed on care and maintenance in 2016 due to poor market conditions for Manganese and provided a strong lesson that agriculture is secondary to mine operations with dewatering projects. [57] Fundamentally, agricultural operations based on dewatering are designed to remove a problem hampering mine production and do not need to be economically sustainable in their own right. To this extent, they are opportunistic and anchored to the supplying mine's viability.

Ongoing Research

The development of Irrigated Mosaic Agriculture in the West Kimberley/Pilbara region is a dynamic environment which has undergone significant change in the last decade through a considerable level of private investment into irrigation infrastructure. In concert with this investment, there has also been strong R&D support, in large part funded by the WA Government Royalties for Regions program. The output of this work is currently being compiled by DPIRD in an Irrigated Mosaic Agriculture in northern WA report in conjunction with KPCA, producers, private agronomists and other agencies. The proposed report will be a significant repository of R&D conducted to date and should be released in 2020.

Constraint Summary

CONSTRAINT	
Crop Genetics	Access to crop varieties available in the rest of Australia. Trialling varieties and farming systems to optimise nutritional outputs.
Environment	Timely and efficient pathways through state and federal regulatory hurdles to allow irrigation development to gain scale for individual enterprises. This includes land tenure, clearing access to water and ability to grow particular forages.
Market and Value Chain	The size, location and nature of the demand for cropping outputs from the beef industry.
Farm Inputs, Capacity and Infrastructure	Investigating irrigation systems that lower the cost of inputs and capital. Building cropping knowledge and capacity in pastoral operations in a farming system context that maximises return across enterprises.

57 https://www.agric.wa.gov.au/newsletters/pilbara-hinterland-agricultural-development-initiative-phadi-issue-2

WESTERN AUSTRALIA The Ord River Irrigation Area (ORIA)

Introduction

The ORIA has been progressively developed for over fifty years and today comprises around 22,000ha of irrigated agriculture, 15,000 ha in Stage 1 and 7,000 ha in Stage 2. The ORIA was initially irrigated with water drawn from the Ord River diversion dam in the 1960s prior to the main Argyle dam being opened in 1972. Early crops were largely experimental and included rice, cotton and sunflower. Cotton was the initial stand out crop and occupied 98% of the irrigable area by the late sixties. Two cotton gins were in operation at that time.

By the early 1970s, the pest issues confronting cotton, namely cotton bollworm, had proven too great and with pesticides comprising 50% of a grower's costs[58] cotton production was abandoned in 1974. Rice and safflower replaced cotton in cropping programs and research started toward establishing a sugar industry. Rice was grown at a commercial scale from 1973 until 1983, with production peaking in 1982 (3,500 t of rice paddy, average yield of 7.1t/ha in dry season and 3.7t/ha in the wet)[59]. A small local processing mill was constructed. Issues with pests, especially the native Australia magpie geese, made rice production unmanageable and it too was abandoned.

By the 1980s niche cropping of rice, sunflower, sorghum, soybean, mungbeans, hay, peanuts, melons, and a range of hybrid seed production was being undertaken with the first export crop of sunflower shipped in 1981.

A sugar mill was constructed by CSR in 1995 and subsequently an 18,000-tonne bulk sugar store and a 7,000 tonne bulk molasses tank were also built.[60] Cheil Jedang Corporation, South Korea's largest food manufacturer, bought the mill in 2000. Sugarcane yields averaged over 100t per ha and around 4000 ha were planted annually. The mill stopped operating in 2007 with low world sugar prices, shrinking production and uncertainty about expansion of the irrigation area cited as the main reasons for the mill closure. A rice trial in 2010 performed well and the production area expanded to 650ha planting in 2011 before succumbing to the fungal disease rice blast.

Indian Sandalwood began replacing sugar in the early 2000s and rapidly expanded to approximately 50% of the ORIA production area over the next decade. Due to expected returns being less than anticipated, hectares allocated to Sandalwood are being sequentially reduced as the wood is harvested. The boom in 'superfoods' saw the development of a chia industry supplying the Chia Co Australia. Ord growers allocated thousands of hectares to chia production and the Chia Co was reported to be the largest single chia production company until cheaper international production flooded the market in the late 2010s.[61]

Today, ORIA Stage 1 is around 15,000 ha growing melons, vegetables, chia, sandalwood, maize, fodder and niche crops. ORIA growers have a history of collaborating and coordinating their efforts to supply niche markets. ORIA Stage 2, comprising almost 7,000ha, was officially leased at the end of 2017 and has been mostly developed by Kimberley Agricultural Investments (KAI) following $300m of public investment, mainly to extend roads and the main channel.[62] On 22 July 2020, the NT Government announced it was offering three parcels of land totalling nearly 100,000 hectares for agricultural development. Notably one of these parcels, the Keep Plains development will result in the Ord irrigation Scheme expanding from WA into the NT.

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58 https://www.cis.org.au/app/uploads/2015/07/pm2.pdf

59 https://www.agric.wa.gov.au/grains-research-development/rice-ord-river-irrigation-area

60 http://ordco.com.au/our-history/

61 https://www.abc.net.au/news/rural/2019-05-27/chia-quinoa-global-oversupply-felt-by-aussie-superfood-growers/11143360

62 https://www.agric.wa.gov.au/resource-assessment/ord-river-irrigation-expansion-goomig-farmlands

Overarching Business Model Elements

As observed over its history, ORIA production is not beholden to a single commodity. It has the capacity to grow many tropical horticultural, silvicultural, pulse, cereal, fibre and fodder crops under irrigation, and in practice, all crops compete for hectares. The interrelated issues of scale, yield, production cost and freight determine whether any single crop will be viable for a given market demand and price. As these variables change over time, ORIA growers move in and out of commodities.

Crop Genetics

ORIA typically requires a baseload crop and capitalises on niche crops around the baseload. Examples of baseload crops over the years have been rice, cotton, sugar, sandalwood and chia. Over the last few years, maize has increasingly replaced chia and there is a renewed significant interest in cotton.

COTTON

Cotton genetics have improved significantly since cotton was abandoned as a crop in the ORIA almost 50 years ago. The genetically modified Bollworm resistant Bollgard III released in 2016, which incorporates three Bt proteins to kill the *Helicoverpa* spp. larvae, has substantially reduced the need for insecticide application. Although this crop has been trialled in the ORIA, the challenges of commercial scale coordination of planting within appropriate sowing windows, particularly as trafficability issues arise through early rains, are still to be fully understood. As a cotton plant in the ORIA will behave differently from cotton grown in NSW, there has been an R&D focus on in-crop management and decision-making around the tools available to influence the plant's behaviour as an annual, including nitrogen and growth regulants such as Pix. The CSIRO authored NorPak cotton guide released in 2007 covers a number of these issues[63].

CHIA

Chia reached peak production around 2015 when it is estimated a crop valued at $10m was produced.[64] Chia can be impacted by rain at harvest and yield is no longer sufficient to compete with international producers. A select breeding program has been instituted and new varieties have been trialled, but it appears that the business model is being challenged beyond benefits achievable through incremental genetic improvements.[65]

MAIZE

Maize has been produced in the ORIA since 2016 and is currently the biggest ORIA export. It is a dry season crop which works within other production systems. There are no obvious genetic constraints currently.

CHICKPEA

Kabuli chickpea is a niche crop in the ORIA. Kimberley Large and Macarena are the two varieties of Kabuli chickpea currently grown in the ORIA. Macarena is an old variety originally bred in 1984 by DAWA and Kimberley Large was specifically bred for the ORIA by DAWA/Centre for Legumes in Mediterranean Agriculture and released in 2004. Up to 500 ha is allocated to chickpea production in ORIA.

Market and Value Chain

The ORIA is off-season to southern Australia and largely on-season to premium markets in Asia. Over its history, ORIA's production across all commodities has been opportunistic and has often ceased during a slump in commodity pricing. The fundamentals are the same in each case - the cost of production combined with freight cost to market, make commodities unviable during market nadirs. Accordingly, most markets are limited to relatively niche volumes when there is premium pricing. ORIA growers are conscious that over-production of niches can lead to market saturation.

The latest crop to come into premium contention is cotton. Cotton production in the ORIA is at a Catch 22 stage where further production will not be scaled up without proximate access to a gin and investment in a gin is contingent on production capability being increased. The closest currently operating gin is in Dalby, Queensland and although cotton produced in trials has been freighted there, costs have been assuaged by utilising back-freighting and revenue enhanced by the recent drought induced tenth decile pricing for

63 http://www.insidecotton.com/xmlui/bitstream/handle/1/204/NORpak.pdf?sequence=2&isAllowed=y

64 Functional Foods Crop Research Alliance Proposal November 2015

65 https://www.abc.net.au/news/rural/2016-09-05/new-variety-of-chia-harvested-in-ord-irrigation-scheme/7805570

cottonseed, neither of which are expected to be sustained in future. Cottonseed is an important driver of cotton production value as it has the potential to fill the current lack of protein feed sources for cattle production in northern WA. However, WA State biosecurity controls prevent boll cotton or cottonseed entering from the Northern Territory. To take advantage of cottonseed as a cattle feed supplement, a gin would need to be operational on the WA side of the border unless an exemption is granted. This would provide the lowest freight cost option of feeding proximate WA cattle with the cottonseed produced in the ORIA.

ORIA is fortunate that in Wyndham Port, it has a proximate bulk export supply chain for crop production that has been used for safflower, sugar, and more recently, maize exports. It is understood that, given the throughput demand for Wyndham, infrastructure capacity for export of current crop exports is currently satisfactory. The *in-situ* ship loader at the Port is not functional so portable loading equipment has been utilised. In addition, a collateral benefit may be derived from an expansion to enable potash exports, comprising a Dolphin berth and conveyor loader which would facilitate loading vessels with 30kt capacity. The closest export container freighting facility is in Darwin, yet its cost structure and limited traffic means that it is comparatively more efficient to road freight crops south to Fremantle, over 3000km away, as has been the case for chia exports. For cotton, container export capacity of approximately 20,000t of lint would be required, the equivalent of 1,000 TEU (twenty-foot equivalent unit containers). With supply chains that have poor throughput, a common issue is gaining access to empty sea containers that have arrived through imports. One possible solution being explored by the NT Government is developing an intermodal logistics hub at Katherine with access to both Port Adelaide and Darwin via rail [66].

Farm Inputs, Capacity and Infrastructure

Like all areas across northern Australia, the tyranny of distance and sparse population impacts the availability of specialist skills and labour in ORIA. DPIRD runs the Frank Wise Research Institute in Kununurra with a team of researchers led by David McNeil as the irrigated cropping principal research scientist and Helen Spafford, an entomologist and weed researcher.

Figure 8 ORDCO Fertiliser blender

Source: ORDCO http://ordco.com.au/wp-content/uploads/2016/07/A_B_C2_Ordco_fertilizer_blending_2-5a31f.jpg

The ORIA growers contribute their own financial resources to R&D through ORDCO, the Chia Company and KAI, and have also sought, and received funding, to undertake research through their research alliance, Northern Australia Crop Research Alliance (NACRA) which has resulted in $15m of R&D since 2015.67

The farm input supply chain is supplied by ORDCO which can land product at Wyndham and has storage and other infrastructure, including fertiliser blending (**Figure 8**), available at Kununurra.

Having an adaptable and agile production approach assists ORIA growers accessing the best markets but the downside is that it requires investment in skills, equipment and infrastructure with each introduced crop. For cotton, this will include specialist harvesters, module/round builders, seeders and most substantially, a cotton gin with construction estimates of more than $30m.68 During the trial stage, specialist equipment has been hired from Queensland and used throughout the NT and ORIA. The decommissioned sugar mill, now owned by KAI, is an example of a previous investment in infrastructure in the ORIA (**Figure 9**).

66 https://dpir.nt.gov.au/primary-industry/agriculture/agricultural-developments/katherine-logistics-and-agribusiness-hub

67 Deb Pearce -NACRA *Pers.Comm.*

68 https://www.abc.net.au/news/rural/2018-08-09/cotton-harvest-comeback-in-the-ord/10082328

Figure 9 ORIA Sugar Mill. Source: ORDCO

Environment

LAND

In addition to the 22,000-ha available in Stage 1 and Stage 2, further expansion into Stage 3, red loamy Cockatoo Sands which are well drained and trafficable in the wet season, have been investigated by DPIRD as to development potential (**Figure 10**). Approximately 6,500 ha of Cockatoo Sands and 2,400 ha of Pago Sands have been identified for expansion with a further 30,000ha of potential Cockatoo Sands north towards the Ord River False Mouths. The area known as Mantinea, downstream of the main Ord River below the Diversion dam has had a resource assessment for 4,000 ha of production.

Accordingly, there is medium term potential for approximately 18,000 additional hectares and long-term potential for another 30,000 ha of land availability. Of this potential, Kimberley Agricultural Investment received environmental approval from the Environmental Protection Authority in 2018 to clear 3,055 ha of land on Carlton Plain with five years to develop.[69]

> *"Depending on the crop choice, sugar, rice and cotton need 8-14,000 ha for themselves alone, to consider building the processing and value adding facilities required. A major hurdle for the Ord Valley could arise if the Government doesn't continue to release land, as there'd be too much land for niche crops, but insufficient for a major crop. Effectively, the Government would then be planning for the future failure of the Valley."*
>
> Christian Bloecker ORIA Grower, 2011, UWA
> http://www.news.uwa.edu.au/ioa/agriculture/christian-devoted-ord

Accessing land has been consistently cited as a significant constraint for ORIA development. The State Department of Biodiversity Conservation and Attractions, Department of Water and Environmental Regulation and Department of Lands, Planning & Heritage implement assessment processes resulting in high costs, long time frames and often result in decisions that growers find questionable and difficult to understand. The application of approval conditions that have significant upfront and/or ongoing costs are a particular constraint to development. Examples of other constraints are prevalent among the ORIA community and a separate CRCNA supported project has been established to understand this constraint more fully across northern WA.[70]

69 https://www.kimberleyecho.com.au/news/the-kimberley-echo/kai-wins-nod-for-large-cotton-farming-venture-ng-b88960399z

70 https://crcna.com.au/research/projects/prioritising-de-risking-and-brokering-agricultural-development-western-australia

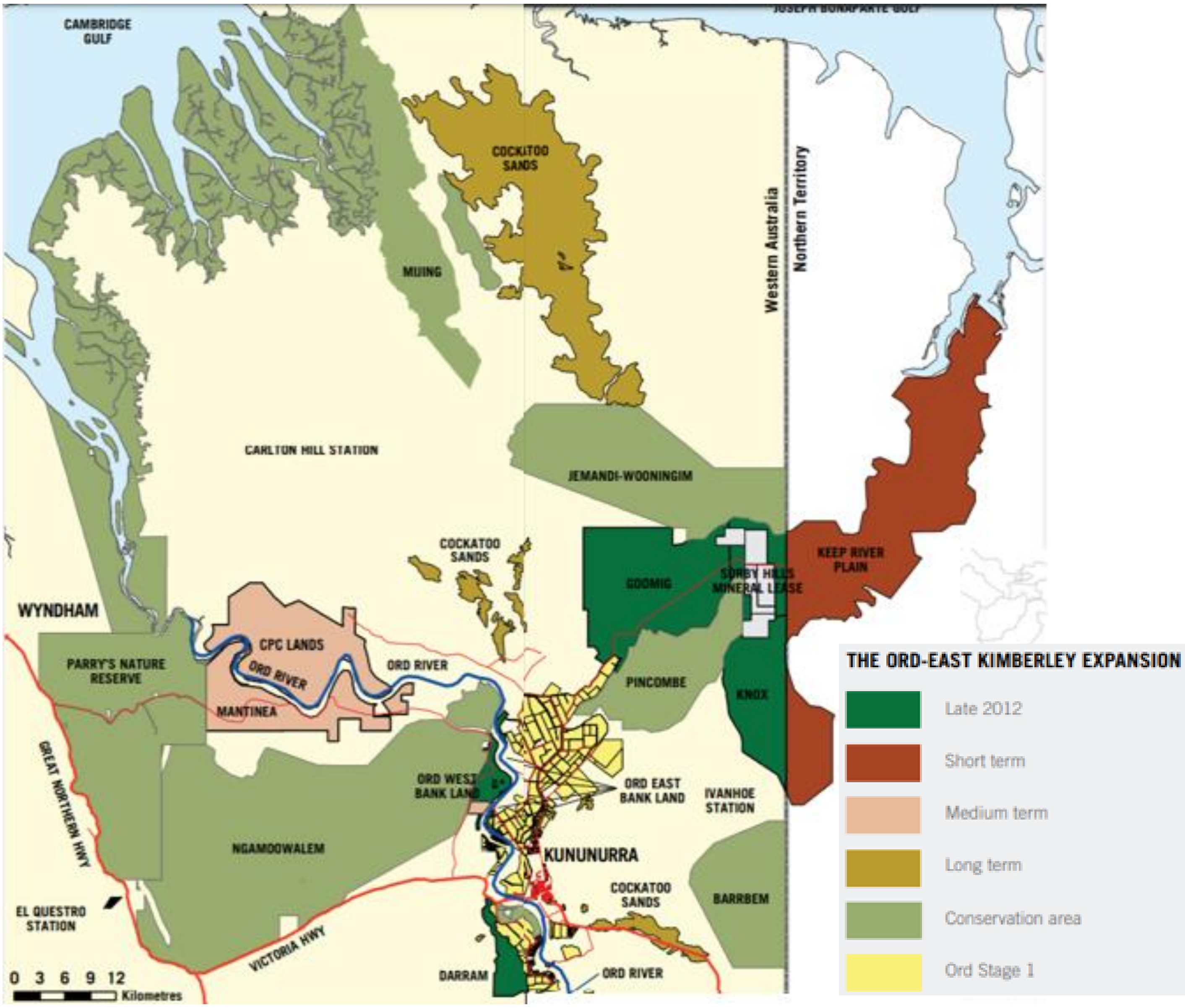

Figure 10 Expansion potential for ORIA. Source: Ord Land Release Brochure - drd.wa.gov.au

WATER

Much has been written about the phenomenal volume of water held in Lake Argyle which is the heart of the ORIA's value proposition. The Ord Irrigation Cooperative (OIC) was formed in 1996 to operate and manage the business of providing water and drainage services to the farms within Stage 1 as part of the transfer of the irrigation assets and business from the State to growers.

Irrigators have a combined 335 gigalitre water licence but this has been under threat with a decision made by the Department of Water and Environmental Regulation to reduce the entitlement by 90 gigalitres based on an assessment that current allocations are under-utilised. The OIC fought the decision and the case was decided by the State Administrative Tribunal in the OIC's favour June 2020.[71]

Each shareholder of the OIC is provided with an annual water allocation of 17ML per hectare.[72] Water pricing is not available to the public but is not significant compared to other regions. For areas downstream of the diversion dam, irrigation may entail pumping directly from the river which could cost $1,200 a hectare per

71 https://www.abc.net.au/news/2020-06-27/ord-valley-irrigators-rejoice-after-water-allocation-ruling/12398736

72 http://www.drd.wa.gov.au/Publications/Documents/Ord_East_Kimberley_Development_Plan.pdf

year.[73] Although the State Government had invested substantial sums in building the broader irrigation infrastructure, additional investment is required for new developments.

The ORIA receives on average 830mm of rainfall over 53 days almost entirely in the wet season with February being the wettest month receiving a quarter of the annual average. As is the case elsewhere in northern Australia, ORIA is subject to weather extremes including cyclonic events and single day rainfall events over 100mm are not uncommon. This poses an issue with wet season trafficability on the black soils comprising most of the developed ORIA. It is estimated that in two out of ten years, black soil will not be able to be planted to cotton or other wet season crops.[74]

PESTS

The warmth and humidity of the ORIA wet season combined with permanent water flows from Lake Argyle create a Ramsar listed wetland with optimum conditions for large insect populations which have provided substantial challenges to crop production including the failure of cotton in the 1970s. Fall Armyworm was confirmed in Kununurra on 1 April 2020 and has been declared as not eradicable. The potential impact of this pest on ORIA cropping is unknown but R&D to establish economic control thresholds will be required as part of an integrated management approach.

Current and Potential Business Models

The ORIA is an agile production system with growers switching between crops as market returns dictate. The following examples are illustrative of business models currently being pursued in the ORIA.

FODDER PRODUCTION

The potential to improve the value of the northern livestock industry, particularly through the dry months, has increased with the price of beef. This has led to the development of fodder cropping systems that provide stored feed with ruminant nutritional value. This provides the opportunity to supplement the lower-value live export trade with heavier cattle to be slaughtered locally or shipped as more valuable animals. With the cheap and plentiful water availability in the ORIA, grass crops such as Rhodes and Panic hay can yield 30 tonnes per hectare a year. Forage sorghum or maize for hay or silage can also yield similarly and maize grain and cottonseed can also be used in the ration providing additional protein.

To date, most focus has been on hay production. Robert Boshammer, a large and established ORIA grower, produced over 10,000t of irrigated hay in 2018.[75] According to Boshammer, the fodder model is limited by freight costs as "Hay is not a crop that you can transport all around the country because it doesn't have a high value and the freight would actually eat up the value of the hay." "A really cheap rate for us is $250 a tonne to Queensland [and] hay is worth anywhere between $150 and $200 a tonne, so you're already behind the eight ball before you put it on the truck."[76]

The counter to freight costs is to bring the cattle to the feed via a feedlot for finishing. To date, the constraint to the establishment of feedlots has been the availability of freehold land. Attempts to find suitable land have been made repeatedly but have largely been stymied by a range of state agency processes. A feedlot is an important component of an enterprise system based on the use of cottonseed processed by the proposed cotton gin. Whole cottonseed contains high levels of gossypol, which is toxic to animals in high doses but remains useful as a high protein and high-fat animal feed supplement – between 1kg and 2kg per day per mature animal[77]. As addressed above, any freight saving by using the cottonseed locally is contingent on the location of the gin. WA biosecurity prevents cottonseed from crossing the WA border from the NT side. There is additional benefit to the cotton business model if forage sorghum or maize could be double cropped in the dry season.

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73 https://abgc.org.au/2017/12/06/kununurra-banana-boom/

74 https://consultation.epa.wa.gov.au/seven-day-comment-on-referrals/carlton-plain-stage-1/supporting_documents/Supporting%20Document%20%20Carlton%20Plain%20Stage%201%20KAI%20Pty%20Ltd%20%2021%20July%202017_Part1.pdf

75 https://www.afr.com/companies/agriculture/the-next-cubbie-station-chinas-400-million-investment-in-northern-australia-20181008-h16dgh

76 Ibid

77 https://www.riverina.com.au/products/whole-cottonseed/

MAIZE PRODUCTION

Maize (corn) is one of the few current cropping business models in the north of Australia with an established export market and supply chain. South Korean demand for non-GM winter-grown Australian gritting maize was tested with the inaugural 2016 ORIA maize shipment, the first bulk crop export through Wyndham since raw sugar in 2007.[78] Although the first harvested crop was less than ideal for growers in terms of yield and poor processing quality for the customer, it provided a base to build from.[79] The timing was serendipitous in that the concept was proven just as eastern Australia entered a prolonged drought. Typical Australian maize production is 450kt and this fell by almost 200kt in 2019. With fixed domestic demand around 200kt, some of the unsatisfied export demand was picked up by ORIA growers. It is estimated around 30kt of maize was exported from ORIA in 2019.[80]

The maize supply chain is a closed-loop system with Dong-Il, South Korea's largest dry miller of human-consumption grit maize and supplier of cornflour, breakfast cereals and snack foods being the end consumer and trader. Robinson's Grain provides the shipping logistics and trade support and ORDCO the land-based freight, handling and storage. The ORIA program has used Pioneer Seeds' P1756, an Australian-bred variety developed for processing markets and suitable for dryland or irrigation environments with the potential for 13t -14t per ha crops.

Maize is planted in May-June and harvested between September and November with the timing beneficial as it is counter to the main eastern Australian harvest in March-April. Exporters out of Victoria have shipped as much as 60kt of maize per annum to Korea in preceding seasons. It is expected that the out-of-season supply will support the northern trade despite drought conditions easing in the east of Australia. In addition to export, maize may also be grown to assist in finishing cattle.

The supply chain is serviced by the Wyndham port which has 15,000t of storage, rudimentary loading infrastructure and limited vessel size capacity. It normally takes three to four days to load a single cargo of 10kt of maize. To date, this has been undertaken using a tractor powered auger (**Figure 11**).

Figure 11 Ship loading maize at Wynham Port. Source: Pioneer Seed Video, YouTube

78 https://www.abc.net.au/news/rural/2016-10-19/ord-valley-corn-set-for-export-to-korea/7940820

79 https://www.graincentral.com/markets/export/ord-ships-30000t-of-corn-to-korean-dry-miller-video/

80 https://www.graincentral.com/cropping/wa-set-to-topple-victoria-as-australias-top-maize-exporter/

THE KAI MODEL

Kimberley Agricultural Investments (KAI) is the wholly owned Australian subsidiary of the Chinese-based Shanghai Zhongfu Group, chaired by its majority shareholder, the billionaire property developer Pui Ngai Wu. In 2012, the WA Government announced that KAI was the successful proponent to lease and develop the Goomig Stage 2 expansion for the ORIA. KAI purchased Carlton Hill Station from Consolidated Pastoral Company in 2016.

KAI has nearly 27,000 hectares of developed or able to be developed land assets in the region including: Goomig (6,670 ha), Knox Plains (5,000 ha), Carlton Hill (9,000 ha), Mantinea (4,000 ha) and land in the original Ord Stage 1 (1,200 ha). Approval was received to clear 3,055 ha at Carlton Plain[81] in 2018. Further development is expected as per KAI's development schedule (**Figure 12**)[82]. A rule of thumb development cost is $10,000 a hectare.

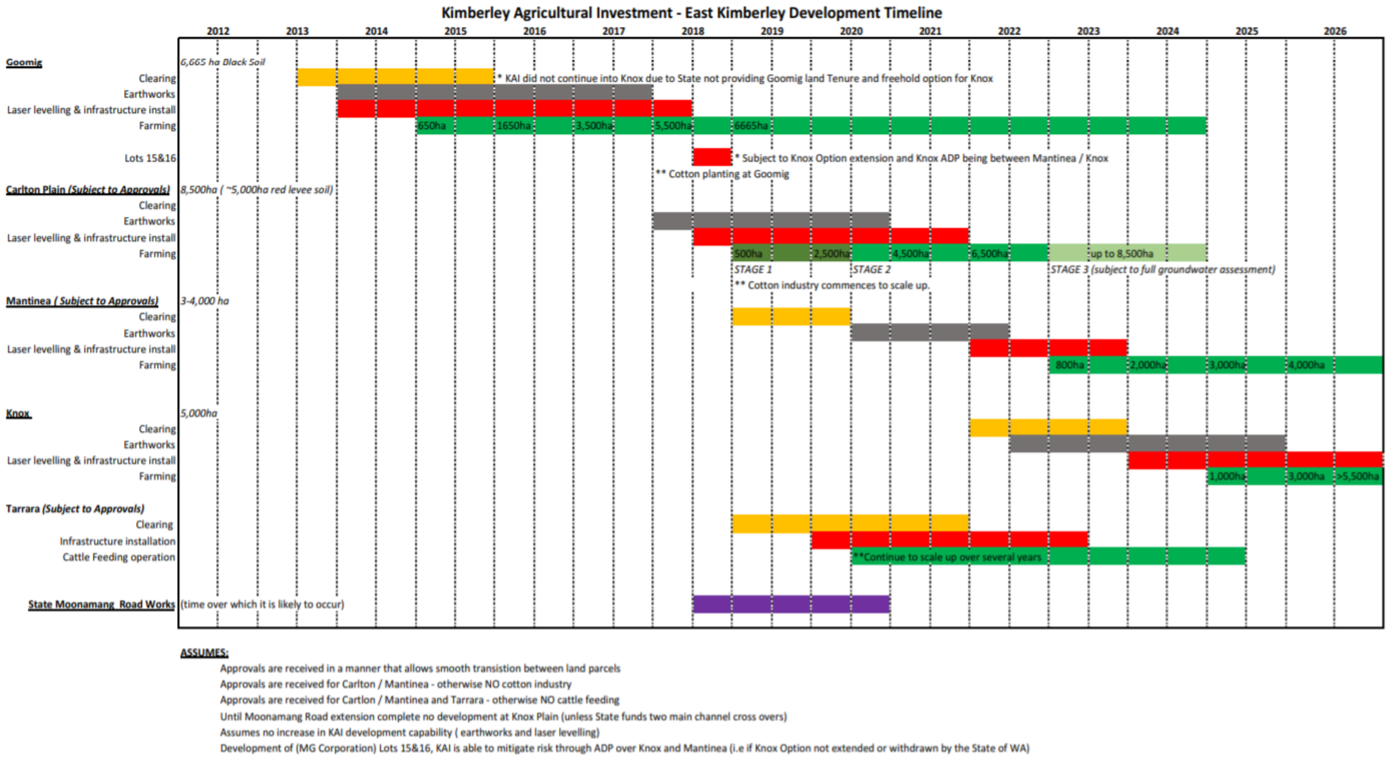

Figure 12 KAI Development schedule

KAI's business model has changed over the last eight years. Initially KAI was seeking to establish a sugar industry and redevelop the sugar mill shut down in 2007 (which it purchased). This was curtailed with significant expansion plans into NT (Keep River) being abandoned by the NT Government. KAI anticipated that 40,000 ha is required to establish a viable sugar industry[83]. KAI's cropping plans adjusted to niche crops including chia, millet and sorghum and a grain grading and packing plant is under construction. In the last three years, cotton trials were introduced, and KAI has publicly stated that a cotton industry is fundamental to its future in the ORIA. Without a gin, KAI is currently freighting its raw cotton 3,400km to Queensland. KAI is now at the crossroads to develop a viable crop for its expanded operation.

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81 https://www.epa.wa.gov.au/1081-carlton-plain-stage-1-irrigated-agriculture

82 https://consultation.epa.wa.gov.au/seven-day-comment-on-referrals/carlton-plain-stage-1/supporting_documents/Supporting%20Document%20%20Carlton%20Plain%20Stage%201%20KAI%20Pty%20Ltd%20%2021%20July%202017_Part1.pdf

83 https://www.abc.net.au/news/2016-01-29/stall-over-development-of-sugar-industry-in-ord-valley/7124630

MOSAIC
In 2019, Argyle Downs Station, situated south of Kununurra, was purchased by Clean Agriculture and International Tourism (CAIT), an agriculture and finance company from Vietnam. The property can draw water directly from Lake Argyle. CAIT aims to diversify Argyle along with two stations in the NT from purely running cattle to high value cropping and non-pastoral use. Whilst cattle production is at least initially expected to be the primary value proposition, CAIT is looking to expand into broadacre cropping with a slow and steady approach for developing forage crops and potentially cotton into a cropping system.

Constraint Summary

CONSTRAINT	
Crop Genetics	Trialling varieties and farming systems to optimise yields and quality.
Environment	Timely and efficient pathways through State and Federal regulatory hurdles to allow irrigation development to gain scale for individual enterprises. This includes land tenure, clearing and access to water.
Market and Value Chain	Commercially viable freight, logistics and ginning for the nascent cotton industry.
Farm Inputs, Capacity and Infrastructure	Developing a commercial scale for new crops, in particular cotton.

Cotton growing, Kununurra

NORTHERN TERRITORY - Big Rivers Area

Introduction

Northern Territory has three agricultural areas; Darwin, Katherine Daly Basin (Katherine-Douglas-Daly Irrigation Area, KDDA) and Central Australia.

The Big Rivers Region (**Figure 13**) is a term adopted by the NT Government in the context of the Katherine agriculture and freight hub. It is a broad area that includes, Mary River, the greater Darwin area, Wadeye, the Katherine/Daly, Roper, Victoria River catchments and Sturt Plateau districts.[84] With respect to broadacre cropping, most of the potential lies within this area.

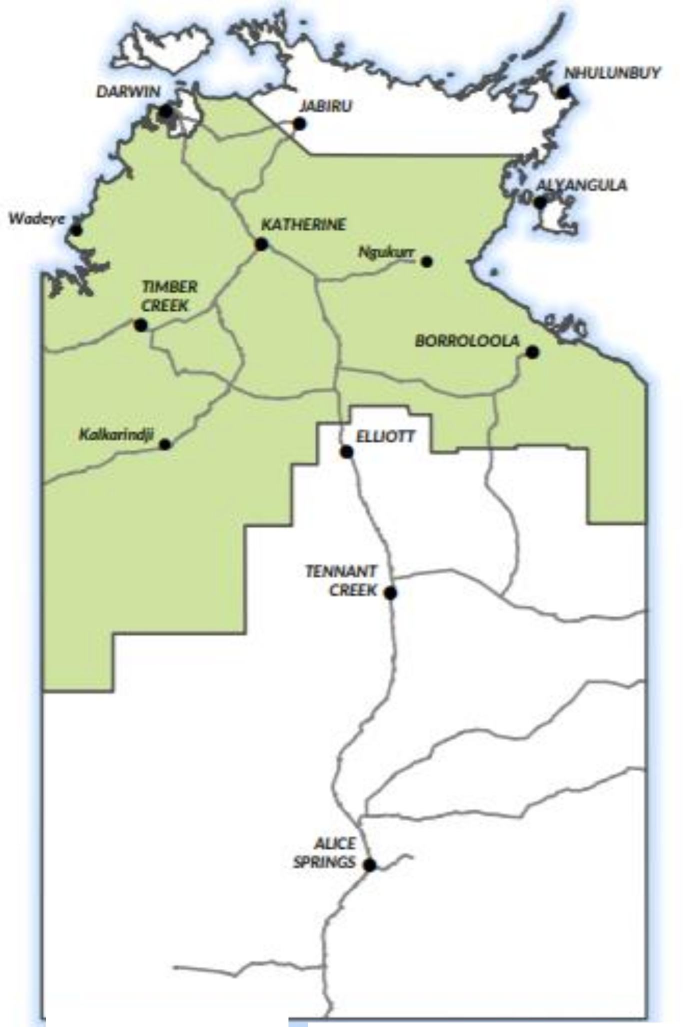

Figure 13 Big Rivers map Source DPIR Big Rivers regional booklet

NT broadacre cropping is currently very limited and largely consists of hay production, a small amount of sorghum, maize, peanut and mungbean production and trial crops such as dryland cotton.

Like other areas of the north, NT's broadacre cropping history is littered with a range of failed large scale cropping ventures. The most prominent is the Northern Agricultural Development Corporation (NADC) which conducted operations in the early 1970s on Willeroo Station near Katherine. NADC had plans to grow more than 25,000 ha of sorghum on Scott Creek (then a part of Willeroo), with the grain to be sold to domestic and export markets. Ten thousand hectares were cleared and sown with dryland sorghum which yielded about 1.85 tonnes a hectare. Poor export supply chains and a slump in cattle price resulted in the exhaustion of cash reserves and the operation was placed into liquidation in 1974.[85] Just prior to the Scott Creek development, nearby Tipperary Station was the site for another investment to establish almost 7,000 ha of sorghum production involving the Texan owned Tipperary Land Corporation,. Yields were lower than expected and the property was sold in 1973 and cropping ceased.[86]

A failed irrigation project was Territory Rice at Humpty Doo that ceased operation in 1963 after flooding.

It should be noted that the NT is also home to successful irrigated agricultural cropping operations, notably horticulture. This industry is characterised by:[87]

- 10,000 ha of irrigation on a range of soils
- 100,000 tonnes/year of refrigerated produce freighted in 200-250 vans/week (refrigerated x 20 tonnes) to southern markets
- around 5,000 casual staff/year recruited and trained for harvest and packing
- sourcing inputs like packaging, chemicals, fertilisers and machinery from local suppliers, and
- dealing with numerous biosecurity outbreaks.

84 https://dpir.nt.gov.au/__data/assets/pdf_file/0003/457095/Big-Rivers-Region-booklet-web.pdf

85 https://www.abc.net.au/news/rural/2019-10-30/why-did-willeroo-scott-creek-sorghum-cattle-empire-go-bust/11462048

86 https://www.publish.csiro.au/rj/pdf/RJ18034

87 Ian Baker, *Pers Comm.*

Overarching Business Model Elements

Crop Genetics

Due to limited broadacre cropping currently in the NT, there is little empirical evidence with respect to particular crop performance. Most recent research has been focussed on cotton demonstration trials using GM Bollgard III cotton in a NT context (**Table 2**).

Table 2 Cotton demonstration trials

Average yields from hand sampling of cotton experiments KRS,2019. Commercially indicative yields achieved by applying harvest and gin factors to gross harvest values.

Experiment	Bollgard3 cotton variety	Irrigation	Plant row configuration	Yield (bales/ha)
IRRI1	Sicot 707B3F	Irrigated	Full plant (100,000 plants/ha)	7.0
	Sicot 714B3F			6.9
	Sicot 746B3F			5.0
	Sicot 748B3F			7.6
IRRI2	Sicot 707B3F	Irrigated	Full plant (100,000 plants/ha)	10.4
	Sicot 714B3F			9.1
	Sicot 746B3F			8.9
	Sicot 748B3F			9.1
IRRI3	Sicot 707B3F	Irrigated	Full plant (100,000 plants/ha)	9.1
	Sicot 714B3F			9.6
	Sicot 746B3F			9.5
	Sicot 748B3F			10.3
RAIN1	Sicot 714B3F	Rain-fed	Full plant (100,000 plants/ha)	1.0
	Sicot 748B3F			1.6
RAIN1	Sicot 714B3F	Rain-fed	Single skip (66,000 plants/ha)	0.7
	Sicot 748B3F			0.7
RAIN1	Sicot 714B3F	Rain-fed	Double skip (50,000 plants/ha)	0.3
	Sicot 748B3F			0.4

Source: Research published by the Department of Primary Industry and Resources centre on the results of trials at Katherine Research Farm in 2019

Cotton crops were sown in late January and early February and harvested by hand in some of the trials in June and July. Average yields in Katherine on irrigated plots produced between 5-10 bales to the hectare against one or less bales on rain-fed trials - which also had lower fibre quality. Anecdotally, producer trials closer to the coast produced five bales to the hectare on dryland, benefiting from regular rainfall over the growing season. Issues around climate induced fruit shedding, boll rot, fibre colour downgrade require further research.

Environment

The mean rainfall in Katherine, Darwin and Timber Creek is 1,000 mm, 1,700 mm and 950 mm respectively. All locations receive highly variable rainfall events over the wet season with almost no rainfall in the dry season. As many top-end soils hold only 80 to 125 mm of plant available water in the root zone and an actively growing crop grown on a soil providing 90 mm of water will extract approximately 6 mm of water per day, water stress avoidance occurs in 8 to 10 days and severe stress after another 15 days.[88]

88 https://www.cottoninfo.com.au/sites/default/files/img/Preliminary%20determination%20of%20dryland%20cotton%20yield%20potential%20in%20the%20NT%20November%202019.pdf

The Darwin rivers catchment comprises the Northern Territory's largest (3,000 ha) and most valuable irrigation area (horticulture), irrigated mainly using groundwater.

Water licences are administered by the Department of Environment and Natural Resources with security levels that account for variability in seasonal aquifer recharge. A reliability number is used to help licence holders understand how much water they will be allocated over a 10-year period, based on the previous 30 years. For example, reliability of 37% will mean that 11 out of 30 years will have an allocation of less than 100%.[89]

Figure 14 provides an overview of the NT soil systems. The most commonly cropped soils - the red earths - are inherently low in phosphorus, sulphur, nitrogen and some trace elements. Potassium is generally deficient in sandy soils. The less utilised clays have greater wet season trafficability issues than the rest of the north but have better water retention properties necessary for dryland production. Issues with the soil as identified by CSIRO include high susceptibility to surface crusting after ploughing and the ease of erosion. These soils can also attain high temperatures that kill establishing seedlings and nitrogen is easily leached below the root zone or lost in runoff water.

If a pastoral leaseholder seeks to undertake activities other than pastoral activities such as tourism or cropping, an application must be made to the Pastoral Lease Board for approval. This includes sub-leased portions of the property. While approval is possible, anecdotal evidence suggests that this process is time-consuming and can be costly. This is because a change of land use triggers native title considerations, the resolution of which may be lengthy (Baker and Vivian 2017).

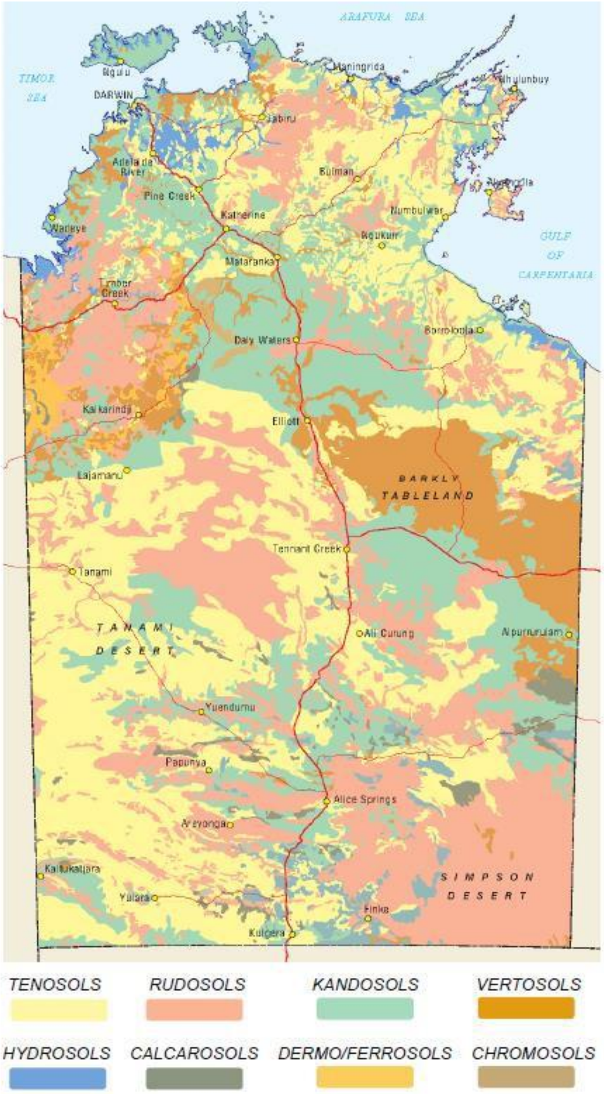

Figure 14 NT soil systems.

Source: NT Department of Environment and Natural Resources, Soils-of-the-nt-factsheet

Most land suitable for broadacre cropping is held in pastoral leases of a much larger size than the parcel required to gain an entry point to broadacre cropping. Pastoral leases require large acreage for the purpose of cattle grazing, in the order of 100,000 ha and above, whereas cropping operations can be adequately scaled at 5,000 ha (or less if irrigated). At this point of time, there is no mechanism to simply secure fit for purpose parcels of broadacre land of that scale.

89 https://denr.nt.gov.au/__data/assets/pdf_file/0011/377174/Oolloo-WAP-Background-Brief.pdf

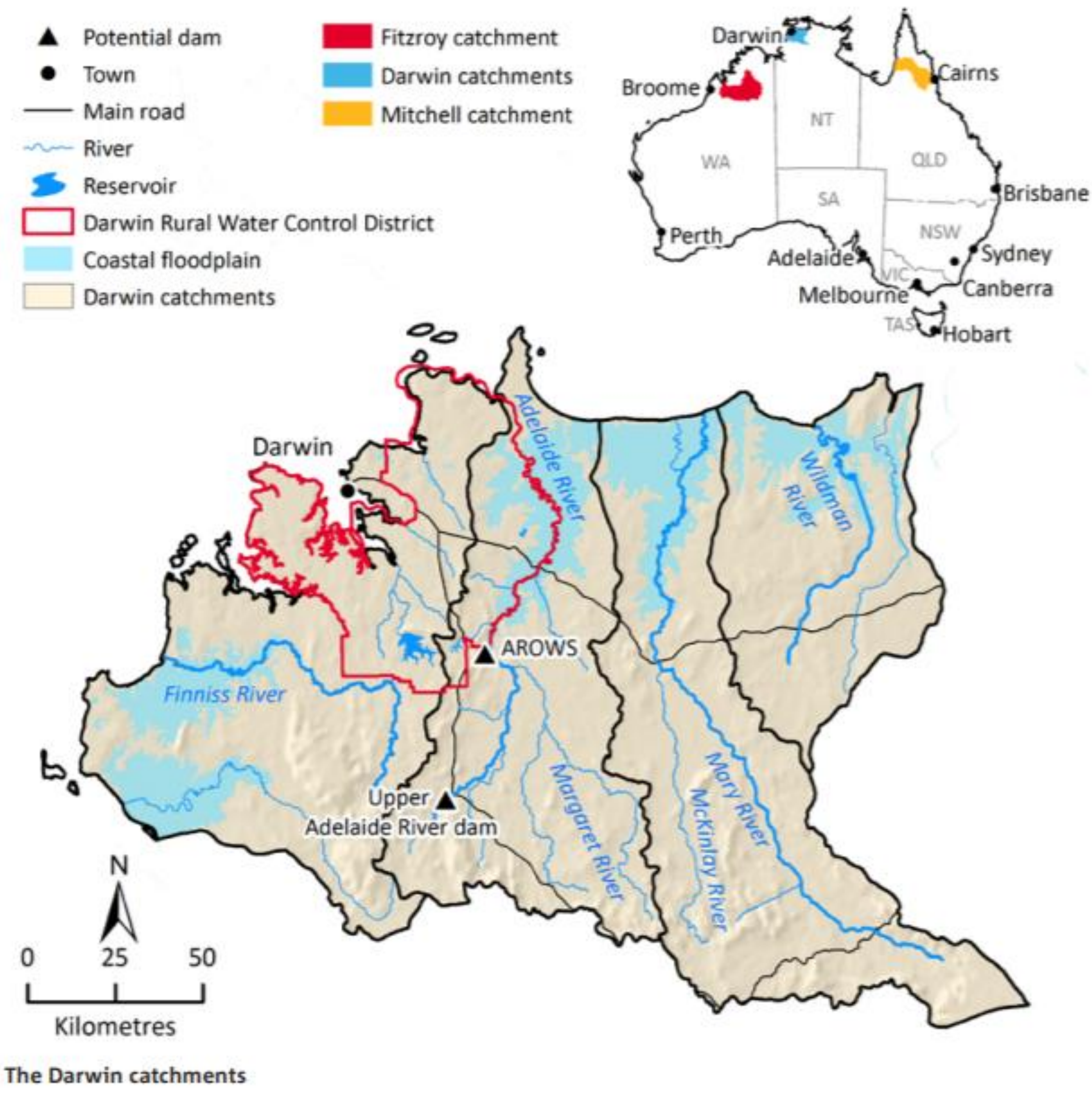

Figure 15 CSIRO Darwin catchment map. Source: CSIRO Darwin Catchment, (CSIRO 2018b)

CSIRO conducted a water resource assessment on the Darwin catchment (a subset of the Big Rivers area (**Figure 15**)). Key highlights from this report relating to broadacre cropping include:

- a trend for increasing rainfall has been observed in the Darwin catchments over the last three to four decades. The Darwin catchments have a hot and humid climate with a more reliable rainfall than other parts of northern Australia.
- on average, the wet-season rain starts earlier in the Darwin catchments than anywhere else in northern Australia. The dry season affords radiation that favours crop growth but, in the absence of irrigation water, dryland cropping is not likely to be economically viable.
- approximately 4,400 ha of land is currently under irrigation in the Darwin catchments, mostly for mangoes, melons, Asian vegetables and other vegetables and minor crops.
- there is currently very little broadacre cropping in the Darwin catchments.
- irrigation in the Darwin catchments, and the NT more generally, has predominantly been undertaken on loamy and sandy soils (e.g. Red Kandosols) with water sourced from groundwater. There is limited irrigated cropping experience on the heavy clay soils of the NT based on surface water (though there is some history with rice), and it will take time to establish reliable farming systems on these soils.
- the development of a range of two-crops-per-year rotation alternatives, and the management packages and skills to support them, is a likely prerequisite for economically sustainable irrigated broadacre cropping. The challenges in developing these should not be underestimated.

CSIRO found that vast hectares of the Darwin catchment (650,000 ha) are theoretically suitable for broadacre cropping but restricted by access to water. In many areas, broadacre cropping will need to compete with high value horticulture and tree crops for scarce water resources. The potential to dam the Adelaide River would most likely benefit those crops rather than broadacre crop production, should it eventuate.

Market and Value Chain

An important driver behind the Katherine Agribusiness and Logistics Hub proposal is to improve the efficiency of the post farm gate supply chain. Katherine is on the Adelaide–Darwin railway and the juncture of three main highways which offers an advantage over many regions in the north. Darwin Port is 320 km from Katherine. It has dry bulk or container loading facilities with cargo handling activities undertaken by either of the two stevedore service providers operating at East Arm Wharf, LINX Stevedoring and QUBE Ports. Cargo transfers are commonly performed by mobile harbour cranes operated by the stevedores. Currently there are no bulk or container exports of cropping produce.

One of the challenges of exporting grain products by container is access to suitable food quality containers available for loading (i.e. through imports).

Figure 16 charts the volume of container traffic through Darwin. Darwin has a thin container market. By way of comparison, Fremantle, the primary container port for WA, has over three times Darwin's annual TEU traffic every month. Although there are more import containers than export, it is not known if they are food quality or when they are received and available over the year. Approximately 20t of grain can be loaded in a single 20ft container, or TEU, (depending on its density) which would mean the best case would be a maximum of 20kt of export capability without dead freighting in empty containers with the associated additional cost.

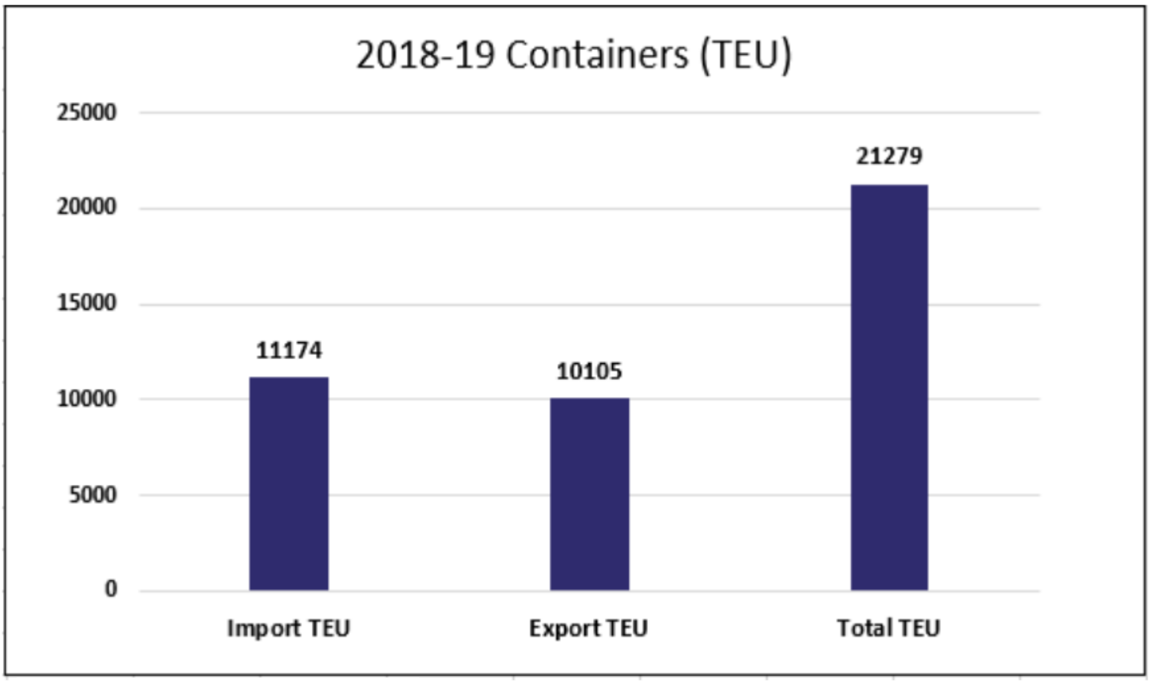

Figure 16 Darwin sea container traffic. Source: Darwin Ports trade statistics

2,700km to the south of Katherine is the Port of Adelaide. In 2019, Flinders Ports handled a total of 330k TEU. Although the distance is greater, the rail access from Katherine to Darwin combined with greater container traffic at port may make Port Adelaide exports competitive, despite the fact the freight movement is in the opposite direction from Asian export markets. (Port Adelaide also has substantial bulk loading facilities.)

A container export pathway is important for the development of a cotton industry and there is no domestic market for cotton lint. The NT Farmers Association has partnered with Queensland Cotton (Olam), that operate a number of gins in Queensland and New South Wales and trading operations globally, to assist in developing infrastructure and the supply chain for cotton production in NT. Biosecurity controls to prevent disease and pest incursion (e.g. Fusarium Wilt) means that Northern Territory cottonseed ginned in Queensland cannot be returned to the Northern Territory.

Farm Inputs, Capacity and Infrastructure

Like all areas in northern Australia the tyranny of distance and sparse population adversely impacts the availability of specialist skills and labour. DPIR operates the Katherine Research Station, the Douglas Daly Research Station and five others. Although there was a significant investment into cropping research undertaken during the days of the statutory Agricultural Development and Marketing Authority, in more recent times, State research capacity has been mostly focussed on cattle and horticulture. With respect to cropping, there has been recent research including into cotton with a renewed focus in modelling based on previous research and the CRCNA's current *Potential for broadacre cropping in the NT* project looking at numerous crops[90].

Current and Potential Business Models

There have been substantial changes in ownership of potential cropping farms in recent times. The list includes Scott Creek (2019), Auvergne and Newry Stations (2020), Willeroo (2017) and Flying Fox (2018) with considerable interest in potential broadacre cropping being spruiked during the various transactions. Currently, there are no established material cropping business models in place. For the scope of the CRCNA Expansion of Broadacre Cropping across NT project, the Northern Territory Farmer's Association states existing and potential NT expansion as:

- peanuts from 0 ha to over 6,000 ha
- sorghum from 70 ha to 5,400 ha
- cotton from 90 ha to over 35,000 ha
- soybean from 0 ha to over 4,000 ha
- mungbeans from 20 ha to 6,000 ha

Such a scale of expansion is not inconsiderable and requires all stakeholders to be aligned.

PEANUTS

The Peanut Company of Australia Pty Ltd (PCA), ran a full-scale commercial peanut operation at Katherine comprising thousands of hectares from 2007 to 2012. The expectation was to have 4,000 ha under cropping with 3,200 ha irrigated under pivots, growing rain-fed wet-season crops (peanuts, maize, hay) and 800 ha of dry season irrigated crops. Although yields for peanuts were commercially viable, PCA made a decision in 2010 to divest its Katherine operations due to a number of strategic decisions including; to invest more effort in the core operations of processing, the consideration of 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. It is believed that the inability to identify a second crop for double cropping to justify the high capital and operating costs was a key issue. The properties in Katherine were disposed of in 2012 and the major agricultural use shifted to sandalwood plantations.[91]

90 https://crcna.com.au/research/projects/potential-broadacre-cropping-nt

91 https://www.publish.csiro.au/rj/pdf/RJ18034

It has been reported that PCA found itself in financial difficulties through the NT investment which resulted in its lender, National Australia Bank converting debt to equity. PCA has since been bought by Bega.[92]
Trials at Katherine Research Station and Douglas Daly Research Station continued in 2015 on the understanding that peanuts were still a viable model, potentially grown in tandem with fodder grasses.[93]
The potential to grow peanuts for purely high value forage purposes or as a dual-purpose crop is another peanut production option being considered.

SORGHUM
The large and experienced Argentinian cropper, the Buratovich family, has bought Scott Creek (along with Manbulloo and Sturt Downs) with the intent of exploring its dryland cropping potential. It has been speculated that this includes sorghum production, as grain and/or fodder. [94] Although Scott River had large scale clearing in the seventies, it does not currently have a water licence.

COTTON
Tipperary Station grew 50 hectares of irrigated and 10 hectares of dryland cotton in 2019 as part of plans for diversification on the property (**Figure 17**).[95] Edith Springs also successfully produced cotton trials which were sent to Queensland for ginning.96 The results of trials growing GM cotton at Katherine and the surrounding region show a vast difference between relying on wet season rain as opposed to irrigation for optimum harvests. It has been reported that there remains community concern about use of irrigation to meet the Territory's ambitions to expand crop growing, primarily environmental impacts through capturing water and land clearing. There has also been some concern about the use of GM crops97. Current trials are mostly focussed on commercial broadacre 'proof of concept' but may serve to allay some of these concerns.

Figure 17 Tipperary Cotton pivot operation. Source: ABC News website (Ian Redfearn)

The further development of the pastoral estate is essential for cotton to establish with the option to sublease

92 https://www.begadistrictnews.com.au/story/5136693/bega-buys-peanut-company-of-australia/
93 https://www.katherinetimes.com.au/story/3167741/trial-aims-for-fantastic-nt-peanut-outcome/
94 https://www.abc.net.au/news/rural/2019-08-29/scott-creek-station-sells-to-argentinian-investors-buratovich/11460120
95 https://www.abc.net.au/news/2019-06-28/cotton-farming-northern-territory-tipperary-station-nt-industry/11258568
96 https://www.abc.net.au/radio/programs/nt-country-hour/new-nt-cotton-growers-group-formed/11291416
97 https://www.irrigationaustralia.com.au/news/cotton-trials-show-irrigation-is-still-key-to-big-yields

pastoral leases introducing a mechanism to allow development. To grow cotton, non-pastoral lease permits are required by application through the Pastoral Land Board.

Constraint Summary

CONSTRAINT	
Crop Genetics	Understanding the performance of cotton in a dryland setting. Finding complimenting rotation crops and understanding the rotation cropping system, especially in dryland management.
Environment	Timely and efficient pathways through State and Federal regulatory hurdles to allow irrigation development to gain scale for individual enterprises. This includes land tenure, clearing and access to water. It would appear necessary scale would most likely be reached with dryland production. Need to educate and communicate with the community to bring them along the journey.
Market and Value Chain	Commercially viable freight, logistics and ginning for the nascent cotton industry. Understand if industry will be viable if dryland cotton lint is of lower quality or whether it is able to be managed.
Farm Inputs, Capacity and Infrastructure	Building to a commercial scale for new crops, in particular, cotton. Building cropping knowledge and capacity in pastoral operations in a farming system context that maximises return across enterprises.

QUEENSLAND

General Observations

Over 133 million hectares of land is held under various landholding agreements for use in agriculture in Queensland. As expected, most of the land is utilised for grazing on native and improved pastures (almost 130 million ha) with cropping (including horticulture) utilising just 2.5 million ha[98]. CSIRO estimates that several million hectares of land could be suitable for cropping in the Flinders, Gilbert and Mitchell catchments although the actual production potential is likely to be just a fraction of this depending on availability of water, transport logistics and other production constraints.

There is potential for significant expansion of broadacre cropping in the current pastoral production systems, especially if irrigation water can be secured and land is available. There is growing interest in cropping in the area supported by the observation that growers with cropping experience from further south have recently produced crops under share-farming arrangements or purchased property outright. Expansion of cropping in the area will be highly dependent on Government regulation of water access and land clearing.

Most landholders have a high degree of consultation fatigue, having been consulted on numerous issues by a range of entities with seemingly little progress. There has been no recognisable cropping systems group (as is common in the south and west) in the region. Advocacy for cropping is via Shire Council initiatives such as the Flinders River Agricultural Precinct (that has ceased to operate), Hughenden Irrigation Proposal, Richmond Irrigation Area, individual growers and the grains committee of AgForce. The newly established Far North Queensland Sustainable Cropping (FNQSC) Group has the potential to be an appropriate grower representative body to advise on constraints and opportunities. The group is in its infancy but has the capacity for growth should more growers perceive an advantage or benefit in participating. There are also significant opportunities for targeted cropping in the Burdekin and the further adoption of rotational crops in the established sugarcane areas.

Environment

WATER

Current water use in north Queensland (**Table 3**Error! Reference source not found.) is dominated by sugarcane production and pasture for grazing or storage as hay or silage. The figures are estimates of the 2017/18 year and may not account for more recent expansion of broadacre cropping. Other agriculture use of water is predominately high value horticulture.

Table 3 Water use in north Queensland

NRM Region	Catchment Example	Total Water ML	Area Irrigated (ha)	Total Water Applied (ML)	Pasture (fed off or stored)	Cotton	Other Grain	Other Crop#	Other Ag
Cape York	Lakeland	1,198 (794*)	133	400	102	-	20	-	288
NQ Dry Tropics	Burdekin	711,000 (332,542)	83,164	686,577	3,816	10,205	953	624,085 (Sugar)	47,518
Northern Gulf	Gilbert, Mitchell	90,104 (7,272)	14,351	74,460	2,263**	-	-	48,110 (Sugar)	24,087
Southern Gulf	Flinders	32,488 (21,596)	2,521	11,273	11,273	-	-	-	-
Terrain	Atherton Tablelands	110,295 (34,376)	22,484	107,062	6,526	-	1,039	26,366 (Sugar)	73,131

Source ABS Water use on Australian Farms 2017-18

 # Does not include rice

**Groundwater used*

***12,505 ha grain production included*

98 ABS Agricultural Commodities, Australia 2017-18

Decisions that balance the needs of the environment, society and industry are notoriously complex, but it is difficult to envisage a broadacre cropping industry in many areas without substantial allocations of water being made available. In Queensland, significant volumes of water for irrigation are already available on the Atherton Tablelands (through the MDWSS) and in the Burdekin. The Flinders, Gilbert and Mitchell catchments have substantial volumes in general reserve that could be made available for irrigation but only part of the water has been allocated. Allocations are made in accordance with regional Water Plans that establish total volumes as well as access regulations based on total flow and flow rate of relevant rivers.

When water is made available, the current process for allocation places restrictions on the amount of water that any one entity can access allowing all potential participants to bid in the market. The approach also aligns with mosaic irrigation strategies (Cook *et al*., 2008) where smaller off-stream storages are co-located with areas of soils most suitable for irrigation that maximise yields and returns and address constraints such as rising water tables and solute concentrations[99]. Large scale storages have been explored and a number of business cases are currently being prepared to support the potential construction of dams in all catchments. Given the high capital costs involved in water storage and irrigation infrastructure; storage efficiency and the timing of water use is a critical determinant of irrigated production viability. Access to water is a common constraint identified by growers in the Gilbert and Flinders catchments in particular. The mechanism to decide how much water will be made available is not well articulated or understood and consequently, there is a significant degree to dissatisfaction in the water allocation process.

LAND

The main legislation regarding management of land tenure and land use in Queensland includes the following as well as ongoing updates and reviews of the legislation that continue to be made:

- *The Land Act, 1994*
- *The Sustainable Planning Act, 2009*
- *The Vegetation Management Act, 1999*

The interpretation of the various pieces of land tenure legislation and how they relate to production activities on leasehold land, the extension of lease terms and conversion of landholdings to different lease or ownership types is extremely complex. Efforts have been made by the Queensland Government to provide guidance on the various tenure and ownership issues (e.g. Published policy on land holdings[100]), but it remains an area of substantial concern and is clearly a high priority for the State farming representative body, AgForce[101] and individual growers. Feedback received highlights concerns around the potential impact that fixed term leases (and the difficulties associated with rolling term leases and conversion to perpetual lease or freehold) have on the capacity to secure the required levels of capital and resource investment that are needed to develop large-scale broadacre agriculture over an extended period.

Land clearing permissions are equally complicated by overlapping State and Federal regulations under the *Vegetation Management Act* and *Environmental Protection and Biodiversity Conservation Act,* respectively. Under the *Vegetation Management Act,* 1999 areas are categorised[102] as:

- Category A - a declared area, an offset area, an exchange area, an area that has been subject to unlawful clearing or an enforcement notice, or an area subject to clearing as a result of a clearing offence.
- Category B - an area which is remnant vegetation.
- Category C - An area which is high-value regrowth vegetation on freehold land, Indigenous land or land the subject of a lease issued under the Land Act 1994 for agriculture or grazing purposes or an occupation licence under that Act, in an area that has not been cleared in the last 15 years which is also an endangered, of concern, or least concern regional ecosystem.

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99 Advantages and Disadvantages of Irrigation Mosaics as an Alternative to Traditional forms of Irrigation in Northern Australia

http://archive.riversymposium.com/2007_Presentations/C3G_Cook.pdf

100 https://www.dnrm.qld.gov.au/?a=109113:policy_registry/early-renewal-conversion.pdf

101 https://agforceqld.org.au/land-tenure

102 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0006/1447098/general-guide-vegetation-clearing-codes.pdf

- Category R - An area which is a regrowth watercourse and drainage feature area located within 50 metres of a watercourse located in the Burdekin, Burnett–Mary, Eastern Cape York, Fitzroy, Mackay-Whitsunday or Wet Tropics catchments identified on the vegetation management watercourse and drainage feature map.
- Category X - All areas other than Category A, B, C and R areas. Category X areas are not generally regulated by the Vegetation Management laws.

Initial vegetation mapping is generated as part of a general vegetation map developed by government agencies. Property holders can generate more accurate property maps of assessable vegetation (PMAV) and a significant number of properties have applied for and been granted a PMAV. A PMAV is made through an agreement between the property holder and the Queensland Government and describes the vegetation on a property in greater detail than the general vegetation map. Once the PMAV is certified, it replaces the regulated vegetation management map for determining the location and extent of the areas of regulated vegetation[103] and is an important part of identifying potential clearing options and requirements. The development of PMAVs imposes additional costs on property holders which may be warranted if growers could envisage the possibility of acquiring a permit to clear land. Feedback suggest this is not a widely held expectation.

The vegetative management policy, under the *Vegetation Management Act* (1999) establishes decision making frameworks that apply the precautionary principle:

> *"lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment if there are threats of serious or irreversible environmental damage"[104].*

A strict interpretation of the principle implies that obtaining a license to clear trees for cropping is likely to be extremely difficult. In addition applications for land clearing can also require Federal Government approval under the *Environmental Protection and Biodiversity Conservation (EPBC) Act* making an already complex process even more complicated.

The *EPBC* Act is currently the subject of an independent review as required under the legislation. That review will be informed by a recently published review into the interaction between the *EPBC* Act and the agriculture sector published last year[105]. The National Farmers Federation (NFF) undertook a survey of 155 growers and consultants who self-selected as wishing to volunteer comment to the review. 39 of 88 respondents on one question confirmed that they were deterred from proceeding with agricultural development because of their understanding of the *EPBC Act* describing the processes as too complicated, too expensive and/or too risky. The survey also highlighted the confusion between Federal and State legislation and how they interact. The review itself found, amongst other things:

- there is a belief that the Department of Environment and Energy tends to engage with growers only when something has gone wrong, rather than working with growers to provide advice and guidance
- there is a widespread perception that environmental law and enforcement is preventing growers from getting on with farming
- there is a lack of common understanding on the vision of the desired outcome from implementing the EPBC Act in agriculture, and
- it is difficult for farmers to obtain advice on EPBC Act obligations at the local level and current guidance materials are not particularly practical or accessible.

These observations had a strong resonance with the stakeholders spoken to as part of this analysis. Feedback supports the widely held belief that between the operation of legislation at the State and Federal levels, broad scale lend clearing is no longer permissible. The uncertainty of land tenure and difficulty in acquiring permits for land development are substantial barriers to development of broadacre cropping in the

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103 https://www.qld.gov.au/environment/land/management/vegetation/maps/map-correction

104 State Policy for Vegetation Management. Version 4 (2019). Department of Natural Resources, Mines & Energy, Qld.

https://www.dnrme.qld.gov.au/?a=109113:policy_registry/state-policy-vegetation-management.pdf

105 https://www.environment.gov.au/system/files/resources/0bb50a4d-b273-4a31-8fdb-dcde90edef3e/files/review-interactions-epbc-act-agriculture-final-report.pdf

north, not only for current land holders but in terms of new land holders entering the market and for accessing the capital investment required.

CROPS

The production of broadacre crops in Queensland is dominated by winter cereal and pulse (mainly chickpea) production in central and southern Queensland in rotation with cotton, sorghum and mungbean production in summer. Hay and silage production are also substantial. Many of the commodities produced in the south are potentially suitable for the north and trials of cotton, maize, sorghum, mungbean, chickpea, soybean, peanuts, sesame and other crops have been undertaken in both irrigated and dryland production systems, some with very impressive results. Given the emerging nature of the northern broadacre cropping industry, commodity statistics (**Table 4**) need to be interpreted with caution but are included here for the sake of completeness and to demonstrate that, for some crops, production figures are at least on the radar of Commonwealth agencies.

Table 4 NQ Commodity estimates

NRM Region	Catchment Example		Total Crop Area (Ha)#	Cotton (Ha)	Grain Sorghum / Maize (Ha)	Winter Cereal (Ha)	Pulse (Ha)	Oilseed (Ha)	Silage (Ha)	Hay (Ha)
Cape York	Lakeland		7,036	-	626 (1,731*)	85	-	-		na
NQ Dry Tropics	Burdekin		210,770	992 (1,080)	3,762 (5,848)	45,553 (69,688)	45,246 (59, 024)	920 (230)	630 (26,251)	2,734 (9,261)
Northern Gulf	Gilbert, Mitchell		38,862	-	10,000 (6,000)	2,505 (2,512)	315 (-)	-	-	1,348 (10,682)
Southern Gulf	Flinders		5,999	-	-	-	-	-	260 (10,994)	3,944 (20,844)
Terrain	Atherton Tablelands		193,097	-	1,323** (14,926)	355 (717)	570 (1,035)	475*# (1,849)	183 (4,837)	na

Source: ABS Agricultural Commodities, Australia 2017-18
 # Includes land left fallow.
** Numbers in () are production figures (t). Figures for cotton are lint only.*
*** Maize production*
**# Peanut production*

Current production figures reflect the more mature status of broadacre crop production in the established sugarcane areas of the Burdekin and Atherton Tablelands where pulses, soybean and maize are utilised as rotational crops. Hay and silage production are growing in importance for cattle production and, while the figures for sorghum and maize are for grain crops, both are also utilised for silage (and/or standing grazing) with suitable varieties in the market from a range of suppliers. Pulses, cotton and oilseeds are all emerging possibilities in the Gulf country.

CAPITAL COSTS AND GROSS MARGINS

Extensive modelling has been undertaken by CSIRO to predict the likelihood of viable dryland cropping as part of the north Queensland catchment characterisations (CSIRO, 2013a; CSIRO 2013b; CSIRO, 2018c). The modelling suggests a gradient of increasing dryland production viability from the Flinders catchment in the south to the Mitchell in the north that is largely aligned with rainfall total and variability. However, there appears to have been minimal subsequent follow up with growers trialling commercial crops in the catchments to determine if the modelling is consistent with real-world experience. This would appear to be a significant gap in current planning as a viable dryland production system, even if only achievable in some years, would provide a more solid base for industry development than reliance on irrigation alone. The pattern of rainfall in the north allows prediction of water availability to be made with some accuracy and would support an approach where a crop is not planted in some years. Indeed, this approach has been adopted for many years by broadacre crop producers in the low rainfall production areas further south.

Irrigated production has been widely promoted as a future industry development opportunity. Irrigated broadacre sugarcane production, together with more intensive horticulture production have been significant contributors to the GVP of both the Burdekin and Atherton Tablelands. More recently, other crops such as cotton, maize, mungbean and soybean have been finding a place in sugarcane production systems not just for their rotational benefits but as cash crops in their own right.

Numerous groups across north Queensland have prepared or are preparing feasibility studies and business cases to support investment in large scale water storages. The CSIRO catchment reports identify sites and provide cost estimates of large scale, in stream storage. These are summarised in the individual catchment sections.

Modelling on irrigation systems for a 500ha development in the Flinders catchment suggests that breakeven gross margins for mosaic irrigation developments (as modelled) based on water harvesting and off-stream storage are unlikely to be profitable (Petheram *et al*., 2016). The marginal nature of irrigated broadacre cropping from the modelling is associated with observation that the land developed for irrigation of short (mungbean) and medium (cotton) season crops returns no income for six months of the year and water storage to allow year round irrigation is prohibitively expensive (Petheram *et al*., 2016). This is consistent with other analyses of northern broadacre irrigation that also identify the significant impact that freight costs have on returns (Ash *et al*.,2017; Baker and Vivian, 2017; Ham 2018). Despite this, it is of interest to note that desktop analysis of irrigation development for single crop models, with many assumptions, suggests break even returns might be achieved if gross margins of $1,650/ha could be realised for short season crops (mungbeans) and $2,350/ha for medium season crops (cotton) (Petheram *et al.*, 2016). Indeed, the estimated costs ($10,000ha) associated with furrow irrigation development on a greenfield site and the associated estimated gross margins of $3,000 - $4,000/ha required to generate a viable return are strongly disputed by some growers based on their experience. The wide variation in costs and required returns reflect the variable nature of the environment, farm enterprise, infrastructure requirements and access to required skills and capacity.

For areas where irrigation exists and costs have been sunk (e.g. the sugarcane production systems of north Queensland), broadacre cropping needs to be complementary with established industries (e.g. as a rotation to sugarcane production) or generate gross margins that are superior to current practices and/or address emerging production risks.

Acknowledging the need for validation of modelled outcomes, analysis of publicly available gross margin data provides at least a rough description of the general potential of a range of broadacre crops in the north of Queensland. The data is general in nature and in most cases based on central Queensland observations. There is likely to be significant variation to other regions and no reliance on the data must be made without seeking prior expert professional advice. Gross margin data has been accessed from AgMargins[106] for available regions and hence will be subject to differences in yield, costs, price and freight.

Market and Value Chain

Broadacre cropping in northern Australia has three potential major markets; feed, fibre and food. It is important to acknowledge that any broadacre cropping system must have the flexibility to adjust inputs (crop, variety, chemical, fertiliser, water etc) in response to markets and climate. It is also important to note the role that integrated farming enterprises play not only in providing value-added options but also in managing production risk. These aspects of farming are not covered well when looking at gross margins in isolation.

FEED

The large cattle properties in the area require a significant feed base to support production and to drought-proof operations.

Pasture hay on the Darling Downs is currently trading at $250-$300/t (down $215/t as widespread rain has provided some feed relief)[107] plus the cost of transport. Producing hay or silage for use on farm would offset a significant transport cost for beef enterprises as well as providing greater capacity to manage periods of adverse climate such as drought and flood. The potential for use of locally grown fodder in beef production is further highlighted by Australian silage research programs which have demonstrated that, in feedlots, cattle live weight gains in the range of 0.9-1.1kg/day can be achieved feeding high metabolisable energy silage

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106 https://agmargins.net.au/Reports/Index#

107 https://www.dairyaustralia.com.au/industry/farm-inputs-and-costs/hay-report

(ME>9.5MJ/kg DM) alone and can be increased further through the inclusion of grains[108]. Modelled data suggests average yields of 7-10t/ha of forage sorghum is achievable (Brennan-McKellar *et al*., 2013). Actual yields in the Flinders catchment have exceeded 30t/ha and have been as high as 40t/ha[109]. Previous modelling (Brennan-MacKellar et al., 2013) suggests that positive returns should not be expected from irrigated sorghum hay or standing forage because of the very high costs of establishing on-farm water storage and overhead irrigation. Positive returns can accrue through liveweight increases associated with supplemental feeding of local irrigated fodder production when the price of beef is relatively high (MacLeod *et al*., 2018) but the underlying value of irrigated fodder to the beef enterprise more likely arises from changes in herd management (e.g. early weaning) or herd structure (ability to finish cattle on a single property and/or the opportunity to introduce new genetics).

As noted above, direct sale of excess hay can contribute to revenue although this is heavily dependent on regional and local demand. Export hay must be processed at an approved facility, be accompanied with export certification and meet importing country requirements[110]. Consequently, the current export hay sector is confined to oaten hay largely grown and processed in SA and southern WA as well as Victoria. Demand in SE Asia and particularly in China could support a level of export hay production but only if internal and external regulatory requirements can be met.

Early assessment of shallow storage irrigation for sorghum grain production as a feed supplement suggested that, while biologically possible, such projects were economically unviable (Clewett, 1971). However, these figures were based on a maximum yield of 4t/ha. Modern hybrids would be expected to yield at least 8t/ha and possibly exceeding 10t/ha on suitable irrigation. Gross margins for irrigated grain sorghum in central Queensland average approximately $700/ha from a yield of 8t/ha and a price of $200/t. Gross margins on dryland production on 3t/ha at $200/t range from $150-$300/ha[111]. Simulation modelling (Ash *et al*., 2017) of irrigated sorghum production in the north based on an average yield of 8-9t/ha and including freight to Emerald indicates a gross margin of minus $930/ha to $30/ha. Freight costs represent 20-63% of value and gross margins improve to $386/ha if grain sorghum was used on farm.

Feedback suggests that growers undertaking dryland sorghum production have realised at least adequate returns from their investment and further consideration of dryland sorghum production warrants attention especially as it relates to on-farm or local use in cattle enterprises. Significant increases in fodder and feed grain production, if not utilised on-farm could be utilised by feedlots if quality and price requirements could be met. Demand for feed could be considerable with feed lot cattle consuming dry matter of an estimated 2.7-3.0% liveweight per day and with dry matter of grain averaging approximately 90% and that of silage 40%[112]. Cattle are either exported live or processed predominately for export. As of October 2017, the only export accredited abattoirs operating in north Queensland were in Townsville, Rockhampton and MacKay[113]. Live exports from the Port of Townsville totalled 146,585 head in 2018/19 and have been as low as 91,131 head in 2017/18, down from 152,890 head in 2014/15[114].

None of the analysis accounts for managing risk associated with climate variability including drought and flood, and while it is difficult to estimate the value of retaining stock through periods of extreme weather, the ability to "drought-proof" a beef enterprise using on-farm fodder and grain production is a significant consideration of many property owners. The role that forage and grain sorghum (or maize) production could play in managing the risks of climate variability in northern cattle production systems warrant further attention.

108 https://www.mla.com.au/download/finalreports?itemId=672

109 https://www.abc.net.au/news/rural/2016-05-03/record-harvest-helps-drought-proof-property/7380592

110 J. McKew - CEO, Australian Fodder Industry Association Ltd *Pers. Comm.*

111 https://agmargins.net.au/Reports/Index#

112 https://futurebeef.com.au/knowledge-centre/beef-cattle-feedlots-feed-consumption-and-liveweight-gain/

113https://australianabattoirs.com/qld/queensland-export-abattoirs-registered-as-at-02-10-2017/

114 https://s3-ap-southeast-2.amazonaws.com/os-data-2/port-townsville/documents/potltradestats_2018-19.pdf

COTTON

The Cotton Research and Development Corporation (CRDC) has long identified north Queensland as a potential area for expansion of the cotton industry. This view has been confirmed by independent analysis (Eco Logical Australia, 2014) that highlights the advantages of the Townsville/Burdekin/Bowen area in particular. The same analysis suggested that, due to the large number of trials already conducted in north Queensland, there is little evidence to suggest that a lack of research is the major impediment to cotton industry establishment. Cotton production R&D in NW Queensland has most recently focussed on CSIRO/grower collaborative trials in the Gilbert catchment as well as rotational trials conducted by DAF with support from the CRCNA. Cotton production in sugarcane rotations has been the subject of extensive R&D and resulted in the production of the NORpak Cotton production and management guidelines for the Burdekin and NQ coastal dry tropics (Grundy *et al*., 2012).

Ash *et al.* (2017) noted the significant impact of transport costs on cotton returns across northern Australia. The closest gin is currently in Emerald requiring transport of cotton approximately 800 -1000km from the Flinders or Gilbert River areas. Positive net present values (NPVs) on irrigation developments would be far more likely if transport costs were reduced through the establishment of a gin in northern Queensland (Ash *et al*., 2017). Modelling of irrigated cotton production associated with a potential dam at Green Hills indicates that it could be profitable (at the farm scale) if a gin were located at Georgetown (within 50km) but it would not be profitable to transport cotton to Emerald (950km) or even a potential gin at Charters Towers (470km) if cotton were priced at $450/bale and irrigation costs are included (Hughes *et al*., 2013).

Careful analysis of integrated cotton production systems with other crops and cattle feeding, impact of price and seasonal variability is required to establish viable production systems. This is particularly important in the greenfield areas of NW Queensland where grower feedback outlines the importance of cotton in an integrated production system and a potential willingness to develop required processing capacity if certainty of water and land access can be established.

GRAINS

A range of grain crops can be grown in northern Queensland but the focus for bulk commodities has been on desi chickpeas, mungbeans and grain/forage sorghum and to a lesser degree on maize and soybean, particularly as rotational crops in sugarcane production systems. Significant areas of winter cereals (predominately wheat, barley and oats) continue to be produced in the Burdekin. The gross margins of all are significantly impacted by high transport costs and price. Transport of high volume, lower value commodities over large distances is clearly an issue that has been recognised previously in several studies (Ash *et al*., 2017). Transport costs in north Queensland may be addressed to some extent if the possibility of greater export from the Port of Townsville is realised[115].

Despite the impact of transport costs, grain crops remain an important rotational option in potential farming systems that includes beef production, sugar production and/or cotton production particularly as part of an integrated program to control weeds, pests and diseases and, in the case of grain legumes, for fixation of nitrogen.

PULSES

Chickpeas and mungbeans both have the potential to attract high prices, but costs are compounded by a lack of export facilities in the region. However, the current export capacity is expected to increase significantly as ADM looks to establish a presence in Townsville focussing on export of pulses in containers in the first instance[116]. Mungbeans have been identified as one of the top 20 opportunities for expanded agricultural production in the NW Queensland in work funded by the Queensland Government[117]. Chickpeas have previously been exported from Mackay and Gladstone and have been received at the GrainCorp Mt McLaren site[118]. Mungbean exports are complicated under Australian Quarantine Inspection Service (AQIS) regulations that require all mungbeans destined for export to be cleaned and packaged at a registered processing establishment. Registered processing establishments are predominately located in southern

115 https://www.northqueenslandregister.com.au/story/6493966/townsville-port-calls-for-grain-storage-facility/

116 T. Henry (ADM) *Pers. Comm.*

117 Twenty Opportunities - Identifying Diversification Opportunities in North West Queensland. Coriolis report to Queensland Government (2018)

118 J. Stuart (Graincorp) *Pers. Comm.*

Queensland[119] although SunRice is providing some processing through the Brandon site that they purchased from Blue Ribbon[120].

Chickpea (Desi) yields of 4t/ha have been reported in the north but an average irrigated yield in central Queensland is closer to 3t/ha. Mungbean yields under irrigation should be at least 2t/ha on an average irrigation of 2ML/ha[121]. Review of gross margin guides produced by the Queensland Government and available at AgMargins[122] demonstrate gross margins for irrigated mungbeans in central Queensland averaged approximately $1,600/ha on a 2.3t/ha yield of which 2t was classified as No.1 processing attracting $1,100/t. Dryland gross margins are, as expected, far more variable across seasons but are approximately $800/ha on average. The gross margins do not account for significant transport costs that could be expected from northern Queensland to an accredited processing site but do highlight the significant potential of mungbeans as a short season rotational crop.

Gross margins for irrigated chickpea in central Queensland averaged approximately $2,200/ha on a 3.2t/ha yield attracting $900/t. Dryland gross margins are again far more variable across seasons but are approximately $1400/ha in average years[123]. The long-term average price for chickpeas is closer to $500-$600/t free in store[124] and the gross margins here could overrepresent the potential return. Despite this, incorporation of chickpea production could have significant potential as part of an integrated system.
The gross margins for chickpeas and mungbeans are highly price sensitive. Underlying export demand for both is strong and is expected to continue in future. However, India has currently imposed tariffs of 60% on chickpea imports[125] that severely impact the viability of production and have resulted in a massive decrease in exports to India[126]. Alternative markets exist predominately in Bangladesh and Pakistan but are not as large as the dominant Indian market. The continuation of Indian tariffs and production from international competitors, predominately Turkey, Canada, Mexico and growth in Africa as well as domestic production in the main export markets of India and Pakistan can be expected to impact price. Mungbean exports are dominated by demand from Vietnam and Bangladesh[127] with significant production competition emerging from Myanmar.

NICHE OPTIONS

Niche options will have a place in any expanded broadacre cropping scenario in the north. They are, however, more likely to be expansion options than pioneer cropping options due to the need to develop capability and/or markets. CRCNA is already supporting some trials of these crops and a brief overview is presented below.

PEANUTS

Dryland trials in southern Queensland have averaged 2.5t/ha (range 1.5-4.0t/ha) while dryland trials in northern Queensland in high rainfall areas averaged 4.0t/ha (2.5-6.0t/ha). Irrigated trials averaged 5.0t/ha (4.0-8.0t/ha) (Wright et al., 2017). PCA continues to support trials at Ali Curung noting the potential for both nut and hay production[128]. Gross margins of irrigated peanuts in central Queensland[129] using current varieties yielding 3.25t/ha (of which 2.5t were premium Jumbo grade) were approximately $2,500/ha. Average irrigated yields exceeding 5t/ha are more common[130] and may contribute to an improved gross margin. Transport for processing is less of an issue than for other commodities with a shelling plant available at Tolga on the Atherton Tablelands. Furthermore, preliminary discussion indicates that a production area of 500ha could justify a dedicated harvester and possibly a small shelling plant with kernels transported to

119 http://www.mungbean.org.au/ama-members.html

120 B. Dembrowski (DAF) *Pers. Comm.*

121 http://www.mungbean.org.au/assets/irrigated_mungbeans_poster.pdf

122 https://agmargins.net.au/Reports/Index#

123 https://agmargins.net.au/Reports/Index#

124 http://www.pulseaus.com.au/storage/app/media/industry/AU-Dchickpea-pricing.pdf

125 http://www.cbic.gov.in/resources//htdocs-cbec/customs/cst1920-311219/Chap%207.pdf

126 Pulse Australia

127 Pulse Australia

128 G. Wright – Peanut Company of Australia *Pers Comm.*

129 https://agmargins.net.au/Reports/Index

130 G. Wright – Peanut Company of Australia *Pers Comm.*

Kingaroy for processing[131]. Pre-cleaning of nuts to remove trash prior to transport would be essential (Wright et al., 2017).

SESAME
In addition to peanuts, the Coriolis report to the Queensland Government identifies sesame as a potential broadacre cropping option that requires capability development. Existing and potential large export markets exist in South Korea, China and Japan and detailed analysis of sesame potential has already been completed by the CRCNA focusing on domestic demand and competition with production from African nations and Myanmar for the Asian market[132]. Domestic demand is predicted to reach 9800t while world demand is expected to grow past 2.5 million tonnes by 2040. Given the current low levels of productivity in Myanmar and Africa, the competitiveness of production in Australia could be significantly impacted by improvements in agronomy, harvest and storage in those countries that could dramatically increase total production and stability of supply.

Initial trials of sesame in north Queensland have been promising. Trials of new non-shattering lines at Fairview Station gave preliminary yields of 2.5t/ha with estimated gross margins of $2,400/ha if priced at $1,300/t (Matchett, 2016; Matchett, 2017). Sesame, as a rotational crop in some production systems clearly has potential but it is less certain that it can become a primary cash crop on significant area. Its potential possibly lies as a high value rotational crop in farming systems where the primary cash crop is more traditional (cotton, sugarcane or grain/hay) and sesame can be planted either as a spring or summer option to provide production flexibility. The constraint to including it in a rotation is that sesame requires about 90 to 120 frost-free days for development and temperatures below 20°C result in lower yield and growth (Decker and Kurnik, 2018).

SAFFLOWER
GO Resources[133] has been conducting trials of genetically modified, super high oleic (SHO) safflower in north Queensland for three years in a joint program with CRCNA. Trials have been ongoing in the Ord for six years. Trials have focussed on basic agronomy to determine planting date to maximise yield (April), nutrition and herbicide options. GO Resources believe the most appropriate fit will be as a rotational crop in cotton or sugarcane to break up hard set clay soils. Safflower has previously been utilised in this role in the cotton growing regions of northern NSW.

Trials at Fairview Station in north Queensland have been successful with safflower identified as potential rotational crop to extract water remaining at depth after other crops (Matchett, 2017). Trials of safflower on a national basis have averaged 3t/ha for the newer varieties with a farm gate price expected to be $650/t +/- $50/t. The low variability in price arises as SHO safflower price is related to the trading price of oleic oils, not soybean vegetable oil (which impacts canola price). Oleic oils are attracting prices in the range of $2500-$3000/t on a raw oil basis. GO Resources is interested in northern production in the contra-season (plant April harvest September) to supplement production further south to ensure continuity of supply as the industry is established.

While a potential niche option as a rotational crop the potential for safflower production, like most other crop commodities, is significantly constrained by transport costs. Given the high value of the oil, solvent extraction is preferred with the closest crushing facility of scale and capability located at Newcastle. Crushing capacity in the north would seem essential to underpin safflower production at scale.

SOYBEAN
Soybean has historically been grown in north Queensland as a rotation crop to sugarcane, either for grain or as a green manure. Crop rotations have become an important part of managing Sugarcane Yield Decline that occurs from poor soil health associated with monoculture production. Breaking the monoculture through the introduction of suitable fallow crops has increased cane yields by up to 15-20% in trials[134]. Adoption in the past has been constrained by limited access to appropriate planting and harvesting equipment. However,

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131 G. Wright – Peanut Company of Australia *Pers Comm.*

132 Market analysis of sesame seed. https://crcna.com.au/sites/default/files/2020-02/200111%20Sesame%20Market%20Analysis.pdf

133 D. Hudson – R&D Manager GO Resources *Pers. Comm.*

134 http://www.australianoilseeds.com/__data/assets/file/0013/1192/Catherine_Charleston-Adoption_of_Soybeans_as_a_Rotation_Crop_in_Far_North_Queensland.pdf

in the Burdekin the number of headers in the area has recently risen from two to 19[135] indicating that growers are making capital purchases and/or generating sufficient demand to warrant investment by contractors. Traditionally, the crushing sector has been the main market for soybeans in Australia. Until the late 1990s, over 50% of the typical 80-100,000 tonne crop was crushed. A further 20 - 25% went into full fat soybean meal for intensive livestock feed. Since the early 2000s, the percentage of the crop for crush and full fat sectors has declined in importance driven by the higher returns from the culinary market. The crush sector still provides an important safety net and fall back for edible grade soybeans that fall short of culinary standards. Soybean grown for culinary use in Australia is of the clear hilum type and utilised predominately in the domestic market. Export figures are difficult to obtain but major current and potential markets are in Japan, Korea, Taiwan and other SE Asian countries. The price of culinary soybeans is based off the global soybean commodity price (for oil) plus a premium of approximately $100/t. Further premiums of $50-$100/t for speciality grades are often negotiated with individual traders[136].

Gross margins for irrigated soybean average around $800/ha based on a 3t/ha yield @$475/t and variable costs of about $600/ha[137]. Gross margins extend beyond $1,200/ha if the current price of $700 is applied but this is expected to decline as production from southern regions re-establishes after drought. Most of the initial soybean production is in rotation with sugarcane where the cost of irrigation is already sunk. As a rotation, their value lies in the benefit they bring to sugarcane production as well as the cash return in their own right. Extensive information from numerous R&D projects supporting soybean production is available[138][139][140]. However, there remains some issues with extension and adoption of best practices to exploit yield potential. In addition, there is variable experience in how to maintain quality in storage and access to agronomy advice across the north remains an issue.

Farm Inputs, Capacity and Infrastructure

Farm chemical inputs will be focussed on nutrition and pesticides as well as some crop specific chemistries such as plant growth regulators in the cotton industry. Most crops will require the major nutrients of phosphorous, nitrogen and potassium as well as zinc and sulphur and potentially other trace elements. It is estimated that 200kg/ha of nitrogen application is required to maximise cotton production at 10 bales/ha (Yeates *et al*., 2013). 60 to 80kg/ha of phosphorous is likely to be required for irrigated cotton (Duggan *et al*., 2007).

Incitec Pivot maintains a primary fertiliser distribution centre in Townsville. Nutrien, Elders and CRT all maintain a presence across north Queensland although most emphasis is on cattle supplies in NW Queensland and Burdekin/Atherton Tablelands focus on sugarcane and horticulture. The silica-based fertiliser producer AgriPower, that has a processing plant at Charters Towers, announced a $663m expansion in 2019 that has received prescribed project status from the Queensland Government.[141] Feedback suggests that access to farm inputs is not necessarily limited but they must be transported from the south or coast, adding to cost.

Access to professional broadacre crop agronomy and farm system advice is currently limited. The emerging nature of the broadacre industry is not a strong incentive for established businesses to push north. However, Chris Radford, an agronomist from northern NSW is providing a service in the Flinders and Gilbert catchments and further agronomic support for broadacre cropping is available at Emerald. Tony Matchett provides broadacre advice in the Mitchell catchment and further north.

The availability of machinery across north Queensland varies with crop, location and property type. Growers in the Burdekin are cropping relatively small areas that possibly do not warrant dedicated cropping machinery. Until recently, access to machinery such as headers has been an issue but as cropping has grown in importance access to headers has increased from just two in the region to 19 last season. Some of

135 B. Dembrowski – DAF *Pers.Comm*.

136 http://www.australianoilseeds.com/__data/assets/pdf_file/0005/8177/Industry__and__Market_Review_2011.pdf

137 https://agmargins.net.au/Reports/Index#

138 https://sugarresearch.com.au/wp-content/uploads/2019/02/Soil-Health_Burdekin-Soybeans-Info-2018_D.01.pdf

139 https://grdc.com.au/resources-and-publications/grownotes/crop-agronomy/soybeansgrownotesnorthern

140 http://www.australianoilseeds.com/__data/assets/pdf_file/0010/7669/Queensland_Soybean_Grower_Guidelines.pdf

141 http://statements.qld.gov.au/Statement/2019/5/23/new-nq-fertiliser-mine-could-have-200year-life

the large growers in the NW have purchased and designed their own machinery to suit their needs. For these growers, access to dedicated mechanics and technicians is more of an issue than access to the actual equipment. Specialist equipment such as cotton pickers and peanut harvesters are expensive, $1.25m for a cotton picker, and while some producers could potentially grow large enough areas of crop to warrant their purchase, growers with smaller areas will likely be reliant on access to contract service providers. In common with access to specialist agronomists, access to contactors and/or equipment technicians will require sufficient scale to attract these services to a region.


Safflower. Photo: David Hudson, SGA Solutions


Early plant soybean variety trial, Walkamin FNQ. Photo Savannah Ag Consulting

QUEENSLAND – Flinders River Catchment

Environment

CSIRO completed an assessment of the Flinders catchment as part of the north Queensland Irrigated Agriculture Strategy (CSIRO, 2013a) and their observations are summarised here. The Flinders River catchment extends for 109,000 km^2 from Hughenden in the south east westward to Cloncurry and north to Karumba (**Figure 18**).

The catchment receives an annual mean rainfall of 492mm with significant variability from 800mm on the west coast to 350mm in the south of the catchment. Potential cropping areas around Richmond, Hughenden and Cloncurry have average annual rainfalls in excess of 450mm (CSIRO, 2013a).

Rainfall patterns allow for reasonably accurate predictions of available water that can assist cropping decisions but there are limited options available for dryland production when rainfall is predicted to be below average. It is most likely that dryland cropping, while a potentially important part of a production system, will be opportunistic.

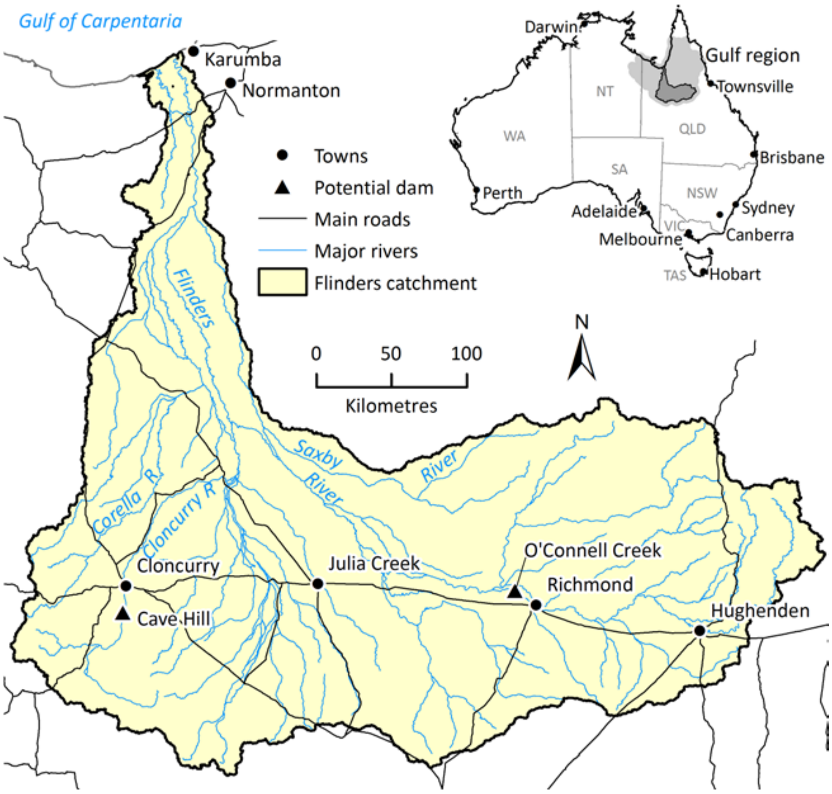

Figure 18 Flinders catchment map. Source: CSIRO (2013a)

CSIRO predicts that break-even yields in a dryland production system might be achieved eight years in ten for mungbeans but only two in ten for chickpeas and sorghum and only one year in ten for cotton and maize which precludes commercial returns on development costs (CSIRO, 2013a). Despite this, impressive dryland yields of both sorghum and chickpeas have been reported. The highly variable nature of dryland cropping also introduces continuity of supply risks for downstream processors and exporters. An important aspect of future work should be to engage with growers in the area to establish the actual experienced yields associated with a range of crop production systems (both irrigated and dryland) in comparison with modelled yields. Enhanced possibilities of successful dryland production in the catchment in particular could fundamentally impact the expansion of cropping. 83% of rainfall occurs in the wet season (**Figure 19**). Rainfall patterns are characterised by extended inter-year periods of above or below average rainfall (highly variable across seasons).

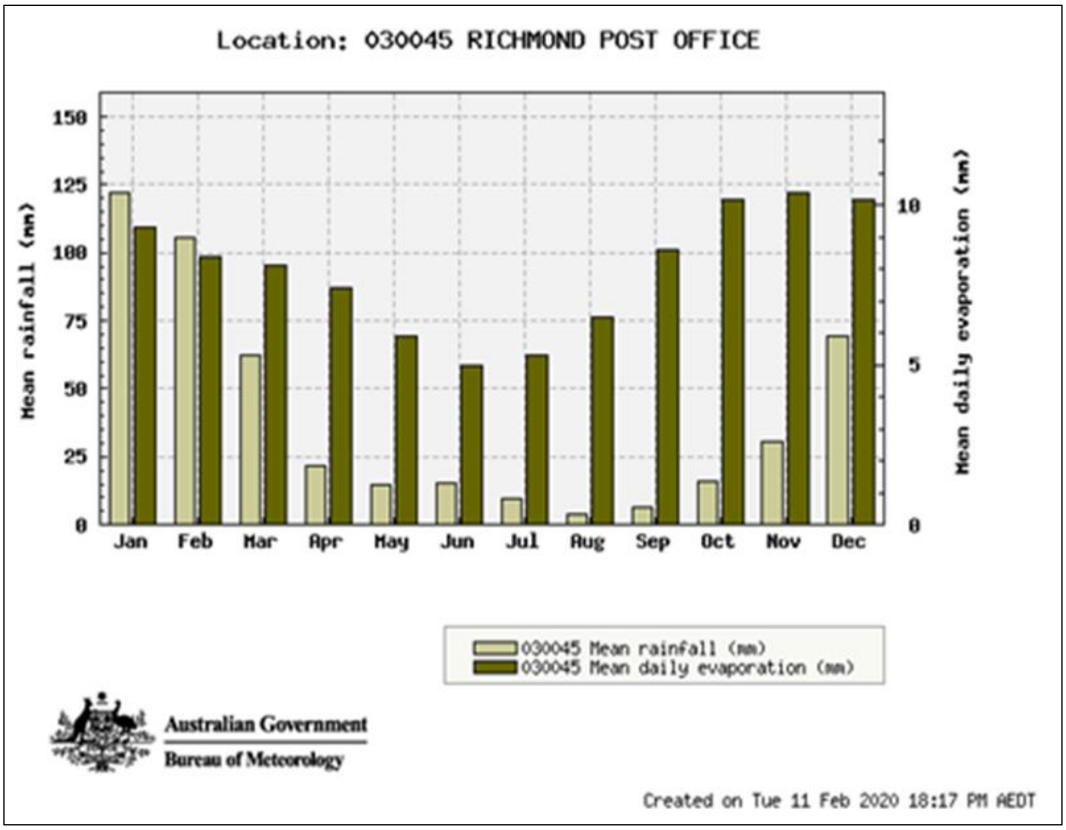

Figure 19 Mean rainfall and evaporation - Richmond, Qld. .Source: BOM

Very high evaporation potential in the dry season exceeds rainfall in most years. Given the limited options for in-stream storage, the high evaporation rate could have a significant impact on water availability and water use patterns from relatively shallow on-farm storage infrastructure. However, early use of water in the dry season would see the impact of evaporation minimised as most water would be applied prior to the high evaporative months between September and December.

The dominant soil of the catchment is black cracking clay (**Figure 20**). They store relatively large amounts of water suitable for production of a range of annual crops but are susceptible to secondary salinisation (salinity issues associated with human activity). Previous assessments indicate that the cracking clays of the Mitchell Grass plains are moderately suitable to irrigated broadacre cropping (Turner and Hughes, 1983). The CSIRO agricultural assessment for the Flinders suggests that the alluvial soils adjacent to the Flinders and Cloncurry rivers are most suitable for agricultural production being less prone to salinity and having moderate to high nutrient levels (Petheram *et al.,* 2013a). The black clay soils of the Flinders catchment are suited to the development of on-farm water storage and furrow irrigation but have issues with trafficability when wet that can limit the timely undertaking of farm operations necessary to maximise yield and quality. Overall, CSIRO predicts that farm dams in the Flinders catchment could support 10,000-20,000ha of irrigation in 70 to 80% of years (CSIRO, 2013a).

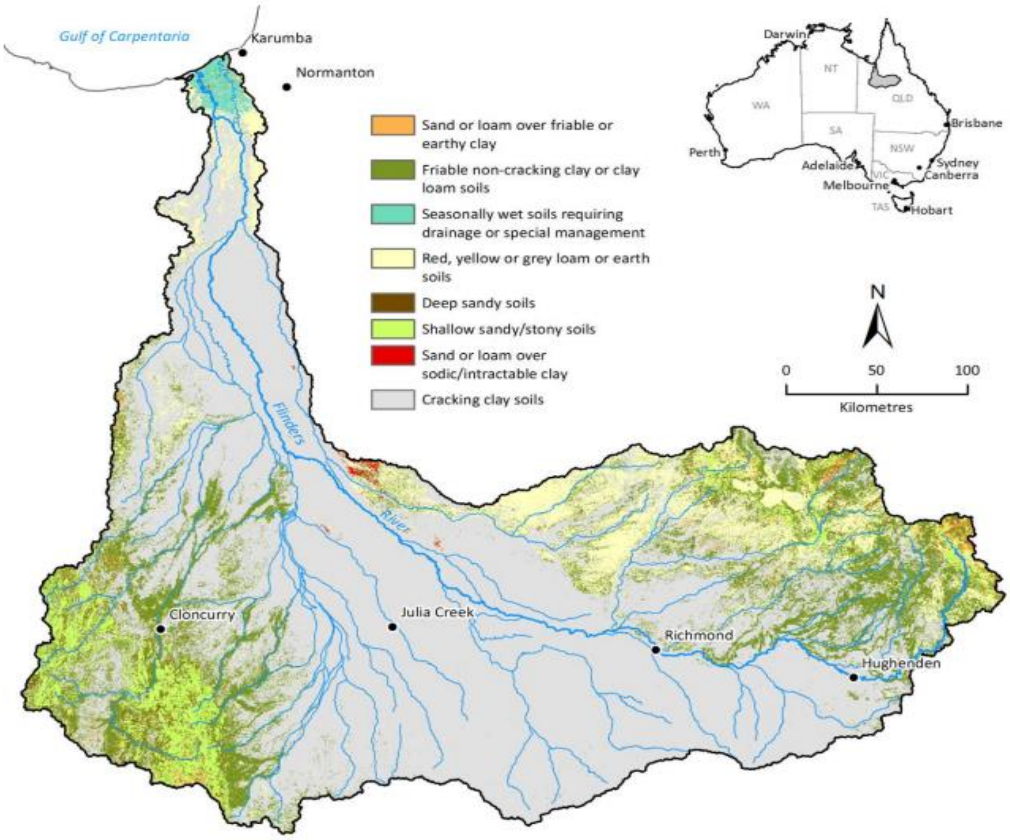

Figure 20 Soil generic group map. Source: Petheram et al (2013a).

WATER

Water tenders were offered in Flinders River catchment in 2012 and 2015[142]. Allocations were restricted to 12ML/ha of available land. 80,000ML of unsupplemented (not from dams) surface water was offered in 2012 and attracted significant attention with 18 tenders lodged for a total of 333,880ML. The entire 80,000ML was allocated to three successful bids as follows:

1. 28,800ML @ $49.82/ML for proposed irrigation of forage sorghum, rye grass, Rhodes grass, grains and lucerne.
2. 32,000ML @ $31.00/ML for proposed irrigation of cotton and complementary crops including chickpeas, soya bean, mungbeans, faba beans, other broad acre crops and rice.
3. 19,200ML @ $30.00/ML for pulse crops (chickpeas and mungbeans) and broadacre crops including cotton.

In 2015, the Queensland Government offered 264,550ML of unallocated surface and overflow water for irrigated agriculture. The water was offered in the Flinders, Norman, Nicholson, Gregory and Leichardt catchments at a minimum reserve price of $45/ML. Water offered in the Flinders in 2015 was split into two products with differing flow thresholds for accessing water. Products were further defined by reach (defined sections of catchment). A total of 112,500ML was allocated to seven successful bids with one applicant subsequently declining the allocation such that a total of 92,500ML was allocated. All applicants declined to allow details of the bid (including location and proposed use) to be made public. Prices of successful bids ranged from $55-$125/ML. In summary, the 2015/16 process allocated:

142 Water Resource (Gulf) Plan (2007) Sale of unallocated water-2012: Tender assessment report. Department of Natural Resources and Mines, Qld.
https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/unallocated-water/completed-processes

1. 6,000ML @ $100.00/ML in reach 1 (product 1)
2. 12,000ML@$100.00/ML in reach 1 (product 1)
3. 4,500ML @ $55.00/ML in reach 2 (product 1)
4. 12,500ML @ $125.00/ML in reach 4 (product 1)
5. 50,000ML @$105.00/ML in reach 3 (product 2)
6. 7,500ML @ $105.00/ML in reach 4 (product 2)

While a total of 92,500ML was allocated, the product constraints on threshold flows mean that not all water will be available in all years. For example, the 50,000ML of product 2 water in reach three will only be accessible when "the flow in the Cloncurry River at Canobie GS915212A exceeds 10 000 ML per day. Despite this, each time the flow exceeds 10,000 ML per day in the period 1 January to 31 March, taking water may only commence after the first peak flow passes the gauge. Taking water may then continue until the flow falls below 10 000 ML/day". Daily limits of 14% of allocation also apply[143].

A further 5,000ML was allocated from the Leichardt River and 2,500ML from the Gregory River in 2015. 7,500ML was made available from the Cloncurry River in July 2017[144] and has been fully subscribed with tender assessment still ongoing. Further allocations from the Flinders River have not been made. Review of water resources through the Queensland Government water entitlements[145] indicates that a further 139,650ML of unallocated surface water in the Flinders catchment is held in general reserve and 15,700ML in strategic reserve. A further 3,000ML in the Norman catchment (to the north) is held in general reserve and 1,000ML in strategic reserve. There is limited access to groundwater reserves in the Flinders catchment

CSIRO estimates that, from total allocations of 350GL (actual numbers closer to 320GL), approximately 50% could be available in 70-80% of years (CSIRO, 2013a). Feedback indicates that a major constraint to broadacre development in the Flinders catchment is access to adequate volumes of water to sustain the risk associated with investment required to establish irrigated production. A lack of transparency in the process for allocation of water and setting reserve prices is a particular frustration of a number of growers.

LAND

Land resources in the Flinders catchment are dominated by freehold and large leaseholds of pastoral country (**Figure 21**) issued under the *Land Act 1994*. Parts of the landscape are subject to Native Title claims and Agreements and several Indigenous Land Use Agreements have been negotiated with various parties

Searches of the Queensland Government remnant vegetation maps[146] shows most of the land in the Flinders catchment is classified as category B.

Several landholders in the catchment have submitted PMAVs to correct inaccuracies in land and ecosystem categorisation. Ongoing updates to PMAVS are available but come at a cost.
The experience of at least some growers is that officials are more intent on applying the technicalities of regulation than working with growers to identify and deliver workable solutions for development.

143 Water Resource (Gulf) Plan 2007 : sale of unallocated water: tender assessment report https://qldgov.softlinkhosting.com.au/liberty/opac/search.do?queryTerm=WRUNALLOCATED&mode=ADVANCED&undefined=undefined&modeRadio=KEYWORD&operator=AND&activeMenuItem=false#

144 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0006/1279761/public-notice-gulf-sale-unallocated-water.pdf

145 http://qgsp.maps.arcgis.com/apps/MapSeries/index.html?appid=610e67fd52e24dbf9168ed812137ff5c

146 https://qldglobe.information.qld.gov.au/

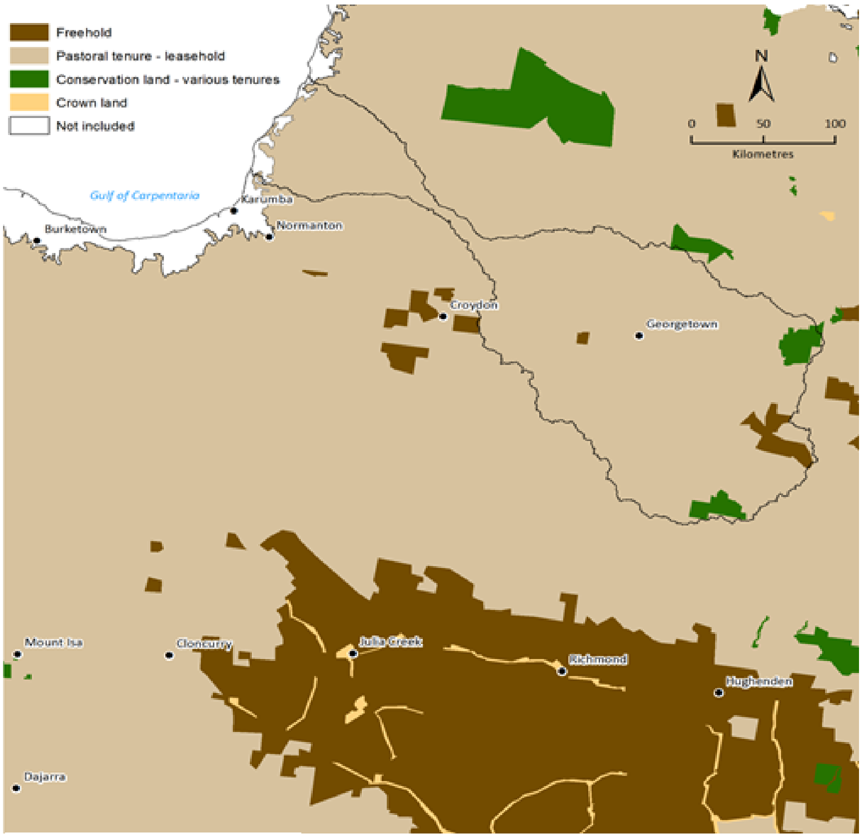

Figure 21 Area categorisation. Source: CSIRO (2013a)

Current and Potential Business Models

A number of operators have been producing irrigated and dryland crops successfully over an extended period including chickpeas, sorghum, lucerne, forage, mungbeans and cotton. The Tritton family has grown irrigated crops at Silver Hills for several decades including cotton, maize, mungbeans, forage and grain sorghum and has built 5000ML of storage (using wet season flood waters diverted from the Flinders)[147]. In 2016 they grew 5200t of forage sorghum on 130ha of irrigated land, with an exceptional yield of 40t/ha. Forage sorghum was silaged for feeding cattle on farm as part of a wider drought proofing strategy[148].

Most current, smaller scale crop producers identify that their skills are based predominately in cattle production and they have therefore collaborated with croppers from further south. Examples include the joint dryland cropping efforts of Dicksons from Warren, NSW with McClymonts that saw 2,800ha planted to chickpeas and 160ha of forage sorghum established on a full moisture profile as flood water receded in 2019[149]. Chickpeas yielded 1.4t/ha which compares favourably with yields in established chickpea production areas where site mean yields from National Variety Trials (NVT) ranged from 1.15t/ha in Roma to 2.87t/ha in Emerald[150]. Chickpea NVT trials planted on 5 February 2019 had a site mean yield of 1.61t/ha[151]. Forage sorghum production is utilised as a substitute to hay transported from further south and stubble is grazed[152].

The Flinders River catchment undoubtedly has significant potential for irrigated and dryland cropping and the model of attempting to attract cropping expertise from the south has been in place since at least 2015

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147 https://www.beefcentral.com/property/weekly-property-review-water-opening-the-potential-in-northern-australia/

148 https://www.abc.net.au/news/rural/2016-05-03/record-harvest-helps-drought-proof-property/7380592

149 https://www.northqueenslandregister.com.au/story/6414364/monsoon-disaster-yields-opportunity-chickpea-crop/

150 Queensland variety sowing guide 2019. https://www.nvtonline.com.au/wp-content/uploads/2019/04/NVT_Qld_VarietySowing_Guide_2019.pdf

151 https://www.nvtonline.com.au/nvt-results-reports/

152 https://www.northqueenslandregister.com.au/story/6444393/forage-sorghum-gamble-pays-off-in-north-west/

through the Flinders River Agricultural Precinct (FRAP) a joint initiative of local shires, Mt Isa-Townsville Economic Development Zone (MITEZ) and the Queensland Government. In 2015, nine properties across the catchment identified the opportunity to diversify production through irrigation based on suitability of soil, access to water and feasibility of extraction, and availability of land that is not prone to flooding. These pastoralists actively sought partners to grow a range of crops including cotton, rice, sugar, mungbeans, soybean, chickpeas, maize, hay, grain sorghum and forage sorghum [153] (**Table 5, Figure 22**).

Table 5 Flinders catchment irrigation tender

Property	Tendered Water (2012)	Proposed Irrigated Farming (ha)	Proposed Dryland Farming (ha)	Land Tenure
Bow Park	20,000ML	1,011-2,000	5,000	Leasehold
Consentes Station	25,000ML	2,500	1,500	Grazing homestead perpetual Lease
Dunluce Station	5,500ML (750ML bore)	530 (40ha in place)	1,000	Freehold
Etta Plains	32,000ML	9,500	10,000	Freehold
Expressman Downs	12,000ML	1,000-1,500	Nil	Perpetual Lease
Glenmoan	5,720ML	530-900	800-1,100	Freehold
Longview	5,000ML	600	Nil	Freehold
Saego Plains	6,000ML	500-1000	Nil	Perpetual Lease
Sutherland	6,000ML (have 500ML bore)	1,000	1,500	Freehold

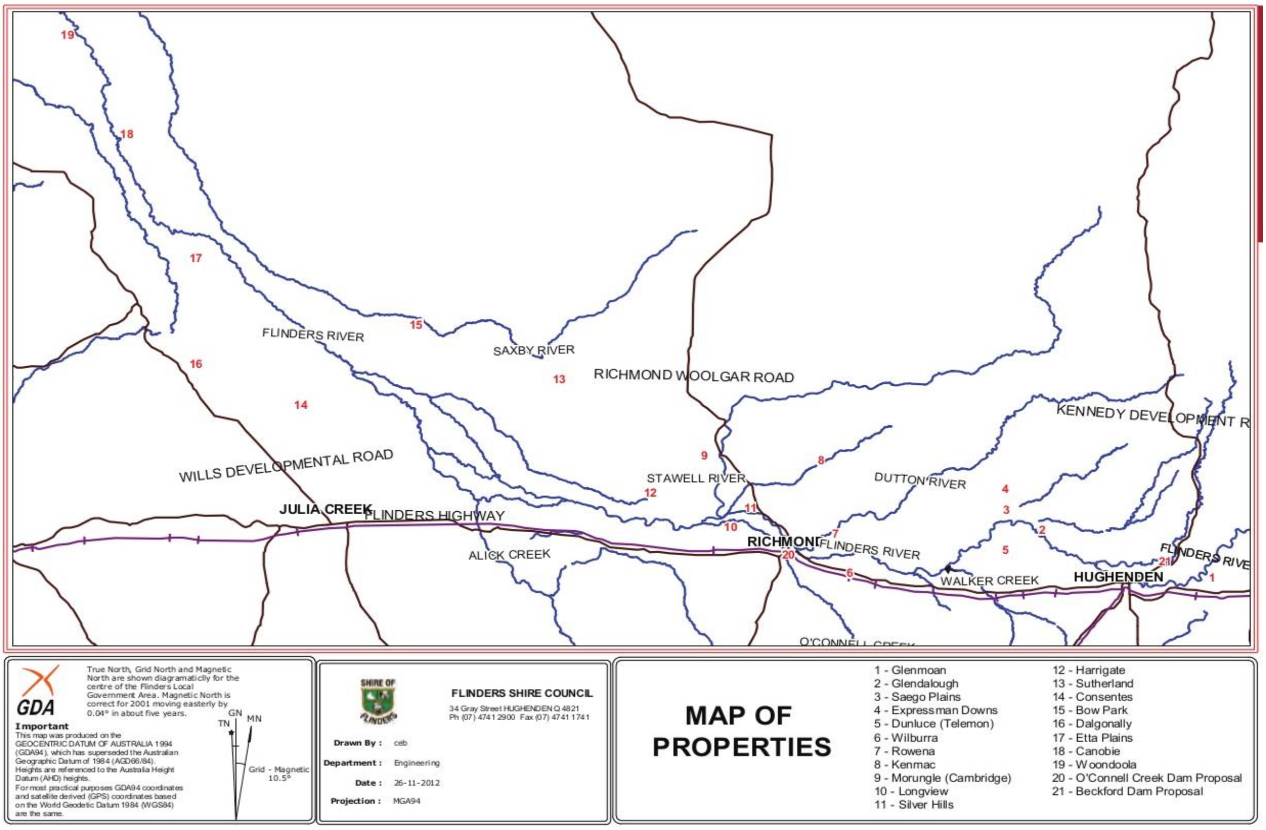


Figure 22 Map of properties in Flinders catchment

153 Flinders River Ag Precinct Investment Profile. https://www.slideshare.net/SaraWestaway/frapinvestmentprofiledaff170915

A significant number of properties have irrigation plans and soil profiling in place. Etta Plains was sold to Findlay Farms (Narrabri) with 39,500ML water licences in November 2019. Findlay has not yet determined what crops will be produced and will be undertaking a trial program to look at options.[154]

In comparison with the published water allocations, it must be concluded that many of the tenders submitted by properties in the 2015 FRAP investment plan were not successful in obtaining water allocations in 2012. As all applicants declined to have details of their bids published in the 2015 round of water allocations, it is difficult to determine which, if any of the above received water under that process.

Current developments in the upper Flinders include the 15-mile irrigation project, Hughenden Irrigation Project and recently announced Richmond Agricultural Project[155]. The 15-mile irrigated agriculture project was proposed by the Flinders Shire[156] and approved in July 2019. The project outlines a high value irrigated agriculture development on the banks of the Flinders River 12km from Hughenden with 2,250ML of off-stream storage supporting an overall 3,395ML irrigation capacity on an initial 150 ha that is expected to include 75 ha of citrus, 50 ha of table grapes and 25 ha of avocado crops[157]. The project does not include broadacre cropping at this stage but the acceptance of the impact assessment report and approval of the project, including limited vegetation clearing, is a positive indicator for other projects.

The Hughenden Irrigation Project (HIP) is a proposed $300m irrigation scheme based on the establishment of a dam on Saego Plains Station north west of Hughenden. The project has secured a $180m commitment from the Federal Government[158] and has recently completed a preliminary business case that has been submitted to Federal and State Governments. HIP entails diversion of water from the Flinders River to an off-stream natural storage site with 200GL capacity and a depth of 14m at its deepest point, potentially reducing the amount of water lost to evaporation. Of 200GL, approximately 80GL could be made available on a reliable basis, with the proponents suggesting this could be allocated to high value horticultural production and broadacre cropping[159]. The potential establishment of an abattoir and feedlot in the area would require access to water and could also make use of available water for fodder production. HIP is yet to undertake a formal impact assessment, awaiting response on the business case before proceeding. Despite, the relative infancy of the project, the biggest potential constraint is already apparent, being the ability to secure the water licenses required to underpin the development.

While much of the development of the Flinders River catchment has most recently focussed on the upper catchment, the largest development proposal in the area was made by Stanbroke Pty Ltd for a 15,000ha cotton farm and associated gin located in the lower catchment at the junction of the Flinders, Cloncurry and Saxby Rivers. Total cost of the project would have exceeded $200m and returns were based on the sale of cotton lint from the gin and the use of cottonseed as supplementary feed to the existing beef cattle enterprise. The project required the allocation of 150GL of water extracted from the river system as well as from overland flow into off-stream storages[160]. The initial advice statement for the project was prepared in June 2015. Following a protracted negotiation process, the project lapsed in early 2019[161].

154 https://www.northqueenslandregister.com.au/story/6486760/etta-plains-sale-starts-nw-irrigation-era/

155 https://www.beefcentral.com/property/weekly-property-review-water-opening-the-potential-in-northern-australia/

156 http://eisdocs.dsdip.qld.gov.au/15%20Mile%20Irrigated%20Agricultural%20Development/Final%20IAR/15-mile-irrigated-agricultural-development-project-iar.pdf

157 http://eisdocs.dsdip.qld.gov.au/15%20Mile%20Irrigated%20Agricultural%20Development/CGER/15-mile-irrigated-agricultural-development-coordinator-generals-evaluation-report.pdf

158 https://www.abc.net.au/news/rural/2019-10-09/hughenden-irrigation-project-launched-but-questions-remain/11581872

159 S McCarthy, Chair Hughenden Irrigation Project *Pers Comm.*

160 https://www.statedevelopment.qld.gov.au/resources/project/three-rivers-irrigation-project/three-rivers-irrigation-project-ias.pdf

161 http://www.statedevelopment.qld.gov.au/coordinator-general/assessments-and-approvals/coordinated-projects/projects-discontinued-or-on-hold/three-rivers-irrigation-project.html

Constraints and Opportunities

Despite the numerous and ongoing initiatives for irrigated agricultural production in the catchment, feedback suggests that progress of development has largely been restricted due to:

1. High levels of uncertainty associated with the release of water and the probability of securing licenses of sufficient volume to underpin the costs and relative risk of investing in capital works required to capture, store and utilise water. Historically, releases have been limited in volume and made available on a tender basis. The approach meets the probity requirements of government and the volumes provide a buffer to allow alterations for environmental or further irrigation needs. However, the approach has made it difficult for growers to aggregate sufficient water allocation to make participation in storage and irrigation feasible at scale. The lack of transparency in the planning processes that determine water allocation has also been highlighted as a concern.

2. Lack of access to agronomy and machinery skills. The relatively large distance between properties, and the distributed nature of water allocations, means that a core of broadacre growers is yet to form. A critical mass of growers is required to encourage agronomists and other specialists (e.g. machinery sellers and repairs etc) to permanently establish a presence in the region.

3. No peer-to-peer learning. Participatory learning is recognised as on one of the most effective methods of extension of R&D knowledge and a lack of a local grower group will have a direct impact on the adoption of R&D outputs (Kuehne *et al*., 2017). The lack of a critical mass of growers in the region makes establishment of grower groups for peer learning complicated. The lack of grower groups also makes it difficult to identify R&D priorities that are determined by growers based on production costs, risks and returns. The current CRCNA projects run by QAAFI, DAF and Savannah Ag are addressing this through regular interaction with growers but the lack of a formal grower base means that these structures are likely to dissolve with the end of the current projects. The Far North Queensland Sustainable Cropping (FNQSC) Group has the potential to be an appropriate grower representative body to advise on constraints and opportunities in future but is in its infancy and will require broader grower engagement and support to develop.

4. Research and development are constrained by the large distances support staff and equipment must travel. Utilisation of grower equipment and resources can go some way to addressing basic trial constraints but cannot come at the expense of commercial operations. In addition, measures on crop physiological development etc require trained staff that currently travel from the coast, Tablelands or southern Queensland.

5. Access to post-farm processing and export. Transport of product to post farm processing or export has a significant adverse impact on gross margin. The nearest cotton gin is at Emerald. While the Port of Townsville is currently undergoing a major expansion and ADM is establishing a presence, export opportunities for pulses are currently limited. CQ Commodities recently led a tour of growers with ADM exploring the options for broadacre cropping and export from Townsville. Food grade soybean must be transported to either southern Queensland or northern NSW for processing and the lack of crushing capacity requires transport of oilseeds to be transported south. A cost that impacts the viability of even high value oilseeds (such as SHO safflower). In a typical catch-22, investment in processing and storage facilities requires consistent supply which is constrained by a lack of production associated with the lack of processing and storage.

6. Poor road and rail infrastructure quality that is addressed on an *ad hoc* basis through a series of relatively inefficient upgrades to small target areas results in a lack of overall improvement in the road network in particular.

7. Local adaptation of varieties that contribute to an integrated farming enterprise, most notably the need for adapted sorghum varieties for fodder production.

Constraints Summary

CONSTRAINT	
Crop Genetics	Development of dryland production management guidelines for the northern environment. Development of cropping systems that accommodate potential double cropping and the integration into whole of farm enterprise management (e.g. integration with cattle operations). High cost and low efficiency of research and development trials due to the large transport distance involved. The importance of planting on time to hit the window that allows land access while maximising yield potential is a key to successful production and requires further development and extension. Access to peer to peer learning mechanisms e.g. farming systems groups.
Environment	Establishment of clear and consistent policy settings based on a joint vision for the development of agriculture.
Market and Value Chain	Access to a regional cotton gin would substantially improve gross margins and NPV on irrigation developments. Access to pulse processing and export facilities at Townsville. Evaluation of integrated enterprises based on crop, cotton and beef production to maximise returns and support sustainability. A need to improve road networks rather than maintenance on an *ad hoc* basis.
Farm Inputs, Capacity and Infrastructure	Investigating irrigation systems that lower the cost of inputs and capital. Building cropping knowledge and capacity in pastoral operations in a farming system context that maximises return across enterprises. Access to knowledgeable agronomists for broadacre cropping. Access to trained labour when required both for farm operations and to support R&D.

QUEENSLAND – Gilbert River Catchment

Introduction

The Gilbert River catchment is dominated by cattle production on a mixture of freehold and pastoral leaseholds. The potential for diversification of agricultural production in the region has been identified for some time with numerous reports prepared for the Queensland and Federal Governments. Initial investigations in the 1990s supported the establishment of the joint State/Federal North Queensland Irrigated Agriculture Strategy (NQIAS) in 2011.

An assessment of the cropping activities in the area in 2009 identified 200ha of mango production, 70-150ha of peanuts, 7-150ha of other broadacre cropping and 150-200ha of hay and fodder production (Mason, 2009). These figures were revised in 2014 indicating an increase of fodder production to1800-1950ha.[162] Significant potential for expansion of high value horticultural production has been identified[163] and broadacre irrigated cropping developments would need to be assessed against these to determine the best return per ML of water and overall return on investment. Opportunistic dryland production will be an important aspect of an integrated farming system and significant areas of dryland production are being brought into production where land clearing has been permitted. Growers in the region have been trialling numerous crops including cotton, mungbean and peanuts on expanded areas and the production knowledge they have gained, and continue to develop, will be a key driver of potential cropping in the region.

The principal requirements for development of a broadacre cropping system in the Gilbert catchment are access to land and access to water, capital and a broad understanding of the farming environment.

Environment

Characterisation of the Gilbert River catchment and assessment of agricultural potential was completed by CSIRO in 2013 (CSIRO, 2013b) and is summarised here.

The Gilbert River catchment extends for 46,000 km^2 from south east of Georgetown, north west to the north to Karumba (**Figure 23**). One to two million hectares of the Gilbert catchment is classified as moderately suitable for cropping, but the actual area is restricted by the availability of water and a range of production factors.

A potential total of 20,000 to 30,000ha of year-round irrigated and dryland cropping has previously been identified (Petheram *et al*., 2013b) but the actual potential area is difficult to determine as the potential impact of dryland cropping is unclear.

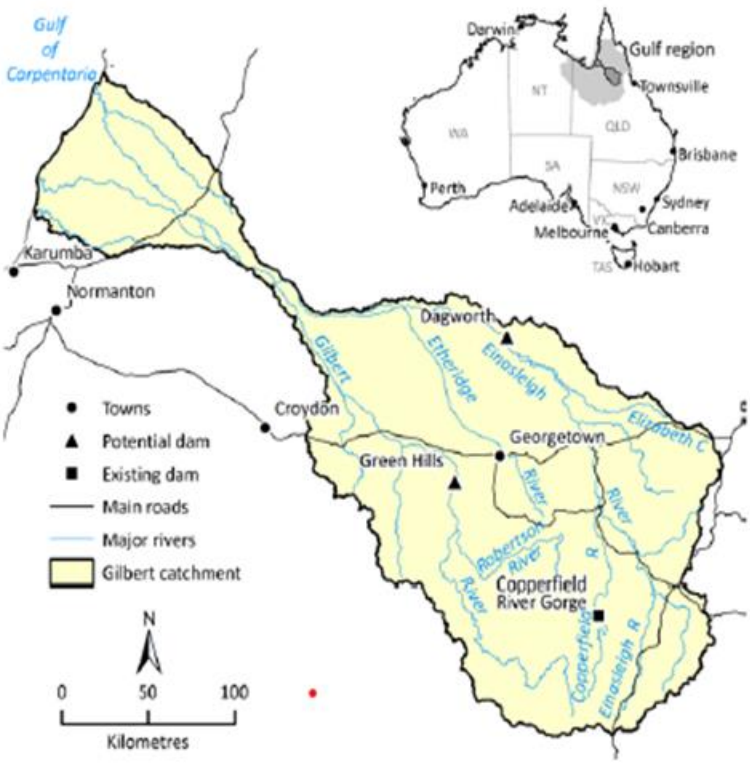


Figure 23 Gilbert Catchment map. Source: CSIRO (2013a)

162 https://www.etheridge.qld.gov.au/downloads/file/207/gsdgil-1-pdf

163 Australians for Northern Development & Economic Vision submission to Australia Parliamentary inquiry into Development of Northern Australia https://www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=jscna/subs/sub0147%20attach%20c.pdf

The catchment receives an annual mean rainfall of 775mm with a significant rain gradient from a mean of 1050mm on the west coast to 650mm in the south east part of the catchment. 93% of rainfall occurs during the wet season (**Figure 24**) but is highly variable across seasons (CSIRO, 2013b).

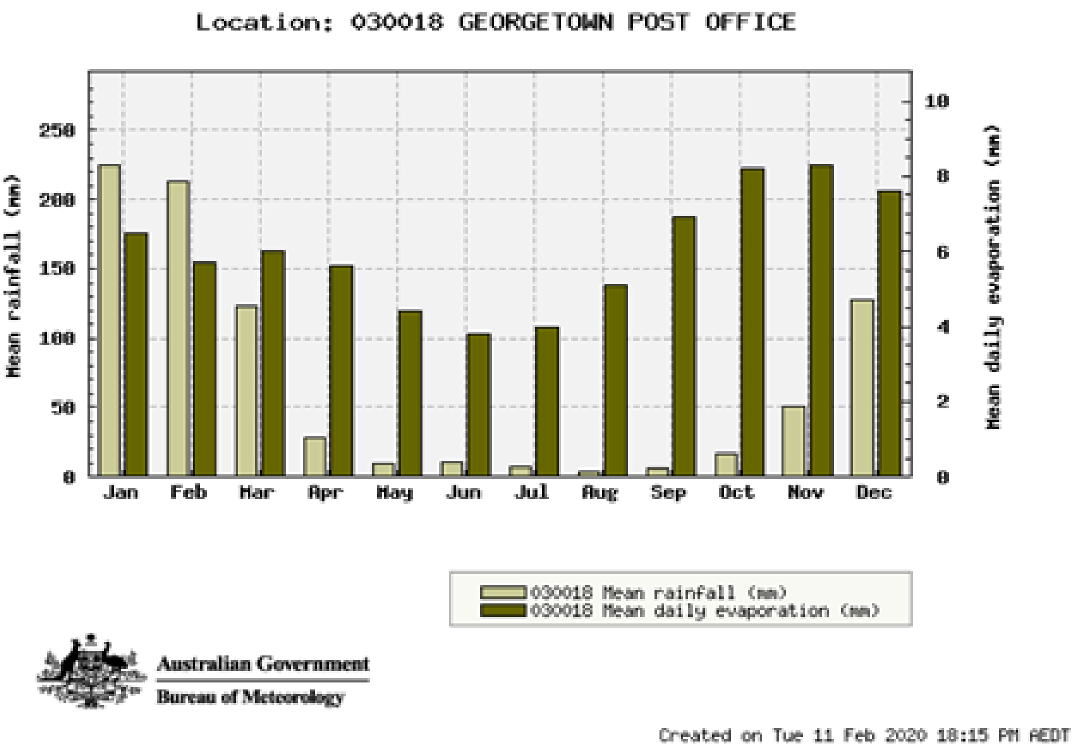


Figure 24 Mean rainfall and evaporation - Georgetown.

Rainfall patterns allow for reasonably accurate predictions of available water in dryland cropping systems that can assist decision making but there are limited dryland cropping options available when rainfall is below average. CSIRO predicts that break-even dryland yields of most crops can only be achieved two-three years in ten which precludes commercial return on development such as land clearing. However, the modelling suggests a very broad range of returns across crops and seasons. Modelling suggests dryland production of mungbeans are expected to generate break even yields more than nine years in ten. This declines to three years in ten for grain sorghum and less than three years in ten for cotton and maize. Feedback received suggests that modelled yield for dryland production may be conservative with growers successfully producing a range of crops including mungbean, sorghum and cotton over a number of years. An important aspect of future work should be to engage with growers in the area to establish the actual experienced yields associated with a range of crop production systems over a number of years. Enhanced possibilities of successful dryland production in the catchment in particular could fundamentally impact the expansion of cropping.

Off stream water storage is limited by the sandy soils that are less suitable to ring tanks although there are areas where on-farm storage could be achieved. Again, consultation with local landholders that have in-depth knowledge of the environment and landscape to confirm previous assumptions will be important. Very high evaporation potential exceeds rainfall in most years (**Figure 25**) impacting off-system water storage although, for many crops planted in January or February, the application of irrigation would see most water utilised prior to the months of maximum evaporation. There is little apparent logic to attempting to store water over seasons on farm.

Two potential dams, at Green Hills and Dagworth, would have the capacity to deliver 250GL of irrigation water in 85% of years. This would be sufficient to irrigate 20,000 – 30,000 ha of the two million hectares of potential arable land. Dagworth dam is estimated to cost $475m to construct and would yield 326GL in 85% of years of which approximately 50% would be lost in transfer. Likely cost of water at the dam wall would be $1450/ML.

Green Hills dam would cost approximately $335m to construct and would yield 172GL in 85% of years of which approximately 15% would be lost in transfer. Likely cost of water at the dam wall would be $1950/ML. Under these costings, it is unlikely that a cropping system could generate returns to cover the high capital costs of combined investment in water assets and irrigated farming.

Soils in the Gilbert River catchment are highly variable ranging from cracking clays, shallow sands to predominately sandy and loamy types (Error! Reference source not found.). The alluvial soils are derived from rhyolitic and granitic parent material and extend for about two kilometres from the river (Mason, 2009). The soils are generally less well suited to off-stream storage or furrow irrigation but are more suitable to horticultural production than those of the black cracking clay type in the Flinders (CSIRO 2013a). This is evident in the establishment of mango orchards in the area. While CSIRO (2013b) and previous assessments report large areas of soils potentially suitable to irrigated agricultural production, latter studies (Brooks and Spencer, 2016) have indicated the possibility of significant sub surface erosion on associated sodic soils in areas where detailed soil analyses have not been undertaken.

In common with the Flinders and Mitchell catchments, the adoption of broadacre cropping in the Gilbert has the potential to impact environments downstream including the Gulf through reduced flows and or reduced water quality associated with erosion on cleared land. As noted in the CSIRO report (2013b), the severity of some of these impacts is yet to be fully understood and the lack of certainty most likely leads to a conservative approach to development regulation. The area is also known to contain important cultural heritage and the indigenous people have an expectation of involvement in catchment water planning (CSIRO, 2013b). Guides to address environmental and cultural issues associated with water use and development are provided in the Gulf Resource Operations Plan (amended 2015)[164].

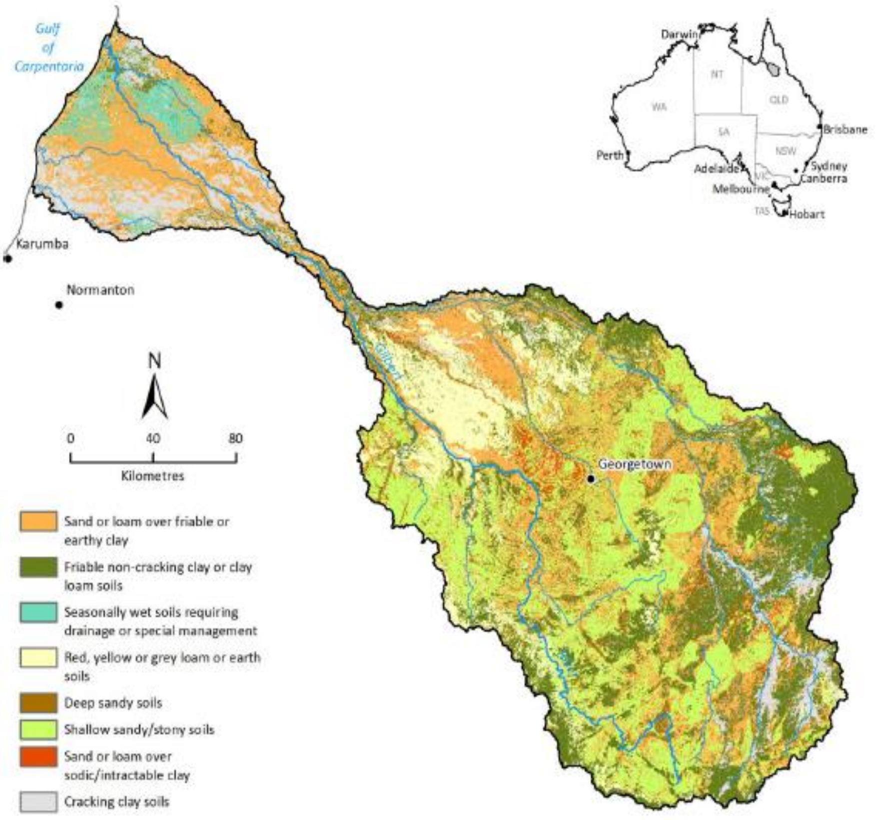


Figure 25 Soil generic map of the Gilbert catchment. Source: CSIRO (2013b)

WATER ALLOCATION

Water allocation tenders were offered in Gilbert River catchment in 2012[165]. Allocations were restricted to 12ML/ha of available land to a maximum of 6,000ML. 15,000ML of surface water was offered in 2012 and attracted four tenders lodged for a total of 161,000 ML including a single tender for 150,000ML that was rejected for exceeding the maximum bid limit of 6,000ML. A total of 14,220ML (with 780ML returned to general reserve) was allocated to three successful bids as follows:

1. 6,000ML @ $42.27/ML for proposed irrigation of forage sorghum, rye grass, Rhodes grass, grains and lucerne.
2. 2,220ML @ $35.00/ML for fodder crops, grain legumes, seed crops such as Seca and Centro, rice, peanuts, cotton, fruit trees, vegetables (pumpkin and melons).
3. 6,000ML @ $35.00/ML for sorghum and maize, chickpeas, mungbeans, faba beans, upland rice.

164 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0005/293927/gulf-rop-amendment-august-2015.pdf

165 Water Resource (Gulf) Plan (2007) Sale of unallocated water-2012: Tender assessment report. Department of Natural Resources and Mines, Qld. https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/unallocated-water/completed-processes

A further tender offer for 85,000ML was opened in July 2017 that remains open[166]. It is possible that interest in obtaining water has been negatively impacted by access to appropriate land and the difficulty in gaining permits to clear land required for irrigation. Review of water resources through the Queensland Government water entitlements[167] indicates that a further 467,000ML of unallocated surface water in the Gilbert catchment is held in general reserve and 5,000 ML in strategic reserve.

LAND

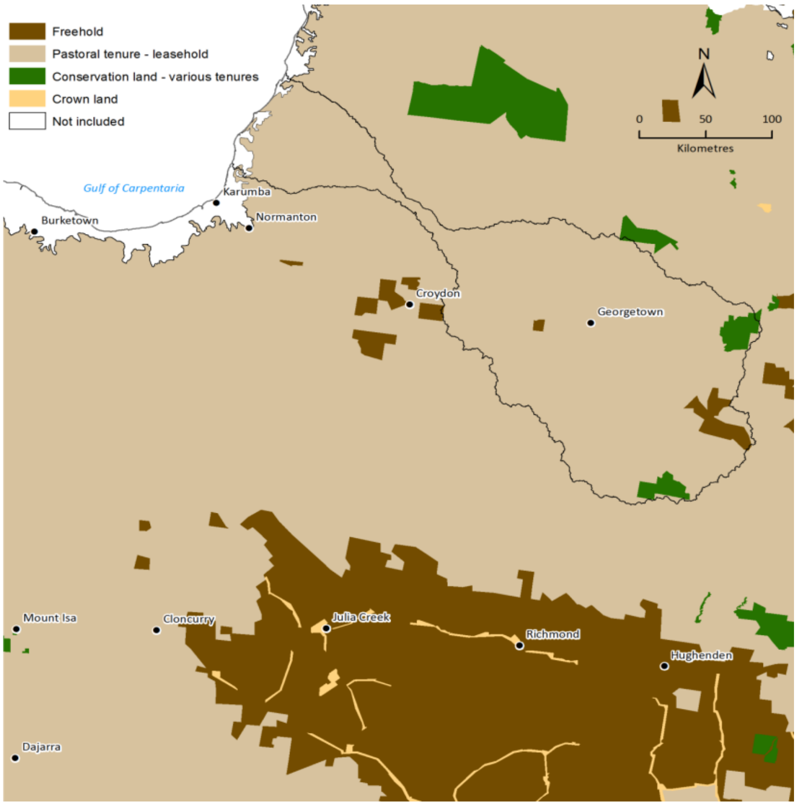


Figure 26 Land tenure in the Flinders & Gilbert catchments. Source: CSIRO (2013a)

The majority of land in the Gilbert catchment is managed under leasehold with limited areas of freehold tenure **(Figure 26**). A survey of 48 land managers from 28 cattle stations conducted by researchers at James Cook University in partnership with Northern Gulf Resource Management Group[168] indicates that most landholders have managed their properties for more than 20 years. Not surprisingly, income is mainly derived from cattle production but 60% of respondents considered that their land had potential for improved pasture or irrigated agriculture.

Land tenure has been identified as a significant constraint to development. Uncertainty of renewing tenures or transitioning between tenure types does not engender an environment that supports the significant capital investment required to establish broadacre cropping in the north.

Equally, access to land development permits is also highlighted as a major impediment to expanding broadacre cropping. Searches of the Queensland Government remnant vegetation maps[169] shows the majority of land in the Gilbert catchment is classified as category B. Feedback from landholders is that the assessment processes at State and Commonwealth levels for development applications are complex, costly

166 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0006/1279761/public-notice-gulf-sale-unallocated-water.pdf.

167 http://qgsp.maps.arcgis.com/apps/MapSeries/index.html?appid=610e67fd52e24dbf9168ed812137ff5c

168 http://plan.northerngulf.com.au/

169 https://qldglobe.information.qld.gov.au/

and generally not completed in a timely fashion. The experience of several parties is that officers enforce technical regulation rather than working with growers to achieve common goals resulting in the belief that land clearing is essentially not permitted.

The higher rainfall of the Gilbert catchment should support options for dryland cropping although some of the sandier soils are not be expected to have the same plant available water storage potential of the cracking clays in other parts of the catchment. Sandier also makes them less suited to furrow or flood irrigation and future irrigation and may require either sprinkler or micro-irrigation technologies. They are, however, likely to be more trafficable after rain and should allow more timely undertaking of essential farm activities such as planting, spraying and harvesting although compaction issues may arise requiring controlled traffic technologies. It will be important to understand the variability of soil types at a local level to identify areas of potential crop expansion. Grower knowledge and input to this process will be essential. Pioneer growers in the region have a good understanding of the suitability of their soils for cropping and are adapting machinery and farming systems for their particular requirements. More generally, there is the potential for underlying subsoil toxicities and soil organic content is low requiring farming systems that build soil carbon and active biology over time[170].

Current and Potential Business Models

There have been numerous reports on potential agricultural development in the Gilbert River catchment stretching back decades. The most recent include the reports of DEEDI (Mason, 2009), CSIRO (2013b), Gulf Savannah Development (2014)[171] and Etheridge Shire Council (ESC) in 2019[172].

Irrigation development in the Gilbert River catchment has previously been dominated by the Etheridge Integrated Agricultural Project, a $2b greenfield irrigation development over 65,000ha proposed by Integrated Food and Energy Developments Pty Ltd (IFED). According to IFED, there was an agreement with the Queensland Government for the allocation of 555GL of water but only if the project gained all required environmental approvals[173]. The first application for the project was submitted in December 2013 and the project lapsed in September 2016. Following the lapse of the project, the Queensland Government released a further 85,000ML of water in the Gilbert River in 2017 some of which at least appears to still be available[174].

The ESC is currently preparing a preliminary business case to support $450m of capital works required for the establishment of the Green Hills dam, identified as a potential dam site in the CSIRO study (2013b). The ESC proposal is for management of 390GL of general water reserve supporting an irrigation scheme on the Gilbert River distributing 200GL of high reliability water to a minimum of 20,000ha of identified irrigable land. The business case is funded by the Queensland Government through the Maturing the Infrastructure Pipeline Program Stage 2 initiative and was expected to be completed in March 2020. The basis of the business case is that scheme infrastructure will be funded by private investment in pre-sold water coupled with Federal Government loan support with water sales expected to attract $120m of the $450m estimated capital cost. According to the National Native Title Tribunal[175] , the area is subject to land title rights of the Ewamian and Tagalaka peoples and a number of Indigenous Land Use Agreements have been negotiated with various parties.

Strathmore Station received State Government approval to clear 58,000ha in 2014 and has successfully produced a range of crops including dryland sorghum, chickpea, sunflower and mungbean. Strathmore has recently grown 12,000ha of sorghum[176]. Integration of cropping with beef cattle production enterprise would allow cattle production to be completed on Strathmore without the need for finishing elsewhere[177]. Cattle can

170 D. Rodriguez (UQ) *Pers. Comm.*

171 https://www.etheridge.qld.gov.au/downloads/file/207/gsdgil-1-pdf

172 https://www.etheridge.qld.gov.au/downloads/file/599/gilbert-river-irrigation-project-brief

173 https://www.abc.net.au/news/rural/2016-09-30/ifed-northern-australia-project-not-going-forward/7894184

174 https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/unallocated-water/gulf

175 http://www.nntt.gov.au/searchRegApps/Pages/default.aspx

176 https://www.northqueenslandregister.com.au/story/3984056/cropping-is-a-success-at-strathmore/

177 http://2016.segra.com.au/perch/resources/michael-kitzelmann-spot10.pdf

be traded through the Port of Townsville and/or processed at the Townsville abattoir. Strathmore has previously hosted large dryland cotton trials.

St Ronans Station near Mt Surprise to the east of Georgetown was purchased by SunDown Pastoral in late 2019 and was reported to have approximately 5,700ha cleared and being prepared for broadacre crop production.[178] There are other developments in the area but public information on activities is limited.

Constraints and Opportunities

Constraints to expanding cropping (dryland and irrigation) include:

1. Lack of a shared vision for agriculture. Feedback suggests that there is no shared vision (across growers, State and Federal Governments and the wider public) for agricultural development in the Gilbert. This leads to lack of clear and consistent policy setting and stalling of many activities. Addressing the many ideological positions held by a range for stakeholders is difficult, but without it there appears to be no supporting basis for discussion and debate.
2. Access to water. There can be no doubt that the availability of a reliable and secure water resource will significantly improve the productivity, profitability and reliability of cropping in the Gilbert catchment. High levels of uncertainty associated with the release of water and the probability of securing licences of sufficient volume to underpin the costs and relative risk of investing in capital works required to capture, store and utilise water is a common issue. Historically, releases have been limited in volume and made available on a competitive tender basis. The approach meets the probity requirements of government and the volumes provide a buffer to allow alterations for environmental or further irrigation needs if required. However, the approach does not engender certainty for growers looking to expand production. Landholder feedback suggests that the current water allocations do not adequately account for variations in the annual and seasonal availability of water and the location of irrigable land and infrastructure. Grower engagement in reviewing access to water is desired. Discussion of feasibility of off-stream storage would be beneficial given that feedback to date indicates strong disagreement with some of the costings utilised to date.
3. Land tenure and clearing. Land tenure is a mixture of freehold, pastoral and grazing leasehold. Depending on tenure type, changes in practice may require review under the Lands Act, 1994 and associated policy. In particular, policy positions that do not favour sub-lease arrangements have the potential to limit the opportunity for current leaseholders to sub-lease country to third parties with cropping experience as a part of a business diversification strategy. Uncertainty in renewing lease tenures or converting tenures does not engender a positive investment environment. Land clearing is subject to the *Vegetation Management* Act, 1999 the application of which does not favour clearing of trees. The matter is further complicated by potentially overlapping requirements of the Commonwealth *EPBC* Act. There is significant scope to increase the co-operation between regulators at the State and Federal levels with growers to identify mutually beneficial outcomes. Successful expansion of cropping is likely to be highly dependent on achieving scale across the catchment that supports a mixture of irrigated and dryland production.
4. Lack of access to agronomy and machinery skills. The relatively large distance between properties, and the distributed nature of water allocations, means that a core of broadacre expertise is yet to form. A critical mass of growers is required to encourage agronomists and other specialists (e.g. machinery sellers and repairs etc) to permanently establish a presence in the region. A certain and secure workforce both in terms of qualification and seasonal availability is critical to the success of agriculture in the Gilbert as they are elsewhere in Australia. Feedback indicates that agronomic support for the production of dryland cotton is a specific gap in current knowledge that is only partially addressed by previous cotton production research.
5. Research and development are constrained by the large distances support staff and equipment must travel. Measures on crop physiological development etc require trained staff that currently travel from the coast, Tablelands or southern Queensland. Utilisation of grower equipment and resources can go some way to addressing basic trial constraints but cannot come at the expense of commercial

178 https://www.beefcentral.com/property/weekly-property-review-recently-completed-sales-8/

operations. Growers are generally willing participants in R&D trials but must prioritise the management of their business enterprises. Considering adoption of R&D outputs, growers have a desire to see small-scale trial results validated in large scale tests that are more reflective of commercial practices.

6. No peer-to-peer learning. Participatory learning is recognised as on one of the most effective methods of extension of R&D knowledge and a lack of a local grower group will have a direct impact on the adoption of R&D outputs (Kuehne *et al*., 2017). The lack of a critical mass of growers in the region makes establishment of grower groups for peer learning complicated. The establishment of the Far North Queensland Sustainable Cropping Group could address some deficiencies in peer to peer learning and the CRCNA and GRDC supported investments (e.g. DAF, QAAFI and Savannah Ag trial programs) utilise participatory approaches to determine trial focus and design. The lack of an established peer grower group also manifested in a lack of a clear vison for agricultural development that is common across NW Queensland. There is an opportunity for the CRCNA to facilitate the establishment of peer grower groups to inform a range of R&D topics from production agronomy through to supply chain analysis and provision of data to inform policy.
7. Access to post-farm processing and export. Transport of product to post farm processing or export has a significant adverse impact on gross margin. The nearest cotton gin is at Emerald. While the Port of Townsville is currently undergoing a major expansion and ADM is establishing a presence, export opportunities for pulses are currently limited. Food grade soybean must be transported to either southern Queensland or northern NSW for processing and the lack of crushing capacity requires transport of oilseeds to be transported south. A cost that impacts the viability of even high value oilseeds (such as SHO safflower). In a typical catch-22, investment in processing and storage facilities requires consistent supply which is constrained by a lack of production associated with the lack of processing and storage. Feedback suggests that the appetite for investment in processing infrastructure is not necessarily a constraint but the lack of certainty regarding access to land and water is a significant barrier to permitting that investment to occur.
8. Poor road and rail infrastructure quality that is addressed on an ad hoc basis through a series of relatively inefficient upgrades to small target areas results in a lack of overall improvement.
9. IT and mobile services are also a significant constraint with some growers investing in core infrastructure to address current issues. The adoption of precision agriculture, including GPS autosteer, yield mapping and tailored inputs (e.g. variable rate fertiliser) will require ongoing and stable access to internet and satellite services.

Varietal development was not identified as a significant constraint to expansion of broadacre cropping. An extensive amount of R&D that has already been undertaken and significant opportunities already exist that require relatively little R&D to implement.

Constraints Summary

CONSTRAINT	
Crop Genetics	Development of dryland cotton production management guidelines for the northern environment. Development of cropping systems that accommodate potential double cropping and the integration into whole of farm enterprise management (e.g. integration with cattle operations). Validation of small-scale trial results on a commercial scale to underpin cropping decisions. Access to peer to peer learning mechanisms such as farming systems groups.
Environment	Establishment of clear and consistent policy settings based on a joint vision for the development of agriculture. Timely and efficient pathways through State and Federal regulatory hurdles to allow irrigation development to gain scale for individual enterprises and joint initiatives. Clarity on potential for land clearing and certainty of tenure are major issues. Access to water licenses of sufficient size to warrant capital irrigation works. Assessment of potential environmental and cultural impacts of water allocation and storage to provide certainty for future applications. Accurate assessment of vegetation maps and a desire to work with regulators on understanding land and water access issues in preference to an enforcement approach.
Market and Value Chain	Access to a regional cotton gin would substantially improve gross margins and NPV on irrigation developments. Access to pulse processing and export facilities at Townsville would significantly lower transport costs. Evaluation of regional and local feed demand required to underpin fodder production cycle. Evaluation of integrated enterprises based on crop, cotton and beef production to maximise returns and support sustainability. A need to improve road networks as a whole rather than maintenance on an *ad hoc* basis.
Farm Inputs, Capacity and Infrastructure	Investigating irrigation systems that lower the cost of inputs and capital. Building cropping knowledge and capacity in pastoral operations in a farming system context that maximises return across enterprises. Access to knowledgeable agronomists. Access to trained labour when required both for farm operations and to support R&D. Access to machinery specialists both for operation and repairs.

QUEENSLAND – Mitchell River Catchment and Normanby Basin

Introduction

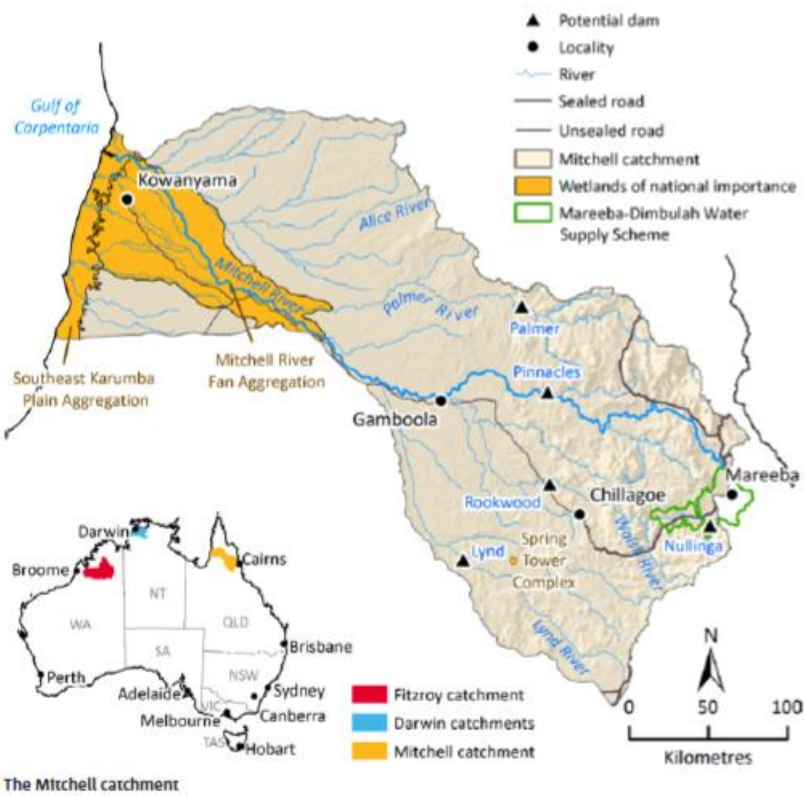
The Mitchell River catchment and areas north (Lakeland and Laura) have been targeted as potential areas of broadacre crop production for decades. Lakeland Downs was purchased in the 1960s with the intent for significant grain sorghum production to supplement local cattle growing and for export. Large areas of land were cleared, and dams constructed but the project was ultimately unsuccessful. While the initial Lakeland Downs project did not eventuate, it left a large area (approximately 10,000ha) of cleared, arable land (Grundy and Heiner, 1994). In the 1980s the area was split into smallholder farming operations (about 400ha each) with cropping continuing on a dryland basis or with supplementary irrigation from on-farm sources (dam or groundwater). Horticultural production in the area has expanded, particularly the production of bananas (Ash and Watson, 2018).

In the Mitchell catchment, there is very little cropping below the Mareeba-Dimbulah Water Supply Scheme (MDWSS) and the Atherton Tablelands although sorghum and Rhodes grass production was attempted in the 1950s (CSIRO, 2018). Gross value of production on the Atherton Tablelands in 2015 was $552m, a 30% increase from 2011 largely attributable to expansion of high value horticulture (avocado, banana, citrus etc) and sugarcane. Cropping is almost exclusively irrigated on the Tablelands and has declined from 37,959ha in 1999 (15,238ha of which was sugarcane) to 31,123ha in 2015 (18,135ha sugarcane). Of 12,784ha of irrigated cropping in 1999 that changed use to 2015, more than 3,000ha each were converted to either sugarcane or perennial horticulture production[179]. Broadacre cropping has been dominated by maize ($11.3m in 2015) and peanut ($4.8m)[180] with PCA maintaining a peanut processing facility at Tolga.

Environment

Characterisation of the Mitchell River catchment and assessment for potential agricultural production was completed by CSIRO (2018c) as part of the National Water Infrastructure Development Fund: Water Resource Assessment and is summarised below, together with other data of relevance.

The Mitchell River catchment (**Figure 27**) extends for 72,000km^2 and includes parts of the MDWSS at the eastern boundary (CSIRO, 2018c). In addition, there are significant areas of agricultural production and potential to the north of the catchment with broadacre trials occurring on Fairview Station at Laura and other horticultural production in the Lakeland district. Rainfall averages 1,300mm/annum in the north west of the catchment declining to 700mm/annum in the south east.



Source: CSIRO (2018c).

Figure 27 Mitchell catchment

179 Land use summary 1999-2015: Atherton Tablelands - https://publications.qld.gov.au/dataset/land-use-summary-1999-2015/resource/d97bee40-5694-424a-9085-c7e4892475b8

180 Tablelands agriculture profile 2015 - https://www.etheridge.qld.gov.au/downloads/file/434/tablelands-agricultural-profile-2015pdf

The majority of rainfall occurs in the wet season (**Figure 28**) with very high evaporation in the dry season generally exceeding rainfall. Rainfall patterns to the north east of the catchment (e.g. Fairview) generally match those east of the catchment (**Figure 29**). Rainfall is characterised by large inter-season variability but seasonal outlooks in January can be made with 65% accuracy. This allows for at least a degree of risk management for growers planning seasonal production, especially for any expanded broadacre dryland cropping.

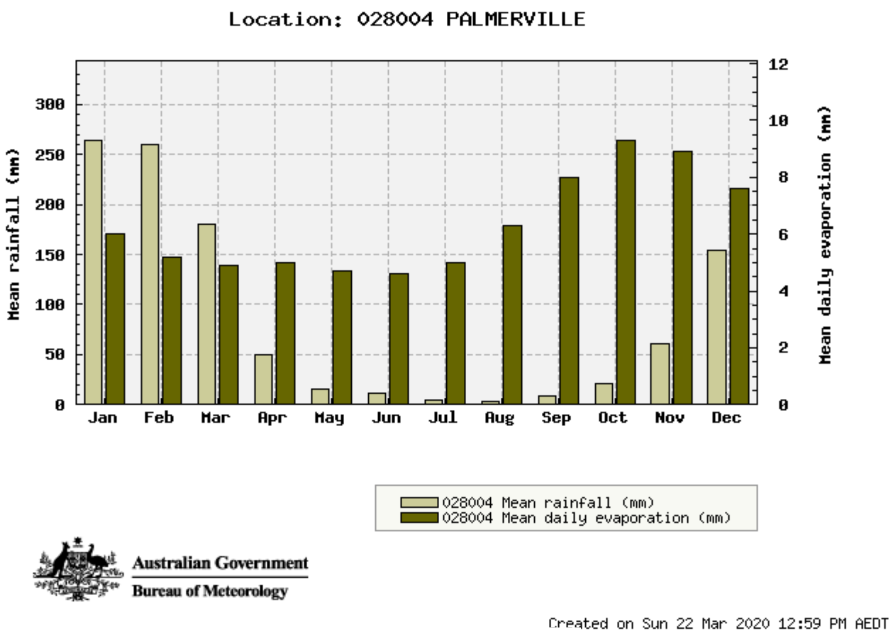


Figure 28 Mean rainfall and evaporation - Palmerville.

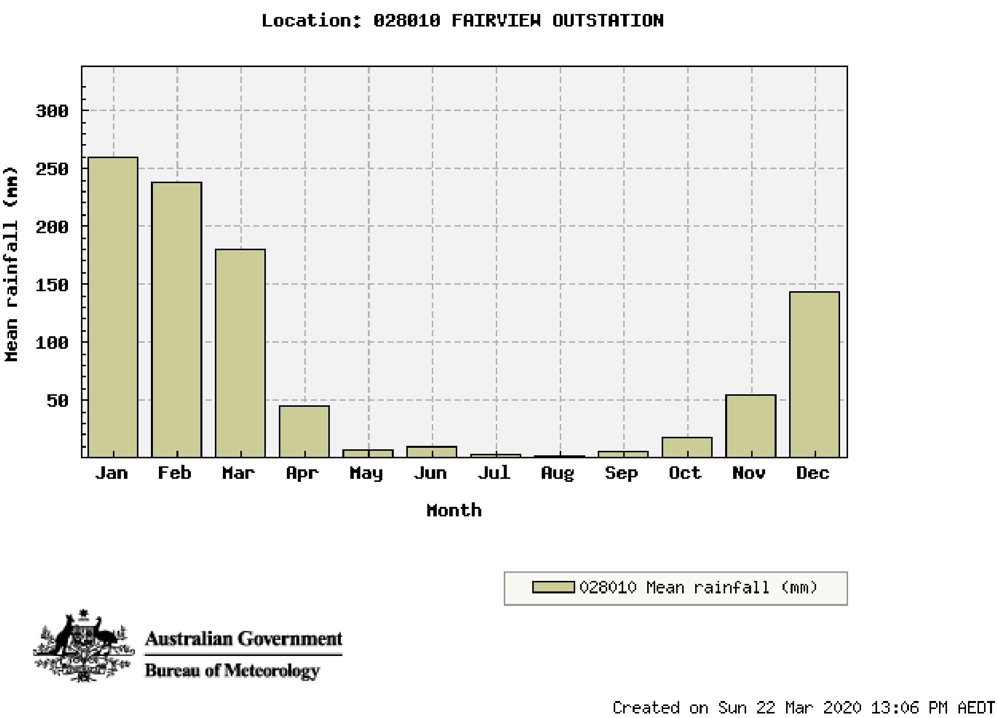


Figure 29 Mean rainfall - Fairview

Potential damage from tropical cyclones is far more likely in the Mitchell catchment with at least one cyclone in 75% of years. Flooding below the confluence of the Mitchell and Palmer rivers can be extensive and is important for the maintenance of finfish and prawn fisheries in the Gulf. Areas above the confluence are less prone to flooding.

The high evaporation means that large, farm-scale ring tanks could lose about 50% of their storage over the dry season. However, use of water earlier in the dry season would see evaporation minimised as dam storage would be minimal in months of highest evaporative potential. In-stream dams are possible but are less preferred by the traditional owners in the region. Traditional owners need to be partners in strategies to develop the area.

There are substantial areas in the upper Mitchell catchment where the soils, while highly variable, would support broadacre cropping **(**Error! Reference source not found.) but issues of salinity and potential secondary salinity would need to be managed (Philips *et al*., 2018). Soils in the Atherton area are often derived from basalt, are well drained and have high fertility[97].

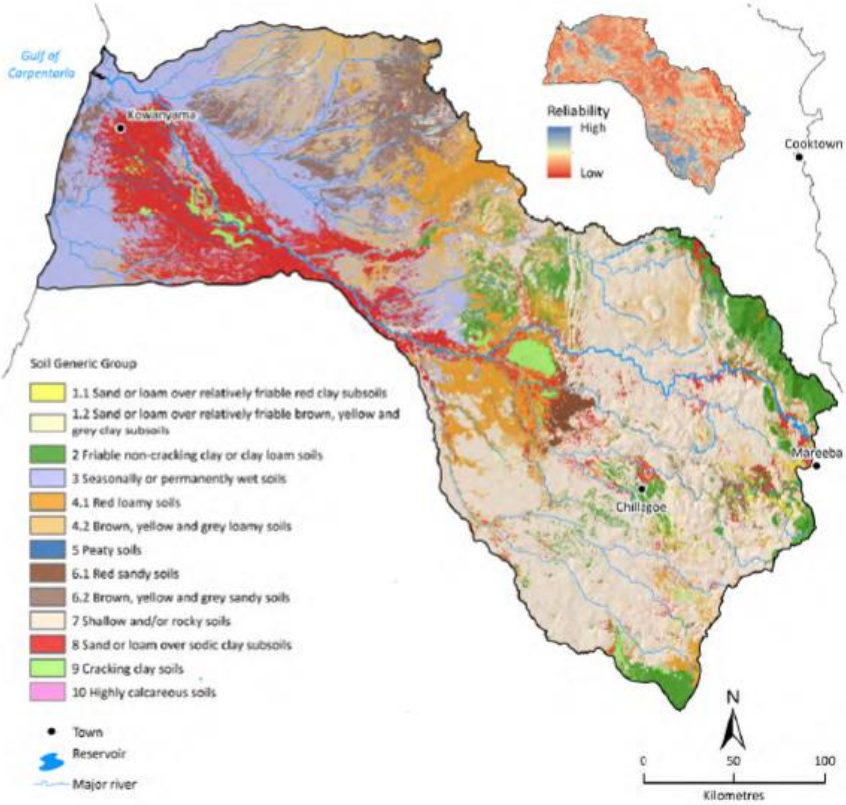


Figure 30 Soils of the Mitchell catchment. Source CSIRO 2018c

The Mitchell River is unique in north Queensland in that it is perennial. It has the highest discharge of any river in northern Australia (Petheram *et al*., 2014) but streamflow is highly variable both between and within years (Philips *et al*., 2018). Most streamflow in the Mitchell cannot be captured in off-stream storages because total streamflow is dominated by a low number of very high-flow days, limiting the opportunities to pump. A total of 2,000GL of water could be pumped in 85% of years. Dams for water storage, while not preferred by traditional owners, are possible and four potential dams could deliver 2,800GL of water in 85% of years, sufficient to irrigate 150,000 -200,00 ha of broadacre crops. Cost of water at the dam wall would be about $980/ML. Most potential dam sites in the Mitchell catchment would inundate some regional ecosystems considered to be 'of concern'. Groundwater access is highly variable and likely limited to 5GL/annum maximum (CSIRO, 2018c).

In the Mitchell catchment, there are up to three million hectares of potentially irrigable soils (CSIRO, 2018c), much more than the potential water availability for irrigation. In the Cape York NRM zone there are 239,000 ha of land suitable for the production of peanuts, sorghum or maize and a further 2,050,000 ha suitable for sorghum or maize production[181].

Dryland cropping on heavier soils in the mid-catchment of the Mitchell with high water storage potential is possible with break-even yields possible in 80% of years if crops are sown in January to maximise yield. However, when wet these soils present trafficability issues and sowing would often be delayed with resultant declines in yield potential (CSIRO, 2018c). Feedback suggests that the CSIRO estimations are conservative

181 http://www.capeyorknrm.com.au/node/579

and, like other catchments, it will be important to validate modelled estimates with actual production data to provide a more accurate description of broadacre cropping potential.

WATER

Water allocations in the Mitchell catchment are regulated under the Mitchell Water Management Protocol (2016)[182]. Review of water resources through the Queensland Government water entitlement viewer[183] indicates that 4,844ML of unsupplemented surface water has been allocated with a further 65,000 ML of unallocated surface water held in general or strategic reserve. Parts of the upper Mitchell River and Walsh River, while part of the Mitchell catchment, are managed under the Barron Water Plan (2002)[184] and the Barron Water Management Protocol (2017)[185] such that the MDWSS water allocations are all managed under a single scheme. Under the entire Barron Water Plan, 204,424ML of supplemented surface water and 22,363ML of unsupplemented surface water has been allocated as has 30,508ML of groundwater. 4,300ML of surface water is currently unallocated. There is no excess water in the MDWSS for allocation unless further storage is constructed, or a review of the water plans is undertaken[186].

Water allocations to the north of the Mitchell catchment are covered by the Cape York Water Plan (2019) with 293,630 of unsupplemented surface water allocated and a further 516,350ML held in reserve. Of the reserve, 485,300ML is held for indigenous peoples use and 6,050ML is held in general reserve (25,000ML is held in strategic reserve). In the Normanby basin, 16,500ML of indigenous use water and 2,000ML of general reserve remain unallocated[187]. A moratorium on releases that was in place while the water plan was finalised was withdrawn in November 2019 but there are no current releases advertised.

Groundwater allocations and reserves are covered under the Great Artesian Basin and Other Regional Aquifers Water Plan[188]. Under the Plan, unallocated water from the general reserve can be granted for any purpose while unallocated water from the State reserve can only be granted for a limited number of reasons, one of which is a project of regional significance. The Plan covers an enormous area of Queensland, from Cape York to the NSW border with different areas split into zones (termed units) and sub- areas. The plan and processes for water allocation at the unit and sub-area scales are complex with the volume of unallocated water for water licences to be granted from reserves listed in Schedule 4 of the Plan.

LAND

The northern grazing lands are dominated by pastoral leases that coexist with Native Title. Pastoral leases were continued as term leases under the Planning Act 1994 that requires the land to be used for grazing and/or agricultural purposes[189]. The major land tenures on Cape York in 1995 were pastoral holdings (7,819,240 ha) constituting 57.2% of the total land area, followed by Aboriginal and Torres Strait Islander Lands (2,023,200 ha) constituting 14.8%, and National Parks (1,367,000 ha) which covered 10% of the total land area[190]. The Lakeland district has 8,250 hectares of cleared land with potential for irrigated cropping[191].

Access to land development permits is also highlighted as a major impediment to expanding broadacre cropping. Land clearing has been complicated by overlapping State and Federal regulations under the *Vegetation Management Act* and *Environmental Protection and Biodiversity Conservation Act* respectively. Searches of the Queensland Government remnant vegetation maps[192] shows the majority of land is category B - remnant vegetation. Feedback from landholders is that land clearing is essentially not permitted.
Some areas may have run-off associated with the health of the Great Barrier Reef (GBR) and will be potentially captured by Reef Protection regulations that started in December 2019. Under the regulations,

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182 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0007/1076038/mitchell-protocol.pdf

183 https://www.business.qld.gov.au/industries/mining-energy-water/water/maps-data/water-entitlement-viewer

184 https://www.legislation.qld.gov.au/view/pdf/inforce/current/sl-2002-0378/lh

185 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0004/1255468/Barron-Water-Management-Protocol.pdf

186 https://www.business.qld.gov.au/industries/mining-energy-water/water/maps-data/water-entitlement-viewer

187 https://www.business.qld.gov.au/industries/mining-energy-water/water/maps-data/water-entitlement-viewer

188 https://www.legislation.qld.gov.au/view/html/inforce/current/sl-2017-0164

189 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0010/389422/landtenureqld.pdf

190 http://www.capeyorknrm.com.au/node/579

191 https://www.rdatropicalnorth.org.au/wp-content/uploads/2019/11/30031836-CYSF-LIA001-REP-Milestone-5-Rev-0-Public.pdf

192 https://qldglobe.information.qld.gov.au/

from June 2020 new or expanded commercial cropping of five hectares or more that does not meet a cropping history test (cropping occurred in three of the last ten years and at least once in the last five), will require a permit before any activity or work is undertaken. Newly cropped land will need to meet minimum practice standards that aim to achieve "no net decline: in water quality by minimising nutrient and sediment runoff[193]. The imposition of these regulations has now been delayed until June 2021[194].

Land in the MDWSS is dominated by horticultural and sugarcane production. Cropping is unlikely to replace either of these industries in the near future and indeed has been declining in the last five years[195]. However, the continued incorporation of cropping into a sugarcane rotation is likely and indeed could be a key component of meeting Reef regulations. To this extent, cropping in the MDWSS in rotation with sugarcane production is analogous to opportunities identified for the Lower Burdekin.

Current and Potential Business Models

One of the largest operations in the region is the Olive Vale/Fairview Station complex at Laura. The owners received permission to clear 32,000ha of land and began development in 2015 as part of a multimillion-dollar plan to develop dryland broadacre cropping focussing initially on chickpea, sorghum and rice[196] on 1,800 ha. 150 ha of forage sorghum was planted in 2016 and rapid expansion was planned but is currently delayed as the project has been referred to the Federal Government for assessment under the *EPBC* Act. That assessment is ongoing.

Approximately 2,000 ha of land was approved for clearing on Kingvale Station in 2014 with the intention to establish cropping. The development has also been referred to the Commonwealth under the *EPBC* Act. The draft recommendation of that review was that clearing of up to 1,846 ha should be approved with strict conditions[197] but a final decision does not appear to have been made to date.

The Lakeland Irrigation Area Project (LIAP) seeks to expand the current 1,300 ha of irrigation in the Lakeland district that is utilised for high-value horticulture production[198]. Specifically, the project seeks "Access to an affordable and reliable water supply capable of supporting a majority of soils suitable to horticulture and broadacre cropping in the LIA". Water is currently sourced from small, on-farm dams and groundwater totalling 14,300ML (about 8,000ML of usable water). The LIAP proposes a dam on either the Normanby River (holding 350-400GL, 40-50GL available) or Palmer River (approximately 200GL with 70GL available) with capital costs in the region of $400-$500m. Both options are estimated to supply water without restrictions in 70% of years. Common to other regions in the north, the availability of suitable land exceeds the availability of potential irrigation water storage. All options involve the expansion of cropping and/or horticulture within the Great Barrier Reef catchment and hence new areas are assumed to be subject to the new Environmental permit requirements. Initial assessment identified a dam on the Palmer River as the preferred option for the LIAP and a more detailed assessment indicates that a positive NPV can be generated (IRR of 11.3%) if water prices were $370-$450/ML for medium security water (broadacre cropping) and $790-$980ML for high security water (horticulture)[199]. For broadacre agriculture, the cost of water would constitute a major variable cost. Ongoing efforts are required to address environmental impacts, land tenure (including traditional ownership), economic feasibility and public/private partnership options.

A proposed dam at Nullinga to augment water in the MDWSS has been advocated for decades (at least since the 1950s). In 2017, Business Queensland undertook a preliminary assessment[200] of options that confirmed that the existing MDWSS would be unable to support additional water allocations for current or new customers without; changes to current rules/operations, improvement of existing water distribution assets, and/or investment in new water storage (Nullinga Dam). Demand for additional water with prices

193 https://www.qld.gov.au/environment/agriculture/sustainable-farming/reef/reef-regulations/producers/cropping

194 https://www.qld.gov.au/environment/agriculture/sustainable-farming/reef/reef-regulations/producers/cropping

195 Land use summary 1999-2015: Atherton Tablelands - https://publications.qld.gov.au/dataset/land-use-summary-1999-2015/resource/d97bee40-5694-424a-9085-c7e4892475b8

196 https://www.cairnspost.com.au/news/cairns/olive-vale-station-to-forge-ahead-with-mega-farm/news-story/1c9bc8de468dbd409fd9f9e0a3e649fc

197 http://epbcnotices.environment.gov.au/_entity/annotation/aae7671b-5d44-e811-886f-005056ba00a8/a71d58ad-4cba-48b6-8dab-f3091fc31cd5?t=1525996108526

198 https://www.rdatropicalnorth.org.au/wp-content/uploads/2019/11/30031836-CYSF-LIA001-REP-Milestone-5-Rev-0-Public.pdf

199 https://www.rdatropicalnorth.org.au/wp-content/uploads/2019/11/30031836-CYSF-LIA001-REP-Milestone-5-Rev-0-Public.pdf

200 http://buildingqueensland.qld.gov.au/wp-content/uploads/2019/11/Nullinga_Dam_CBA_Summary.pdf

between $2,000-$3,000/ML identified a potential new allocation need of more the 80,000ML with high security water in demand for horticulture and medium security demand linked to sugarcane production. The proposed Nullinga dam would have a full storage capacity of 491,000 ML but analysis suggests a yield of only 65,000 and 90,000 ML per year and the dam did not proceed. There seems to be a significant anomaly between total additional volume and water availability in comparison to the analyses that have been undertaken for dams in a range of other locations in NW Queensland.

The proposed dam on the Tablelands at Woodleigh would have the potential to provide up to 36,000ML per annum and could result in a positive return on investment. However, given the cost of the scheme, the production required to generate the returns to make the scheme feasible it is unlikely to include broadacre crops[201].

Constraints and Opportunities

Despite the numerous and ongoing initiatives for irrigated agricultural production in the catchment, feedback suggests that progress of development has largely been restricted due to:

1. Lack of a shared vision for agriculture. Feedback in the Mitchell was very pertinent. It is difficult to debate the relative merits of development and conservation if the parties have no shared vision. This leads to lack of clear and consistent policy setting and stalling of any activities. Addressing the many ideological positions held by a range for stakeholders is difficult, but without it there appears to be no supporting basis for discussion and debate.
2. Lack of access to land. The requirements of the *Vegetation Management Act* and *Environmental Protection and Biodiversity Conservation Act* combine to make an extremely complex and complicated regulatory system apply to applications for land clearing. The complex regulatory system has delayed some approved land clearing as they are reviewed by different levels of government. New applications for development would appear to have a low probability of success.
3. Access to agronomy skills and farm management skills. Similar to other regions in NW Queensland, landholders do not necessarily possess the cropping skills and management to develop a commercial cropping enterprise. Access to agronomy and farm management skills, either through contractors, farm managers or joint ventures will be critical to the establishment of successful broadacre cropping.
4. Lack of access to machinery skills. The large number of growers in sugarcane systems with small areas of grain production make it un-economical for individuals to purchase large-scale machinery. In contrast, the total area under broadacre cropping must be sufficiently large to attract contractors, particularly those with specialist equipment such as cotton pickers. Growers with larger areas of land may purchase requisite machinery but must still have access to skilled operators and mechanics that can repair broken machinery on-site. A critical mass of growers is required to encourage crop agronomists and other specialists to permanently establish a presence in the region. The isolation of the regions makes this particularly difficult and novel mechanisms to attract the required skills will be needed.
5. Integration with sugarcane production. For integration with sugarcane production, short season grain varieties that allow harvesting in time for sugarcane to be planted in April are required. These exist for mungbean, but other crop varieties still take a little too long to mature for short fallow applications. For longer rotational options, confirmation that grain crops can be grown with minimal overall impact on sugarcane yield across the rotation would contribute enormously to supply confidence of mills. Other, less obvious production issues also require some work such as the width of operating machinery between sugarcane and cropping is often not consistent which inhibits controlled traffic farming and can make contract operations more difficult.
6. Peer-to-peer learning. Participatory learning is recognised as on one of the most effective methods of extension of R&D knowledge and a lack of a local grower group will have a direct impact on the adoption of R&D outputs (Kuehne *et al*., 2017). In the Lower Burdekin, an alternative cropping group supported by DAF is an excellent example of the results that can be achieved using participatory

201 https://www.trc.qld.gov.au/download/tablelands-irrigation-project-preliminary-business-case/

approaches. In sugarcane production systems further north such farming groups do not exist as the lack of critical mass of growers in the region makes establishment of grower groups for peer learning complicated.

7. Grains storage expertise and facilities are lacking in the area. High quality grain storage provides growers with a mechanism to manage price risk whereas low quality storage exposes them to losses and downgrades associated with insect and fungal damage.

8. Access to grain marketing expertise and trading options is a constraint. The use of private grain market advisers is commonplace for growers in southern Australia. The large number of domestic and export trading options in the south supports a more competitive trading environment. The small scale of initial grain production in the north will not support multiple trading entities initially but systems to ensure traders and market advisers can operate in an environment that supports emerging grain production will be critical.

9. Access to post-farm processing and export. Ongoing access to regional traders is a significant impediment to broadacre grain production, albeit the Port of Townsville is currently undergoing a major expansion and ADM is establishing a presence. In the absence of local processing and export opportunities grain must be transported to either southern Queensland or northern NSW. Similarly, for cotton, the lack of regional processing requires cotton to be transported to Emerald for ginning which significantly impacts gross margins as well as inhibiting the return of cottonseed for use in regional livestock production. Oilseeds (sesame, safflowers and soybean) offer potential but require local or regional crushing capacity that, in the case of safflower, needs to include solvent extraction. In a typical catch-22, investment in processing and storage facilities requires a consistent supply which is constrained by a lack of production associated with the lack of processing and storage.


Lakeland Irrigation Scheme

Constraint Summary

CONSTRAINT	
Crop Genetics	Access to short season crop varieties for use in short fallow sugarcane production. Confirmation of sugarcane yields in a longer rotation that encompasses multiple grain/cotton options. Access to peer to peer learning mechanisms such as farming systems groups.
Environment	Establishment of clear and consistent policy settings based on a joint vision for the development of agriculture. Timely and efficient pathways through State and Federal regulatory hurdles to allow land and irrigation development to gain scale for individual enterprises and joint initiatives. Clarity on potential for land clearing is a major issue. Assessment of potential environmental and cultural impacts of water storage to support future applications. Addressing of potential NRM issues associated with run-off impacts on the Great Barrier Reef.
Market and Value Chain	Access to regional grain processing and containerisation facilities, including potential oilseed crushing etc. Evaluation of regional and local feed demand required to underpin fodder production cycle and possibly support feedlot operations. Access to ongoing regional and local market and trading expertise and export opportunities.
Farm Inputs, Capacity and Infrastructure	Access to knowledgeable agronomists and farm business managers. Access to trained labour when required both for farm operations and to support R&D. Access to machinery specialists both for operation and repairs. Building cropping knowledge and capacity in pastoral operations in a farming system context that maximises return across enterprises. Access to broadacre cropping equipment that is compatible with other farming systems (e.g. sugarcane). Increased understanding and adoption of high-quality grain storage to ensure quality.

QUEENSLAND – Burdekin

Introduction

The Burdekin catchment consists of eight subregions[202]. For the purpose of exploring broadacre cropping options, the subregions of most interest are the:

- Burdekin rangelands – that extend west from Townsville past Charters Towers
- Belyando-Suttor catchment – that runs south of the Burdekin dam south toward Emerald
- Lower Burdekin – around Ayr and south to the Burdekin dam

Outside of the Lower Burdekin (LB), the catchment is dominated by cattle production on mostly natural pastures. Dryland broadacre cropping is restricted to an area of the Belyando-Suttor. Irrigated production occurs in both the Lower Burdekin (LB) and Bowen catchments that together constitute the largest irrigation area in northern Australia at 1,100km^2. The focus in the Bowen area is on high value horticultural production and the opportunities for broadacre cropping are very limited.

Irrigated broadacre production in the LB is focussed heavily on sugarcane worth $355.2m per annum. Broadacre cropping is expanding but historically has been centred around providing a rotation to the sugarcane monoculture. As of 2019, there were approximately 550 growers managing 101,500 ha for sugarcane production in the LB [203] of which approximately 20% is in fallow or planted to a rotational crop in any one year. There are clear opportunities for further development of irrigated broadacre cropping in a sugar rotation that maintains sugarcane yields while diversifying production and managing runoff as well as specialist crop production.

Burdekin Rangelands

The rangelands are predominately un-improved and improved grazing country on generally less fertile gradational earths and shallow duplex soils. Over 70% of the area still retains remnant woody vegetation. These soils are susceptible to erosion where there is limited ground cover. The area supports an extensive cattle industry, although isolated pockets of irrigated farming occur[204].

There are calls for expanded irrigation based on a dam at Hells Gates and Big Rocks Weir at Charters Towers. Charters Towers is the main town of the region and could become an important consolidation hub for product out of the Flinders, Gilbert, Burdekin and Mitchell catchments depending on the economic feasibility of integrated expansion models. In terms of broadacre cropping, the rangelands are likely to encounter largely the same constraints and opportunities as the Flinders and Gilbert River catchments.

Lower Burdekin (LB)

The LB is characterised by extensive irrigated crop production on the Burdekin River delta predominately supported by groundwater and production on the alluvial soils of the river irrigated with surface water from the Burdekin Falls dam. The dam was completed in 1987 as part of the Burdekin-Haughton Water Supply Scheme (BHWSS). The region has significant potential for diversified production that can assist in addressing current and potential downstream impacts on high value wetlands and the Great Barrier Reef (GBR) as well as providing solid gross margins. Current soil productivity and natural resource issues include declining soil carbon, secondary salinisation, waterlogging, soil erosion and nutrient runoff (especially nitrogen and phosphorous). The sugar industry has committed to significant expenditure for practice change required for best management practice adoption to limit adverse natural resource impacts[205]. However, to date, practice change in the Burdekin has been modest[206].

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202 Burdekin Dry Tropics Natural Resource Management Plan (2016-2026) https://drive.google.com/a/nqdrytropics.com.au/file/d/0B2eYGb5_I-adVXJVOVN2bWcyOFE/view?usp=sharing

203 https://reportcard.reefplan.qld.gov.au/home?report=target&measure=GRN&area=GBR

204 https://www.etheridge.qld.gov.au/downloads/file/432/northr-1-pdf

205 https://www.publications.qld.gov.au/dataset/05fe1bbd-1933-4205-851b-a469f915327e/resource/0de77def-fd92-4cf7-a325-bcd51cde562e/fs_download/burdekin-sugarcane-ipc-guide.pdf

206 https://reportcard.reefplan.qld.gov.au/home?report=target&measure=GRN&area=GBR

Environment

The Burdekin basin spans more than 130,000km^2 from Greenvale in the north west to Alpha in the south west extending eastward to the coast (**Figure 31**)[207].

Rainfall is high on the coast averaging 1,000mm though with very high evaporation (2,080mm) that significantly exceeds rainfall (**Figure 32**). Rainfall declines toward the west with an annual average rainfall at Charters Towers being about 700mm (**Figure 33**). Like other areas of the north, annual and monthly rainfall is highly variable (Petheram *et al*., 2008). Irrigation in the Burdekin catchment occurs upon relatively fertile soils that have formed from derived sediments of the LB delta, the alluvial floodplains of the BHWSS and separate alluvial deposits on the margins of the Burdekin River. The dominant soils of the BHWSS are cracking grey clays and black earths although a wide range of soils occur throughout the area. Soils of the delta include black and grey cracking clays, sands and duplex soils (Petheram *et al*., 2008).

Groundwater levels in the BHWSS have risen steadily since the scheme began and are associated with deep drainage of irrigation systems (Petheram *et al*., 2006). This contributes to secondary salinisation in the area as well as seawater encroachment of the coastal aquifer.

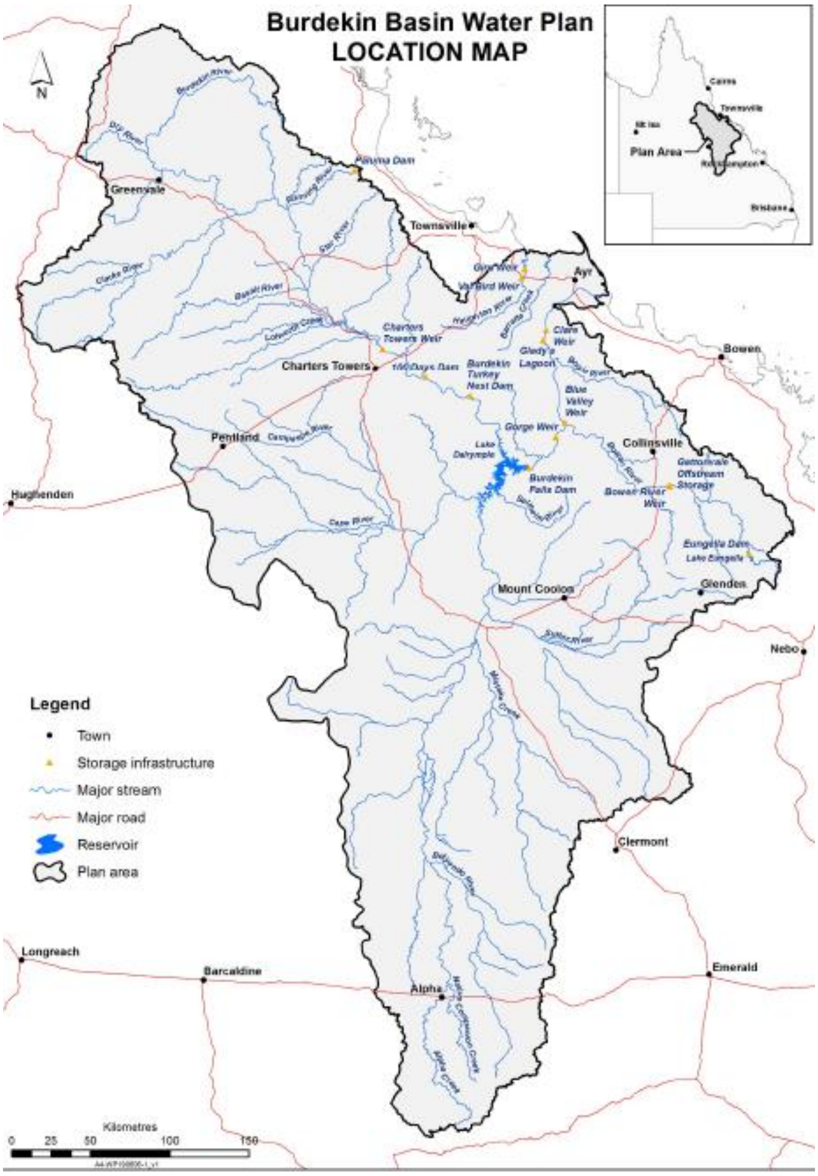

Figure 31 Burdekin Basin. Source: Business Qld.

Groundwater quality and impacts of agriculture on adjacent wetland and the GBR are significant factors that will require whole of system approaches to address.

207 Burdekin Basin water plan https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0004/1447582/burdekin-basin-water-plan-map-2019.pdf

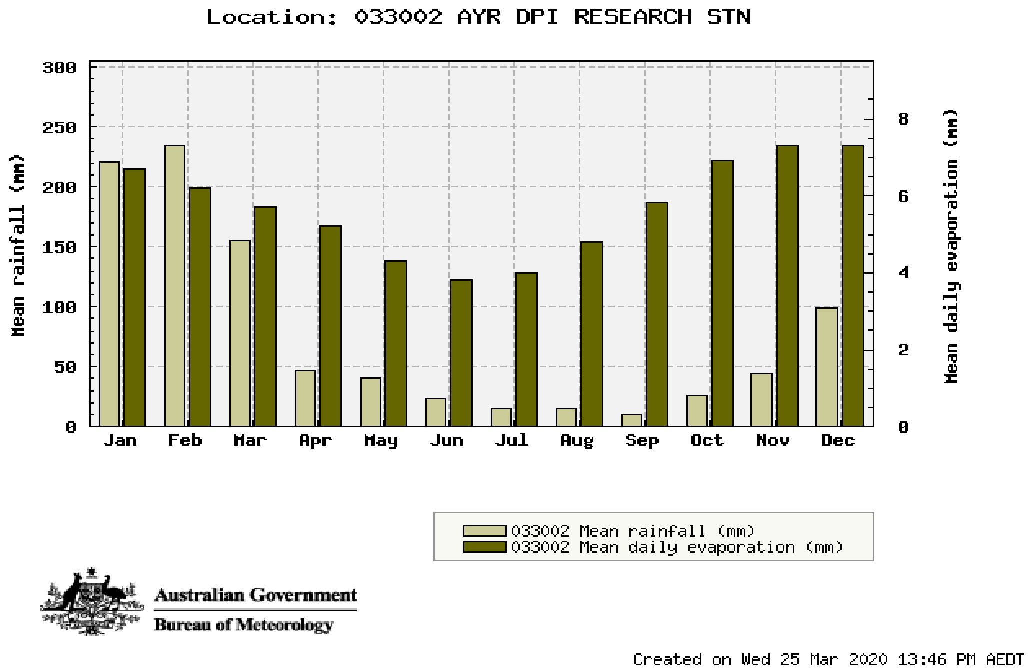

Figure 32 Mean rainfall and evaporation - Ayr.

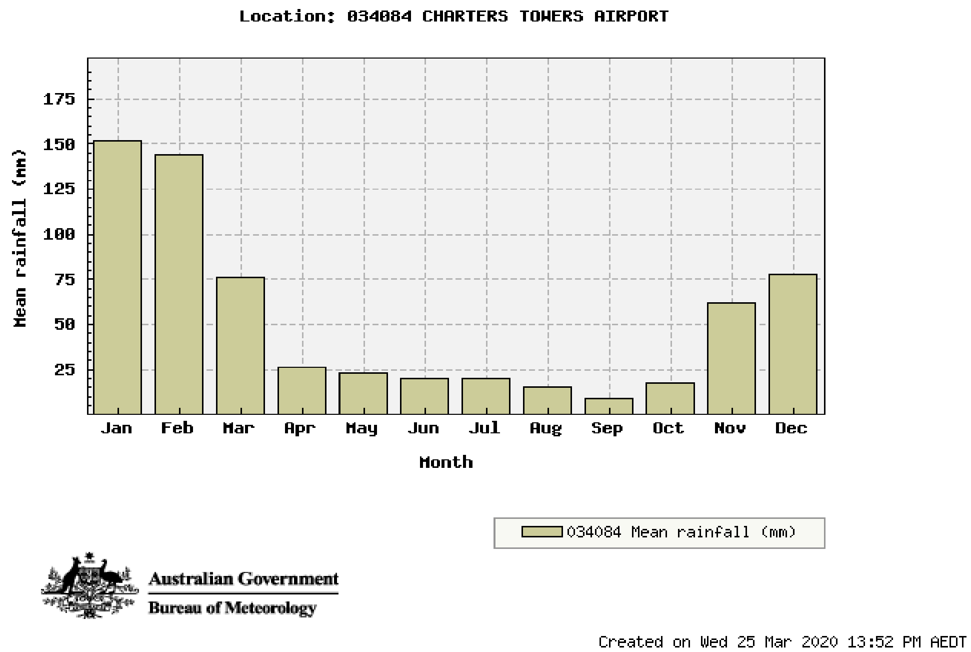

Figure 33 Mean rainfall - Charters Towers

WATER
Across the Burdekin 1,118,522ML of supplemented surface water has been allocated together with a further 38,023ML of unsupplemented surface water. 532,944ML of surface water remains unallocated[208]. Groundwater is managed by Lower Burdekin Water with 2019/20 allocation in the Northern Division of 152,880ML (98% of capacity) and 97,020ML in the Southern Division (also 98% of allocation)[209]. Electricity supply and costs for pumping are a significant issue as well as a large contributor to variable costs.

LAND
Land tenure in the Burdekin catchment is a mixture of perpetual lease, rolling lease and areas of freehold tenure (Error! Reference source not found.**)**[210]. The rangelands are mostly pastoral or grazing lease. Uncertainty of renewing tenures or transitioning between tenure types does not engender an environment that supports the significant capital investment required to establish broadacre cropping in the rangelands. Land tenure is not a significant issue in the LB.

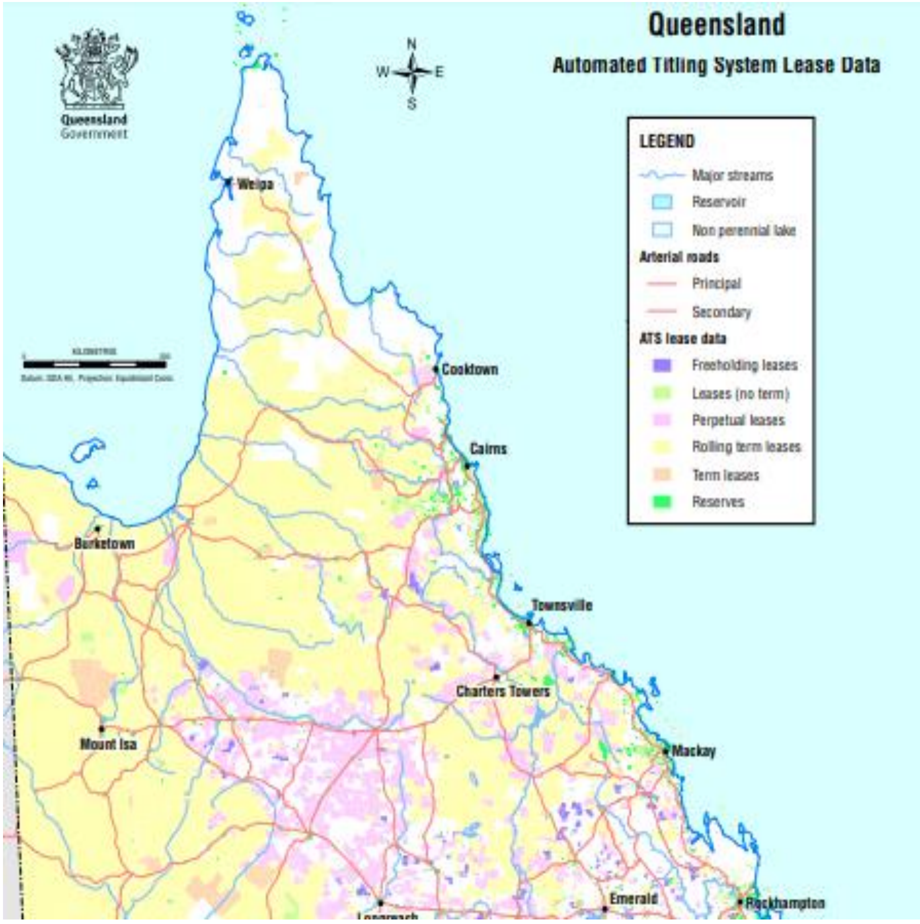

Figure 34 Land tenure in the Burdekin. Source: Qld Government.

Current and Potential Business Models

Integration into Sugarcane production (LB)

Sugarcane remains the dominant crop in the region but has been subject to increasing social pressure associated with the health of the Great Barrier Reef. Despite this, it remains a major agricultural source of economic activity in Queensland and in particular regional communities with every dollar in economic activity in cane growing supporting an additional $6.40 elsewhere in the Queensland economy[211].

Mills operate on very tight margins and both mills and growers are subject to volatility in prices as world sugar production varies. There is a strong incentive to maintain the volume of cane supply by mills and options that incorporate broadacre cropping at the expense of sugarcane production are likely to be met with some resistance. However, options to integrate broadacre cropping into a sugarcane rotation that increases yields of subsequent cane crops to compensate for a lower area of production, diversify businesses and

208 https://www.business.qld.gov.au/industries/mining-energy-water/water/maps-data/water-entitlement-viewer

209 http://lowerburdekinwater.com.au/usage/

210 https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0009/389421/qld-leasehold-land-map.pdf

211 The economic contribution of the sugarcane industry to Queensland and its regional communities https://www.bdbcanegrowers.com.au/wp-content/uploads/2019/11/310175_economic-contribution-of-the-sugarcane-industry-to-queensland.pdf

potentially address natural resource issues are being supported[212] [213]. Consequently, a number of mills actively promote rotations that improve yield of subsequent sugarcane crops.

Traditionally cane is planted then ratooned for up to five years, ploughed out and replanted. The non-cane period between plough out in November and replanting varies depending on the system[214]:

- 6-month rotations utilise a legume planted in December and harvested in April or green manured with cane replanted before June
- 9-month rotations utilise two break crops with cane harvested in June/July followed by a short season mungbean crop harvested in November and soybean planted in December for harvest in April prior to replanting sugarcane.
- 18-month rotations are becoming more popular, applying to at least 20% of sugar rotations. They generally utilise soybean planted in December and harvested in April/May followed by a cereal crop planted in June and harvested in November followed by another legume planted in December and harvested in time for cane to be replanted between April and June.

The advantages of rotational crops in supplying nitrogen (from legumes), providing ground cover to limit erosion and address sugarcane yield decline are well known. Gross margins (Thompson *et al*., 2017) for a traditional sugarcane crop utilising bare fallow are in the region of $2,550/ha/yr but can exceed $2,700/ha/yr when mungbean is included as a rotational crop, $2,750/ha/yr when soybean or cotton are utilised, exceed $2,850/ha/yr when mungbeans and maize are double cropped in rotation and can exceed $2,900/ha/yr when soy and maize are utilised. Gross margins are however very dependent on price and on risk associated with rain during harvest of these rotational crops that can have a major impact both on yield and price.

Extensive inquiry into the feasibility of cotton production in the Burdekin has been made and confirms that high quality, high yielding cotton can be successfully grown The key climate constraint is the occurrence of wetter than average seasons and excessive cloud cover associated with later than normal monsoon weather seasons. Despite this, the agronomic practices developed (varietal selection, optimal sowing window, sowing rates, canopy and nitrogen management strategies) can be used to produce acceptable yields of 7-8.5 bales/ha in constrained seasons (approximately 30% of seasons) sufficient to recoup costs and generate modest returns for growers. For drier autumns that occur more than 50% of the time, research has demonstrated that high yields (>8.5bales/ha) of cotton can be grown with locally tailored agronomic practices[215].

Research and development exploring the integration of rotational crops into sugarcane production has been ongoing for decades and includes projects by Sugar Research Australia (e.g. Burdekin Legume Fallow[216]), CRDC (e.g. NorPak Burdekin and NQ coastal dry tropics (Grundy *et al*., 2012)) and GRDC (e.g. Cropping solutions for the sugarcane farming systems of the Burdekin[217]). Most recently, trials sponsored by the GRDC[218] demonstrated that rotational grains generate significant returns to growers and increased yield from subsequent sugarcane production but the question of whether such systems can generate the equivalent yield of cane over the entire rotation compared to short fallow is yet to be answered.
While integration of rotational grain and cotton crops into sugarcane rotations has received considerable attention, a significant portion of land has been purchased by growers from further south and converted to broadacre cropping. While the rotation is different to that in sugarcane, and the pressures to identify a short season grain option are lower, the constraints and opportunities on-farm and post farm have a number of commonalities including, natural resource management and protection of the Great Barrier Reef, agronomy extension, grain storage, labour access and post farm gate market access.

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212 B. Ashburner (CaneGrowers) *Pers. Comm.*

213 https://grdc.com.au/research/reports/report?id=6774

214 B Dembowski (DAF) *Pers. Comm.*

215http://www.insidecotton.com/xmlui/bitstream/handle/1/4220/CRC1106%20Final%20Report.pdf?sequence=1&isAllowed=y

216 https://sugarresearch.com.au/wp-content/uploads/2019/02/Soil-Health_Burdekin-Legume-Fallow-2018_web.pdf

217 https://grdc.com.au/research/reports/report?id=6774

218 https://grdc.com.au/research/reports/report?id=6774

Hells Gates Dam

The current Hells Gates Dam study is focussed on the potential construction of a 2,110 GL dam that would cost in excess of $5bn and supply water to a 50,000 ha irrigated infrastructure scheme including 5000ha of broadacre cropping and/or horticulture production from water extracted at the Big Rocks weir outside of Charters Towers[219]. The study is based on an initial feasibility assessment that acknowledged significant further assessment was required. Keeping this in mind, the initial assessment found that an attractive investment proposition requires expansion of export quantities of high value crops, and/or a substantial increase in grower returns for traditional broadacre cropping. While there would be potential for broadacre farming of crops such as sugar and cotton, they would not form the core investment return for the scheme[220].

Burdekin Falls Dam

A study on the feasibility of raising the wall of the Burdekin Falls Dam has recently been completed[221]. The study reviews the feasibility of raising the dam wall by two metres to increase capacity and allow a further 150GL to be available for use (in irrigated agriculture or other industries). While the study found the project was economically viable in some scenarios that permit users to pay required water prices, current production of broadacre crops such as sugarcane and fodder were unlikely to have the capacity to pay even with substantial subsidies. In addition, expanded irrigation associated with the project would need to address current and future environmental impacts, the costs of which may have the potential to exceed any economic benefits. Bearing these findings in mind, SunWater, the operator of the dam has commissioned further work on a detailed business case[222].

Constraints and Opportunities

Despite the numerous and ongoing initiatives for irrigated agricultural production in the catchment, feedback suggests that progress of development has largely been restricted due to:

1. Lack of access to agronomy and machinery skills. The large number of growers with small areas of grain production make it un-economical for individuals to purchase large-scale machinery. In contrast, the total area under broadacre cropping must be sufficiently large to attract contractors, particularly those with specialist equipment such as cotton pickers. A critical mass of growers is required to encourage crop agronomists and other specialists (e.g. machinery sellers and repairs etc) to permanently establish a presence in the region.
2. Integration with sugarcane production. For integration with sugarcane production, short season grain varieties that allow harvesting in time for sugarcane to be planted in April are required. These exist for mungbean, but other crop varieties still take a little too long to mature for short fallow applications. For longer rotational options, confirmation that grain crops can be grown with minimal overall impact on sugarcane production across the rotation would contribute enormously to supply confidence of mills. Other, less obvious production issues also require some work e.g. the width of operating machinery between sugarcane and cropping is often not consistent which inhibits controlled traffic farming and can make contract operations more difficult.
3. Peer-to-peer learning. Participatory learning is recognised as one of the most effective methods of extension of R&D knowledge and a lack of a local grower group will have a direct impact on the adoption of R&D outputs (Kuehne *et al*., 2017). In the LB, an alternative cropping group supported by DAF is an excellent example of the results that can be achieved using participatory approaches. In sugarcane production systems further north such farming groups do not exist as the lack of critical mass of growers in the region makes establishment of grower groups for peer learning complicated.

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219 http://statements.qld.gov.au/Statement/2019/7/31/palaszczuk-government-backs-next-steps-for-hells-gate

220 Hells Gates Dam Feasibility Study Final Feasibility Report https://s3-ap-southeast-2.amazonaws.com/os-data-2/townsvilleenterprise-com-au/documents/hells_gates_dam_-_executive_summary.pdf

221 https://www.business.qld.gov.au/industries/mining-energy-water/water/industry-infrastructure/supply-planning/nwidf-feasibility-studies

222 https://www.sunwater.com.au/projects/burdekin-falls-dam-raising/

4. Grains storage expertise and facilities are lacking in the area. High quality grain storage provides growers with a mechanism to manage price risk whereas low quality storage exposes them to losses and downgrades associated with insect and fungal damage.
5. Access to grain marketing expertise and trading options is a constraint. The use of private grain market advisers is becoming commonplace for growers in southern Australia. The large number of domestic and export trading options in the south supports a more competitive trading environment. The small scale of initial grain production in the north will not support multiple trading entities initially but systems to ensure traders and market advisers can operate in an environment that supports emerging grain production will be critical.
6. Access to post-farm processing and export. Ongoing access to regional traders is a significant impediment to broadacre grain production albeit the Port of Townsville is currently undergoing a major expansion and ADM is establishing a presence. CQ Commodities is also looking to be active in the region and recently conducted a tour of growers with ADM. In the absence of local processing and export opportunities grain must be transported to either southern Queensland or northern NSW. Similarly, for cotton, the lack of regional processing requires cotton to be transported 650km to Emerald for ginning which significantly impacts gross margin as well as inhibiting the return of cottonseed for use in regional livestock production. In a typical catch-22, investment in processing and storage facilities requires consistent supply which is constrained by a lack of production associated with the lack of processing and storage.

Constraint Summary

CONSTRAINT	
Crop Genetics	Access to short season crop varieties for use in short fallow phase of sugarcane production. Confirmation of sugarcane yields in a longer rotation that encompasses multiple grain/cotton options. Access to peer to peer learning mechanisms e.g. farming systems groups. Access to knowledgeable agronomists especially for cotton production.
Environment	Address of NRM issues associated with run-off impacts on the GBR. Address of water table and aquifer issues associated with deep drainage. Access to additional water for cropping expansion.
Market and Value Chain	Access to a regional cotton gin would substantially improve gross margins and NPV on irrigation developments. Access to grain processing and containerisation facilities at Townsville. Evaluation of regional and local feed demand required to underpin fodder production cycle. Access to ongoing regional and local trading and marketing expertise and export opportunities.
Farm Inputs, Capacity and Infrastructure	Access to skilled labour when required both for farm operations but also to support R&D.

	Increased understanding and adoption of high-quality grain storage to ensure quality. Compatibility of machinery between broadacre cropping and sugarcane to allow controlled traffic farming and ease of operations.

CRCNA Recommendations

There is enormous potential for the development of broadacre cropping across northern Australia. Realising that potential will require the current constraints which arise from a complex interaction of production environment, regulation, market requirements and infrastructure support, to be addressed. The CRCNA cannot address all the current constraints but it can play a central role in facilitating the interaction of stakeholders and delivery of core knowledge to contribute to broader development efforts. The recommendations below outline options for industry and government as a whole to consider and highlight the contribution that CRCNA might make.

VISION

Many of the current barriers to the development of broadacre cropping in the north stem from a lack of a shared vision for the region across multiple stakeholders. Stakeholders variously wish to:

- develop agriculture as an economic driver supporting employment and other social outcomes, and
- conserve the ecological and cultural value of the region.

While these drivers are not necessarily mutually exclusive, compromise is needed if the future of broadacre cropping in the north is to be realised. Speaking to producers as part of this review, it was advised it was not unusual for two State/Territory Departments, in some cases under the same Minister, to argue diametrically opposed positions about a proposal, inevitably stalling its progress.

Describing and committing to a joint vision that gives all stakeholders a level of certainty for future planning is difficult and for that reason, most often it is overlooked in favour of “action on the ground”. As a result, there has been significant investment in various agriculture and development that generates some value but are unlikely to meet the needs of many stakeholders. This ultimately leads to disappointment and withdrawal of stakeholders from the debate. Indeed, one of the observations from this study is the number of industry participants displaying clear signs of consultation fatigue and disengaging.

A clear vision allows all stakeholders to contribute to debate and realise the opportunities that development of broadacre cropping could deliver while conserving ecological and cultural values. A “whole of the north” vision is unlikely to be either practical or realistic given the different priorities across jurisdictions and environments but a shared vision at the State or even regional scale would be a major contribution to progressing the necessary discussions.

Recommendation 1: The development of a joint vision for agricultural development across each State or region involving growers, processors, members of the public and government is needed to support discussion and debate on how the opportunities afforded by development of broadacre cropping (or even agriculture as a whole) can be realised while protecting inherent ecological and cultural values . The CRCNA cannot own this process but could facilitate the interaction of stakeholders and provide rigorously reviewed information to support an evidence-based discussion.

ESTABLISHMENT OF LANDHOLDER ADVISORY GROUPS

A common element of feedback was the lack of formal input from growers and their advisers to assist in the expansion of broadacre agriculture. Landholder advice and engagement is critical for many different aspects of cropping expansion. At the strategic level, landholders are a critical group of stakeholders that must be involved in developing a joint vision and in advising on underlying land and water access policy and legislation. At the technical level landholder input can contribute to:

1. Validation of research findings – this is particularly important in providing validation of modelled cropping outputs in the field as discussed below.
2. Setting of research priorities – the effectiveness of participatory R&D, whereby growers determine the best approach to delivering a desired outcome based on expert input (rather than researcher led approaches), has been well established. The Water-use Efficiency Initiative established by GRDC with CSIRO was one such approach where growers in the southern and western cropping zones determined the best approach to achieving a 10% increase in water use efficiency then implemented the required practice changes. The approach achieved the objective and was subsequently recognised in the national Eureka Awards for science. This is but one example of where participation in local farming systems groups a recognised driver of technology adoption is (Kuehne *et al.*, 2017).

The CRCNA already has established landholder participation in some broadacre cropping projects and the opportunity exists to build on this to develop more formal Landholder Advisory Groups (LAGs). In addition, there are several researchers and consultants that have extensive experience and have the respect of growers required to bring such advisory groups together.

Mere provision of advice on R&D priorities will not be a enough enticement to elicit landholder engagement in LAGs. To gain true participation, growers must see how their contributions directly influence policy, strategic planning and investment decisions – not just participate in a 'think-tank'. Their involvement in R&D as partners is critical to prioritising approaches and maximising adoption of R&D outputs.

Establishing LAGs in the north is complicated by the sparse population separated by significant distances. In many instances, telecommunications do not adequately support the use of videoconferencing and novel ways of facilitating communication within and between LAGs need to be assessed. Despite the difficulties, several LAG type groups have either formed or have the potential to form including:

- Northern Australia Crop Research Alliance formed as a private company by the key producers in the ORIA to facilitate profitable outcomes for the Ord.
- Kimberley Pastoralist Cattleman's Association working on cropping ventures to support cattle production in the Kimberley/Pilbara
- Northern Territory Farmers Federation actively pursuing cropping expansion.
- Far North Queensland Sustainable Cropping Group in the Gilbert catchment
- Participatory cropping groups being coordinated by DAF in the Gilbert (Pendergast) and Burdekin (Dembowski) catchments and participatory groups being coordinated within CRCNA projects such as in the Mitchell (Matchett) that may not be of sufficient size to have critical mass but could collaborate with other groups such as FNQSC.

Recommendation 2: CRCNA works with existing Landholder Advisory Groups (LAG) and seeks to develop LAG support across north Queensland initially focussing on the Flinders catchment, Gilbert catchment, Mitchell catchment and sugarcane production systems in the Burdekin and MDWSS. LAGs should be encouraged to identify cropping R&D priorities within overall farming systems (e.g across cattle, cotton, sugarcane enterprises etc) and actively participate in R&D activities. LAGs should be actively involved in forming the vision for agriculture in their State and/or region as well as catchment-based strategies for broadacre agriculture development.

LAND AND WATER

There are growers and others willing to invest the money and effort required to establish a broadacre cropping system in greenfield and/or brownfield locations. However, reliable access to land and water are consistently identified as the major impediments to broadacre cropping expansion in northern Australia. Implementing any new production system is inherently risky, regardless of location, the fact that growers are willing to take that risk and invest speaks to the potential for broadacre crop production. However, any investment must be underpinned by certainty regarding access to water and land.

All stakeholders have highlighted the complex, time consuming and complicated processes for accessing water and identifying when water licences might be made available. There is a significant body of opinion from landholders that water allocation processes are overly conservative. This view is further entrenched by the lack of clarity around water access decision making processes. Without certainty on the likelihood of gaining access to water, and having the capacity to exploit that access, it is difficult for landholders to assess the viability of irrigated cropping development and/or attract/commit the capital required for development investment.

Feedback indicates that regulation around land usage impacts the development of broadacre cropping in all areas of the north. Restrictions surrounding tenure, the purpose of leases, and the process to seek approvals to alter them remain a constraint to investment.

The application of legislation and policy to approvals for land development that overlap between State and Federal jurisdictions is widely interpreted as being established to prevent any clearing of trees. Where land clearing is a pre-requisite to establishing either dryland or irrigated cropping, the complexity of obtaining the required approvals is a major deterrent to investment. The lack of clarity in the intent of the legislation leads to scepticism that any development will be approved and consequently there is a lack of enthusiasm for investment and engagement.

Recommendation 3: In the absence of a shared vision across growers, industry, indigenous Australians, the broader public and Government, it is difficult to envisage how agreed strategies for catchment-based development of broadacre agriculture can be developed and implemented. Strategies should inform regulation of access to water and land to provide the certainty required for investment while meeting broader conservation and cultural needs. In line with Recommendation 1, the CRCNA could facilitate the interaction of stakeholders and provide rigorously reviewed information to support an evidence-based development of catchment wide strategies.

VALIDATION OF RESEARCH

By necessity, many studies of broadacre cropping in the north have utilised crop and climate models to estimate the areas of potential production. The crop model (APSIM) is amongst the most sophisticated models available worldwide but models and their estimates of both dryland and irrigated production are influenced by a range of assumptions. Recognising this, there is a critical need to validate previous modelling with the actual experience of growers in the various catchments. Many of these growers have been successfully producing broadacre crops for a number of years and have data for a range of crops, production systems and environments.

Comparison of this data with modelled expectations, and adjustment of the underlying assumptions, is important to accurately determine the actual potential of broadacre cropping. Validation of dryland crop production is of particular interest as the potential to complement irrigation development is an important aspect of broadacre crop expansion. However, as trust is low, this information is generally well protected. There must be a value proposition to growers to share their experience and data to validate current understanding. Northern Australian growers compete with other producers globally and undermining their commercial position is counter-productive to developing the north.

Validation of small scale trials in commercial settings is also important. In particular, participatory approaches to validating rotation options in various farming systems will be an important aspect of maximising adoption of crops that contribute to the bottom line of farm businesses and address sustainable production.

Recommendation 4: Commercial production data needs to be generated or accessed to validate and update previous modelling predictions as well as providing feedback on how current, small-scale trial results are best implemented into commercial farming business operations to maximise profit and sustainability (commercial sensitivities need to be understood and protected). The CRCNA is in a strong position to contribute as it already funds a range of small-scale and larger commercial scale trials and could consider further investment with private sector companies and growers that are interested in trials of rotational crops in a whole of farming system context. Previous estimates of production potential based on modelling require urgent validation to underpin evidence-based policy decisions.

RESEARCH AND DEVELOPMENT CAPACITY

Current cropping R&D in many areas of northern Australia is either conducted with grower equipment (strip trials), limited locally available equipment or equipment transported from the south at considerable cost. The cost of trials is further increased by the need to cover travel costs of R&D staff located in regional centres. In addition to increasing the expense of trials, the remote location of staff also complicates the day to day management of trials and recording of required observations. Growers are willing to host trials and to contribute to management where possible, but this cannot come at the expense of their businesses. Private sector companies are also contributing to trial costs through cash and in-kind and have expressed an interest in continuing to support relevant R&D. Local placement of equipment and staff would be a preferable outcome but may not feasible until core capacity of crop production is established warranting a greater investment in R&D. In the interim, it will be important to recognise that trials in many areas will not conform to normal expectations of costs and this will need to be factored into R&D budgets. There are opportunities for greater collaboration across research entities and the private sector to share equipment, co-locate trials and coordinate day to day management of trial sites to minimise costs overall and maximise the probability of generating the best possible data from current and future trial work. A greater level of collaboration could also address some of the current issues of sporadic funding for R&D that does not allow for training and ongoing deployment of staff and results in the regular loss of regional experience and rapport with growers.

Recommendation 5: Opportunities exist to minimise the cost of trials (although they will remain expensive relative to trials further south) and to ensure availability of critical infrastructure (trial equipment, irrigation, storage etc.) through greater collaboration between research entities and with potential private sector suppliers. The CRCNA already funds a range of trials that utilise on-farm equipment and collaborates with seed companies to access new varieties. There is potential to extend the approach to generate further input from other suppliers (seed, equipment, inputs) as well as facilitate greater levels of collaboration across different trial operators. A number of private sector entities would welcome the opportunity to work more closely with the CRCNA, particularly in trialling new crops and varieties in commercial farming systems. Co-location of trials and trial management to deliver the highest possible standard of R&D for northern Australian broadacre cropping businesses and leverage investment and expertise where possible is also encouraged.

AGRONOMY EXPERTISE

Most broadacre crop growers utilise professional agronomy advice either through retailers such as Nutrien and Elders or by engaging an independent consultant. Agronomy support is targeted toward the established industries such as horticulture, sugarcane and cattle. Independent cropping advice is somewhat restricted but is increasing either as agronomists from the south move north or through training of agronomists in the north. It can be expected that more agronomy expertise will become available if and when expanded cropping achieves a critical mass to support them. It will be important to include agronomy experts in LAGs or other forms of extension and communication as they are an effective conduit to provide advice to a wide range of growers.

Recommendation 6: CRCNA encourages regional agronomists to participate in LAGs to provide feedback and information from and to their wide range of grower clients.

LABOUR

Access to skilled labour is an issue across much of agriculture in Australia and the remoteness of some regions of northern Australia add to the difficulties in attracting required labour to undertake time-critical operations. Australian agriculture has a high reliance on the use of foreign workers on working holidays, especially for seasonal work. The Federal Government formed an Agricultural Labour Advisory Committee in December 2019 to develop a National Agriculture Workforce Strategy[223]. Current debate on labour in agriculture is dominated by the horticulture industry, but it will be important that the national strategy considers the needs of the broadacre sector and in particular the needs of the emerging broadacre cropping sector in the north.

Recommendation 7: The Agricultural Labour Advisory Committee consideration of labour constraints is an important aspect of increasing productivity and profitability across the agriculture sector including pre and post-farm value chains. While a National Agriculture Workforce Strategy will seek to provide a pathway to addressing labour issues nationally, it is important that the unique features of the north that add complexity to attracting required skilled labour to the region are clear. The CRCNA should consider the potential to facilitate ongoing interaction between the Committee and interested grower and industry groups to ensure that strategic options are suitable for and can be implemented in northern Australia.

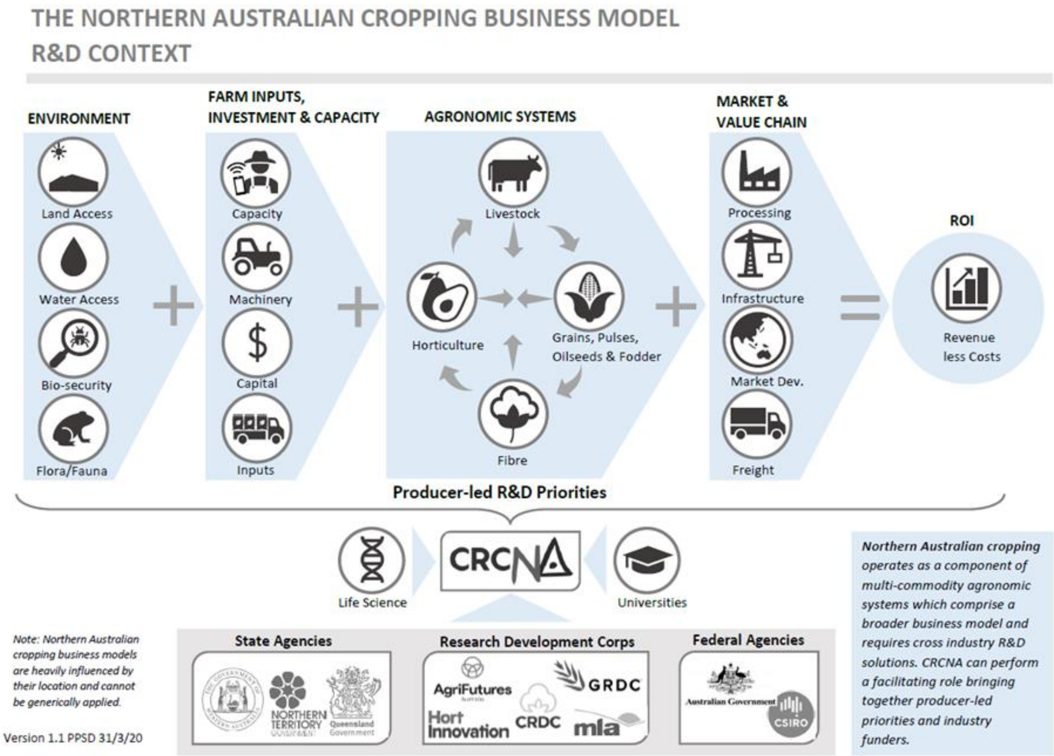
INTEGRATED SYSTEMS

Expansion of broadacre cropping is largely focussed on diversification and/or supplementation of cattle production properties and the adoption of sustainable rotations in other production systems. Broadacre cropping on cattle properties is focussed on the production of fodder and feed grains, cotton production for lint and seed as an alternative cattle feed source, and the production of rotational cash crops such as mungbeans, soybean, oilseeds and other pulses. Crops working in conjunction with another system (e.g. sugar or maize) are focussed on short rotational options or integration into a longer fallow with a preference for cash crop options. The variable nature of the environment, especially for dryland production, requires a flexible approach to cropping that remains integrated with other enterprises. It seems likely that for irrigated broadacre grain production to be viable, either two crops per year are required (with accompanying increases in water storage requirements) and/or irrigated cropping needs to be integrated with dryland production and other enterprises (cattle, cotton and sugarcane production). As noted above, there is a need to validate the modelled production numbers for dryland and irrigated cropping using actual production figures from growers.

Current activities are focussed on:

- production of cotton for lint with seed utilised in cattle production systems
- production of grain or fodder either in opportunistic dryland systems or as part of an irrigated crop rotation
- trials of oilseeds to support potential local processing with by-products used in supplementary feed
- trials exploring rotations for cotton production that either generate cash crops in their own right and/or contribute to soil quality and the feedbase for cattle production.

223 https://haveyoursay.agriculture.gov.au/national-agricultural-workforce-strategy



All the emerging production systems in the north envisage a flexible approach integrating grain and fodder production into broader enterprises. Growers have inherent skills in understanding how these enterprises interact to maximise profit and sustainability for their businesses. Ultimately, growers are looking to maximise the return on land and water assets be that from individual cash crops, the use of dual purpose crops such as sorghum and peanuts for hay or the use of high value by-products from the value chain such as cotton seed or meal from oilseed processing in cattle rations. In all cases systems must be optimised across enterprises to maximise returns and sustainability.

Recommendation 8: The rural Research and Development Corporations (RRDCs) are adept in identifying R&D needs, developing investment strategies and implementing required RD&E activities for their respective commodities. There is however more limited capacity for RD&E into production integration across enterprises that will be a key feature of expanded broadacre cropping in the north. The opportunity exists to work with growers, industry and RRDCs to identify and address RD&E needs on a whole of farm and value chain basis. The opportunity exists for the CRCNA to work with RRDCs to identify business constraints and opportunities across multiple commodities and develop required RD&E strategies that will contribute to the profitability and sustainability of northern Australian farming businesses.

STORAGE & HANDLING SUPPLY CHAINS

Regional storage and handling opportunities are a key aspect of limiting costs post farm gate. As broadacre cropping expands, the north will need to service markets domestically to the south as well as export to the north. Efficiency improvements in supply chains can result in the difference between a viable business model and not. Scale for broadacre cropping on its own is unlikely to justify specialist supply chains so working in with other systems is essential. For bulk commodities, this could include sugar, rice and woodchips.

> **Recommendation 9**: CRCNA is already investing in supply chain analysis through the "Reframing supply chains in northern Australia" investment. The opportunity is available to link this work strongly with large trading companies operating in the north such as GrainCorp and ADM as well as smaller accumulators such as CQ Commodities to further understand the key storage and handling requirements underpinning a viable model. This will be key to designing the R&D into the most efficient solution.
>
> As the industry matures, there is also the potential to utilise the well-established and still in demand grower storage workshops run by the GRDC.

VALUE CHAINS

Just because it can be grown doesn't mean it can be sold – at least for a viable price. Understanding the current markets and their needs as well as emerging markets and the support they require is essential for determining the viability of a business model. It is difficult for producers to do this when markets are distant (export or southern states), even when they have significant scale. Hence there can be a reliance on interposed traders or downstream processors which may have significant market power. It is critical that the market is fully understood before significant capital is invested into a venture. Varying solutions can assist growers strengthen their market access. Producer owned marketing and/or processing cooperatives are common to assist in establishing scale which can then develop relationships further down the chain which bring value back to the grower.

> **Recommendation 10**: CRCNA facilitates research into current and new markets and assists producer groups in finding structural solutions that strengthen their marketing position. At least some of this is already being addressed in the "Reframing supply chains in northern Australia" but the importance of adopting sustainable farming systems generating product that is driven by market demand cannot be overstated.

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APPENDIX A – Relevant Research

Extensive R&D of relevance to the region has been conducted by a number of research agencies. A non-exhaustive list is below:

R&D	Lead Agency	Year
Future vision for irrigation research, development and extension	CRDC	2010
Development of A Quantitative Set of Enviro-Economic Sustainability Indicators	CRDC	2012
The Development of Sustainable Cotton Farming Systems for Coastal North Qld	CRDC	2013
Completion of Burdekin Cotton Feasibility Study	CRDC	2013
Assisting cotton industry diversification in coastal Northern Queensland & tropical Australia	CRDC	2016
Development Tour for Northern Australia	CRDC	2019
Potential for Growth in the Australian Cotton Industry	CRDC	2014
Capital: Sundown Smart Farm Development	CRDC	current
Science leadership for cotton development in Northern Australia	CRDC	current
NorPAK Cotton production and management guidelines for the Burdekin and north Queensland coastal dry tropics region	Cotton Catchment Communities CRC	2012
Developing profitable strategies for increasing growth rates of cattle grazing tropical pastures	MLA	1997
Supplementary feeding to improve breeder and weaner performance	MLA	2012
Improving profit from pasture through increased feed efficiency	MLA	current
Revise Australian feeding standards to better achieve product specifications and improve ruminant efficiency	MLA	current
Optimising nutritional supplement use in Australia's northern beef industry	MLA	current
An exploratory analysis of the scope for dispersed small-scale irrigation developments to enhance the productivity of northern beef cattle enterprises	CSIRO	2018
Northern Australia Food and Fibre Supply Chains Study	CSIRO	2014
Irrigation costs and benefits : A technical report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment, part of the North Queensland Irrigated Agriculture Strategy	CSIRO	2013
Costs, benefits, institutional and social considerations for irrigation development: A technical report to the Australian Government	CSIRO	2017

from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments		
Climate data and their characterisation for hydrological and agricultural scenario modelling across the Flinders and Gilbert catchments: A technical report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment, part of the North Queensland Irrigated Agriculture Strategy	CSIRO	2013
Agricultural resource assessment for the Flinders catchment: An overview report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment, part of the North Queensland Irrigated Agriculture Strategy	CSIRO	2013
TraNSIT: Unlocking options for efficient logistics infrastructure in Australian Agriculture	CSIRO	2017
North West Regional Plan	Qld Govt.	2010
Cropping in far North Queensland	Qld Govt.	2016 &2017
Gulf Rivers Agricultural Zone: An overview of the project's development over time	Qld Govt	2016
White Paper on Developing Northern Australia	Aust. Govt.	2015
North West Queensland Strategic Development Study	MITEZ	2014
Gilbert River Irrigation Area Investment Report	Gulf Savannah Development	2014
Opportunities and Barriers for Grains Research and Development Corporation (GRDC) leviable crops in areas north of the Tropic of Capricorn.	GRDC	2017
GRDC GrowNotes – Northern: Mungbeans, Chickpeas, Maize, Safflower, Soybean, Sorghum and Peanuts	GRDC	Multiple
Irrigated Pulses	GRDC	2018
Australian Herbicide Resistance Initiative	GRDC	Ongoing
Innovative crop weed control for northern region cropping systems	GRDC	Ongoing
Biosecurity preparedness for the grains industry - Preparation and review of emerging pests and diseases	GRDC	2020
Australian Soybean Breeding Program	GRDC	Ongoing
Australian Chickpea Breeding Program	GRDC	Ongoing
National Mungbean Improvement Program	GRDC	Ongoing
Australian Peanut Genetic Improvement Program	GRDC	Ongoing
Sorghum core pre-breeding program	GRDC	Ongoing
National Maize Enhancement and Productivity Improvement	GRDC	2014
Better sorghum: larger grain with more protein	GRDC	Ongoing
Improving the integration of legumes in grain and sugarcane farming systems in southern Queensland	GRDC	2012
Cropping solutions for the sugarcane farming systems of the Burdekin	GRDC	2015
Identifying Candidate Genes for Stay-Green in Sorghum	GRDC	2014

Grain Storage Extension	GRDC	Ongoing
Population genetics of Heliothis migration, recruitment and origins	GRDC	2003
Assessment of the potential for canola in the northern region	GRDC	2001
Effective and safe rodent management in grain cropping systems	GRDC	2009
Optimising mungbean yield in the northern region - Mungbean physiology	GRDC	Ongoing
Optimising mungbean yields - Determining factors contributing to yield gap in mungbean in the northern region	GRDC	Ongoing
Optimising mungbean yield in the northern region - mungbean agronomy	GRDC	Ongoing
Optimising mungbean yield in the northern region - Mungbean irrigation	GRDC	Ongoing
Australian Pulse opportunity analysis	GRDC	2019
Expanding options for sorghum- Food and distilling	GRDC	Ongoing
Conventional insecticide resistance in Helicoverpa – monitoring, management and novel mitigation strategies in Bollgard iii	GRDC	Ongoing
From paddock to port: supply chain opportunities for central Queensland with the Port of Townsville (POT), Port of Mackay (North Queensland Bulk Ports	Corporation) (NQBPC) and Gladstone Port Corporation (GPC)	GRDC
Northern Australian Water Resource Assessment (NAWRA) - Fitzroy	CSIRO	2018
West Canning Water Groundwater Resource Assessment	DWER (RfR)	2017
La Grange Land and Water assessment	DPIRD (RfR)	2016
Fitzroy Valley groundwater	DWER (RfR)	2016
Mowanjum irrigation trial	DWER (RfR)	2018
La Grange – West Canning groundwater assessment	DWER (RfR)	2018
Pilbara Hinterland Agricultural Development Initiative	DPIRD (RfR)	2016
Transforming Agriculture in the Pilbara (TAP) project	DPIRD (RfR)	Current
Northern Beef Futures (NBF) project	DPIRD (RfR)	2017
Agriculture and Pastoral contribution to the Broome Growth Plan	Kimberley Development Commission	2016
An exploratory analysis of the scope for dispersed small-scale irrigation developments to enhance the productivity of northern beef cattle enterprises	CSIRO	2018
Ord Stage 2 and 3 Assessments	Various State Agencies (RfR)	2009-13
Development of top field cropping production systems[1]	NACRA	2017
Ord River Irrigation Area pulse product and market research project	ORDCO	2018
Cotton research (Kimberley Agricultural Investment, The Chia Company, Department of Primary Industries and Regional Development, University of Western Australia, University of	NACRA	2017

Sydney, Queensland Government, CSIRO and Saudi Arabia's King Abdullah University of Science and Technology.		
Cotton Trials	NT Department of Primary Industry	2019
Preliminary Determination of Dryland Cotton Yield Potential in the NT[2]	CSIRO	2019
CRDC 'Science leadership for cotton development in northern Australia' project	CSIRO	2018 -
Assessment of the development potential of the water and soil resources of the Roper River catchment in the NT	CSIRO	2019
Cotton Gin Assessment	PWC	2019
Broadacre Cropping in the NT	DPIR	2020
De-risking agriculture in the NT	NAJA	2019
Adelaide River Off-Stream Water Storage facility business case	CSIRO	2020
Northern Australian Water Resource Assessment (NAWRA) – Darwin catchment	CSIRO	2018