HERBERT VALLEY

ALTERNATIVE CROPPING

STUDY

HINCHINBROOK SHIRE COUNCIL
PROJECT RFQ002279 -
NOVEMBER 2018

Capability and Feasibility Study into the identification of agricultural crops capable of being grown in the Herbert River district, including crops complementary to sugar cane.

TROP CROP PTY LTD

Science Technology & Sustainability

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1. EXECUTIVE SUMMARY

RECOMMENDATIONS

1. It's all about water

The limited access of irrigation water through irrigation licences and allocations in the lower Herbert Valley via the Herbert River Resource Operations Plan restricts prospects and feasibility for a lot of alternate and complementary cropping. The current moratorium on granting access to additional groundwater is a constraint. This needs to be worked through with the end point in mind that the availability of water for irrigation is increased.

The Hinchinbrook Shire Council is in discussion with Department of Natural Resources Mines and Energy with a view to expediting water licensing and water trading in the Lower Herbert. The Hinchinbrook Shire Council is in the best position to do this.

It is important that Herbert growers contribute to any review of the Resource Operation Plan. The bottom line, it is all about water!

2. What are we supplying and where are we selling it

There now needs to be a stronger focus on identifying future market demand and future trends in consumption. What are the markets?

This was outside the scope of this study. Our brief was to look at the more basic questions on soils and climate suitability, and cropping environments for the district, identifying a capacity for the district to grow a diversity of crops.

The impetus for growers to look at complementary crops and to integrate them into the local production system has to come from a prospect of being able to sell a product and to make a profit. The next step is to identify opportunities either in local and domestic markets, or in export to overseas trading partners.

This requires stronger and longer-term relationships with marketers and participants in the supply chain.

3. Best use of fallow ground

One of the challenges is for production in the Herbert to achieve an economy of scale.

A farming model to coordinate the availability and management of fallow ground so that reasonably contiguous or proximal areas are cropped in any one season will help. Conceivably this is on a share-farming basis, where cropping is managed by a single operator or as a coordinated effort.

Such a model would assist with timely access to machinery, timely execution of operations, optimisation of soil testing and inputs, and timely harvest. It should also deliver sufficient area and size of production for a crop to be a significant player in the market, and lessen risk of overcapitalisation. For individual growers participating it should also reduce conflict of demands on the grower's time and energy with different crops.

There is no set formula or protocol however the model has operated on a small scale in the district with rice and melon production. Coordinated management and scale will be a plus in negotiations with marketers where they can see an outcome and success for all parties.

4. Capital funding for infrastructure

A business case is required for the establishment of adequate receival, handling and storage facilities. The ability to store and dry down grains to an optimal moisture content before transport to market will be a plus for the district, evening out the effect of variation in seasonal conditions at harvest.

This will include a funding pathway for the necessary infrastructure.

Shipment from storage in bulk lots will enable an economy of scale for transport, improve efficiency and reduce costs. District efforts to date with various crops with transport to marketers have been fragmented. This has meant high freight costs and probably downgraded product quality at the point of delivery.

5. Grower participation and incentive

It remains important to promote participation with growers and harness the interest of younger growers in pursuing a more diversified agricultural regime. Diversified cropping and rotation with sugarcane should contribute to a more robust regional economy. The aim is also to improve soil health with break crops and in the medium to long term to improve the soil condition for the sugarcane crop cycle.

The Hinchinbrook Shire Council is actively engaged with a young farmers group to explore future diversification options and farming practices. As an impartial body the Shire is probably the right vehicle to do this, acting in the interests of economic development.

There is opportunity to bring in occasional expert guest speakers for grower information sessions to discuss potential opportunities and identify solutions. The key is for growers to identify and work out the most innovative and productive crop diversification pathway.

6. Dedicated agronomy and technical resources

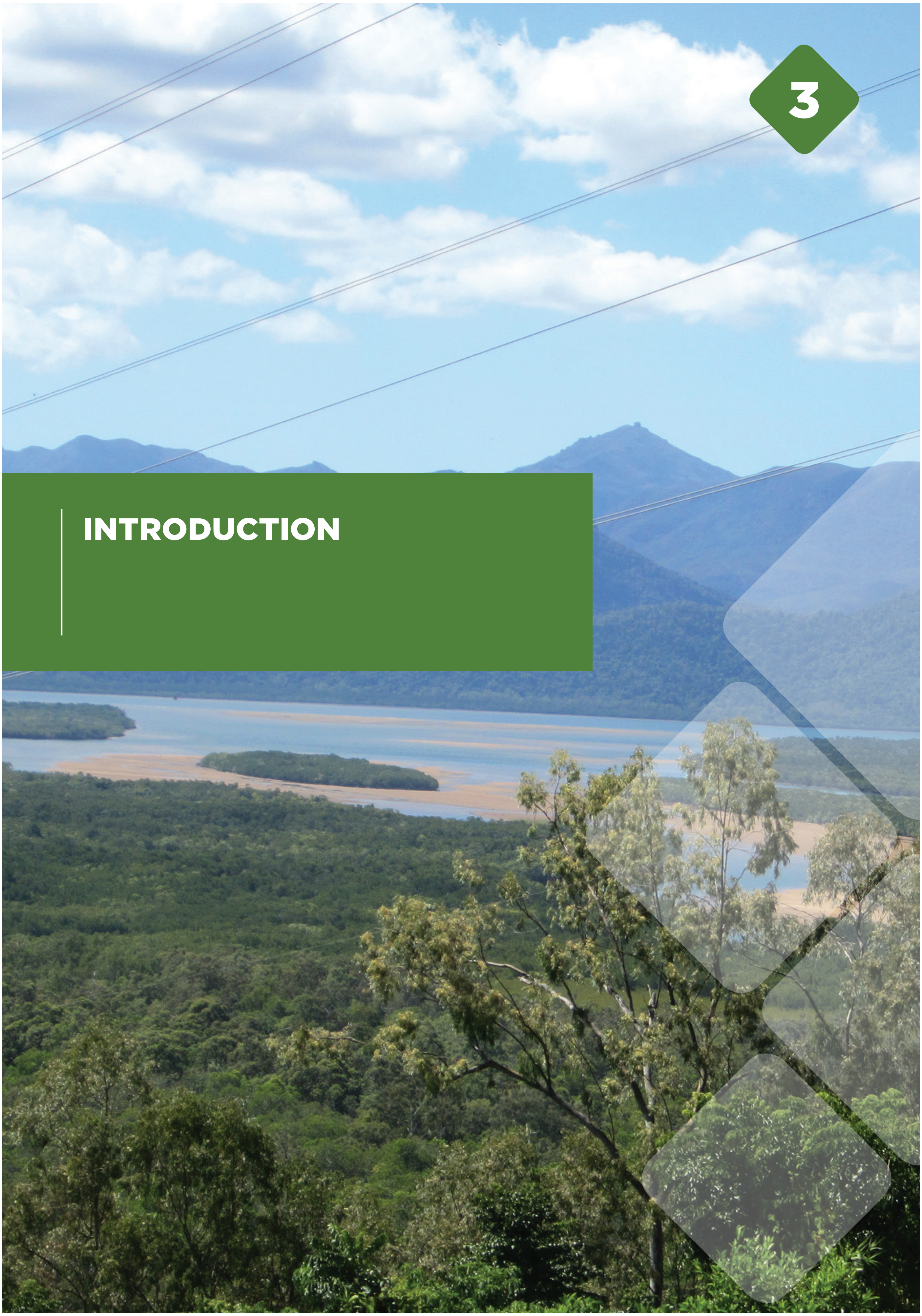
The Herbert is well serviced with expert advisory support for sugarcane. For success with alternative and complementary crops growers need support with specialist agronomy and plant protection skills. Feedback from growers has highlighted the need for agronomy and plant protection advice.

Such services need to be brought into play. This will be a combination of commercial and private sector enterprise, and possibly government agencies. Crop agronomy capacity and service has to be recognised in the value chain, the availability and supply of agronomy capacity needs to be sustainable.

While this is outside the control and budget of the Hinchinbrook Shire, there may be development funding available to assist in this area.

PROJECT RFQ002279

CAPABILITY AND FEASIBILITY STUDY INTO THE POTENTIAL GROWING OF CROPS IN THE HERBERT RIVER DISTRICT



3

INTRODUCTION

3. INTRODUCTION

The Hinchinbrook Shire Council in 2018 requested an assessment of cropping potential in the Herbert River Valley. The heading was 'Capability and Feasibility Study into the identification of agricultural crops capable of being grown in the Herbert River district, including crops complementary to sugar cane.'

The district currently relies upon sugarcane as the principal crop grown in the district. The single reliance on one major crop poses issues in terms of reliance on a single crop influencing jobs, job creation and income to the region and also with continuous cane cropping in a monoculture system. The premise is that complimentary rotational cropping may improve soil condition and lift productivity in the cropping system.

The Hinchinbrook Shire Council is seeking ways for agriculture and agri-business to improve the resilience of the regional economy.

This Hinchinbrook Shire Council initiative is a component of a larger project being undertaken into emerging markets, supply chain gap and sector capacity in the agricultural sector of North Queensland by the North Queensland Regional Organisation of Councils (NQROC). Here the objective is to identify high return and demand products for both export and domestic markets and assess trend forecasts.

The purpose and objective of the Hinchinbrook Shire study is the identification of suitable agricultural / horticultural crops that may be grown and harvested in the Herbert River district having regard to soil / climate suitability and limited by rain-fed water resources.

Objectives are:

- identify crops that may be grown in the region and with conceivable commercial feasibility;
- restricted to agricultural / horticultural crops;
- that may be grown in rotation to cane, both long and short-term rotations, or as a stand-alone crop;
- relate the potential identified crops to geographical areas / or soil types of the district based on soil suitability and will provide comments on other potential constraints such as slopes etc;
- provide an industry-based indication of time of year suitable for identified crop growing and indicative quantity of water demand relative to the identified crop for premium yield of product;
- provide an indicative guide of potential yield of potential crops on different soils / districts;
- identify any particular need for industry specialised practice pertaining to identified crop to allow structural adjustment (if any) and where possible (but not necessary) an indicative cost;
- identify risks to production of identified crops including climatic and legislative constraints;
- identify best growing time for identified crops (particularly for rotation with cane opportunities); and finally;
- identify harvest, storage transport needs / requirements and suggested methods to address.

The Herbert River region has long demonstrated success with the production of sugarcane and milling to produce raw sugar and associated products. The Herbert has one of the longest histories of sugarcane production in Australia.

The work undertaken to support sugarcane by long-time sugar millers CSR and more recently Sucrogen and Wilmar, the BSES / Sugar Research Australia, and industry productivity bodies has contributed enormously to characterisation and understanding of local soils and production constraints. The region is a rich land resource, a vast area well suited to rain fed agriculture and has always been at the forefront of industry innovation in soil management and agricultural practices.

There has been less attention given to the production of other crops. Horticultural and grain crops and plantation forestry have had a place in the Herbert for a long time but have established only on a relatively small scale. Additionally, the extent of crops other than sugarcane has diminished in recent times with expansion of the sugar industry.

This corresponds with a paucity of research over time into other crops and agricultural pursuits compared with neighbouring regions such as the Burdekin, Mareeba and Atherton Tablelands, and more distant Bundaberg. Irrigation is a factor here and an impetus for high value agricultural production in those districts where irrigation has been available through supplemented schemes following significant public investment.

The most significant study undertaken for the Herbert as a fundamental background for agriculture other than sugarcane has been the Queensland Department of Primary Industries Land Resources Bulletin – 'Soils and Agricultural Land Suitability of the Wet Tropical Coast of North Queensland: Ingham Area' completed in 1990. This valuable work covered a detailed survey and mapping of the districts soils and included assessment of the suitability for 20 crops throughout the region.

Despite being a considerable investment into understanding the region's natural resources much of this report appears to have remained underutilised. There is not a wide awareness of this report and the soils mapping undertaken.

We have attempted to revisit the findings of the 1990 work and apply them to consideration of other crops, with the aim of fitting in with the sugarcane cropping cycle and to deliver a benefit from increased cropping diversity to farm profitability and soil health.

The principal challenges for cropping in the Herbert are to manage

- significant fluctuations in seasonal conditions;
- excess and deficits of rainfall;
- limited access to irrigation in certain geographical areas in the district;
- price and profitability fluctuations with agricultural commodities.

4

THE APPEALING CLIMATE OF THE HINCHINBROOK SHIRE

HERBERT VALLEY REGION, QUEENSLAND, AUSTRALIA

4. THE APPEALING CLIMATE OF THE HINCHINBROOK SHIRE

HERBERT VALLEY REGION, QUEENSLAND, AUSTRALIA

The Hinchinbrook Shire is centred on Ingham in the Herbert River Valley, 18.65 Degrees South, 146.18 Degrees East in the Queensland east coast tropics. The region has a monsoonal rainfall receiving on average 2062 mm per year (most recent 30 years). Typical summer rainfall occurs from November to March.

As a growing region the Herbert has a more moderate climate than areas further to the north and the northwest inland, avoiding higher summer temperatures and climate extremes. Maximum monthly mean temperatures in the most recent 30 years have tracked between 22.8° C and 35.6° C, (mean 29.3° C), and minimum temperatures between 10.8° C and 24.2° C (mean 19.1° C). Agriculture is predominately rain-fed with some irrigated areas. Generally, the wetter areas are in the north with lower rainfall in the south and in sheltered pockets in the main Herbert River valley.

The geographical distribution of various climate measures can be seen in Figures 1 to 6, with notes on the data used in Appendix 1. Annual precipitation (Figure 1) is highest (circa 2500mm) in the northeast of the Shire and lowest in the southeast (circa 1000mm) due to the orographic influence of the coastal ranges and their orientation. The precipitation in the driest quarter of the year (Figure 2: July to September) follows the same pattern with minima around 40mm and maxima around 180mm. Areas in the west of the Shire receive increased rainfall due to the orographic effect of the coastal escarpment.

Maximum temperatures for the warmest month (Figure 3: December) are remarkably uniform across the Shire and range from 28 to 33° C. These are not extreme and in comparison minimum temperatures for the coldest month (Figure 4: July) range from 10 to 16° C, again very mild for the broader region. There is a strong temperature gradient inland from the coast due to topography and the fact that sea temperatures have a much lower range than land.

Maximum monthly solar radiation (Figure 5: October) is highest on the coast and declines along the Herbert valley but the range from 23 to 25 MJm-2day-1 is not great and nowhere is solar radiation limiting for crop growth. Likewise, minimum monthly solar radiation (Figure 6: July) ranges from 14 to 15 MJm-2day-1 and again is not limiting for plant growth. This effectively means that plant photosynthesis can occur in any month and there is no limiting effect of sunlight receipt in any season.

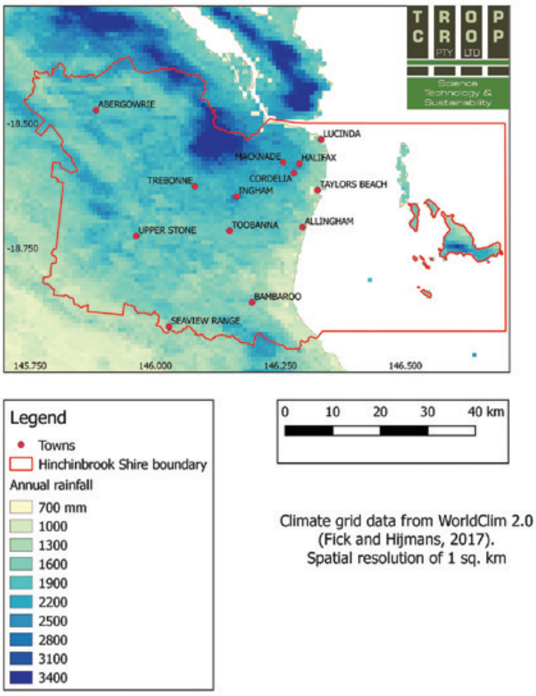


Figure 1: Annual precipitation for the Hinchinbrook Shire. Source: WorldClim version 2.0

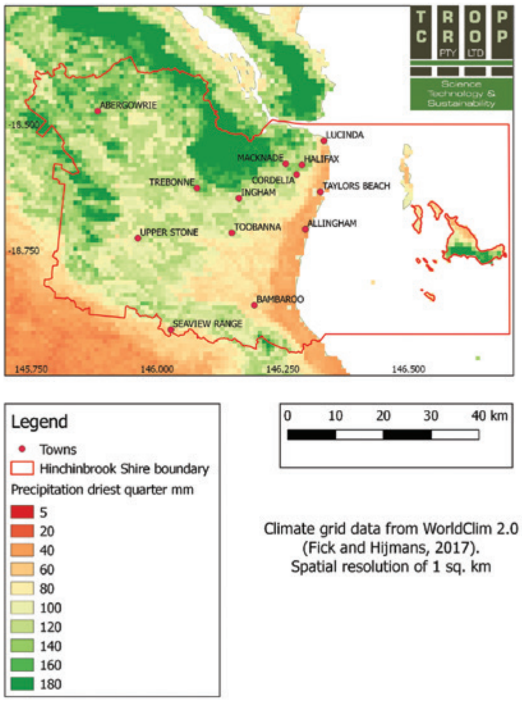


Figure 2: Precipitation for the driest quarter of the year, Hinchinbrook Shire. Source: WorldClim version 2.0

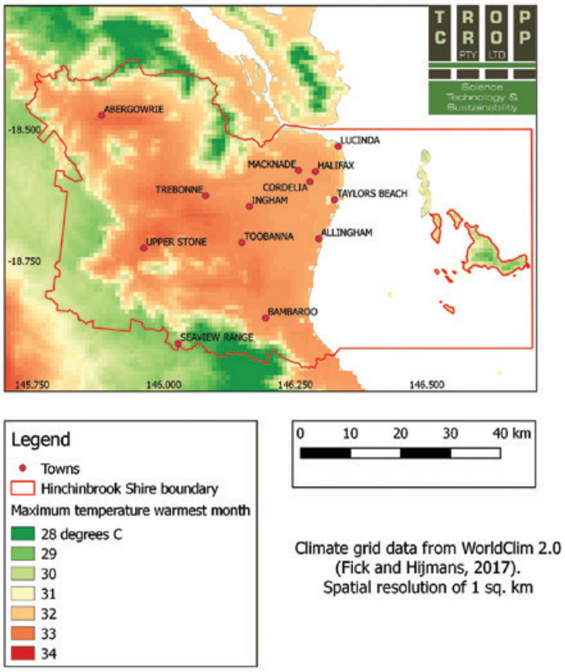


Figure 3: Maximum temperature for warmest month, Hinchinbrook Shire. Source: WorldClim version 2.0

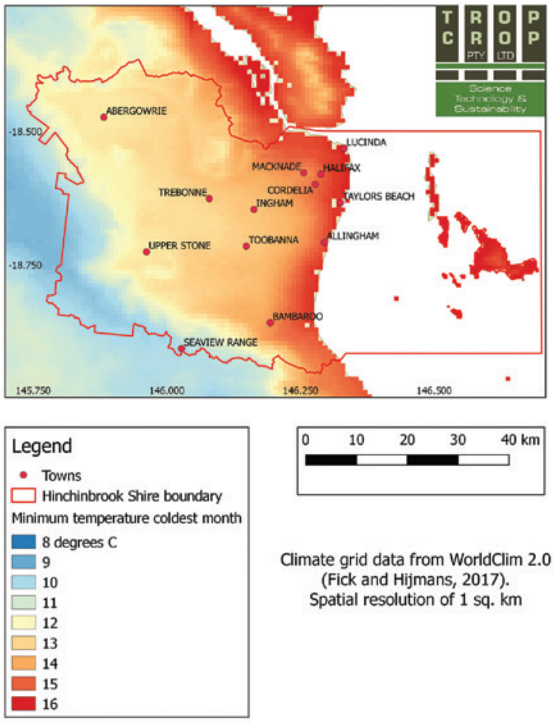


Figure 4: Minimum temperature for coldest month, Hinchinbrook Shire. Source: WorldClim version 2.0

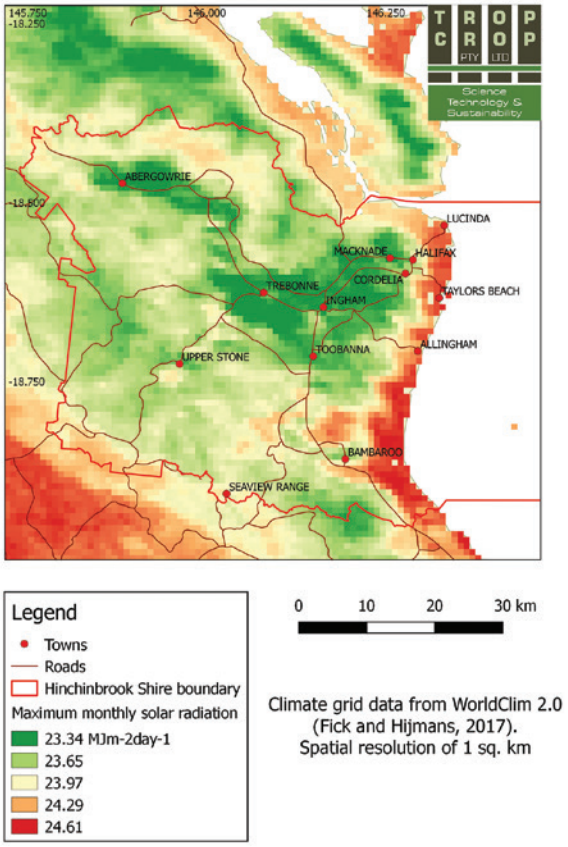


Figure 5: Maximum monthly solar radiation, Hinchinbrook Shire. Source: WorldClim version 2.0

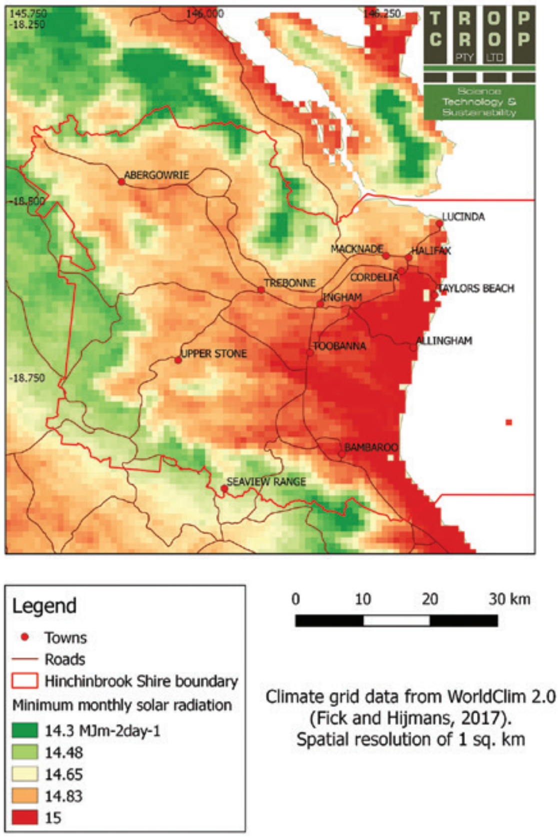


Figure 6: Minimum monthly solar radiation, Hinchinbrook Shire. Source: WorldClim version 2.0

The region is serviced by 32 Bureau of Meteorology weather stations which provide a good climate record and are geographically well distributed. Climate data for seven individual weather stations in the Shire were obtained from the Bureau of Meteorology online data source (http://www.bom.gov.au/climate/data/). The distribution of the stations used is shown in Figure 7. Rainfall data are available for all seven sites, but a temperature record is only available for Ingham. Data for the Ingham Composite station (site 032078) are presented and discussed here. Rainfall data for the other stations are available.

For agriculture it is most relevant to consider the rainfall pattern for the growing season, with precipitation hopefully coinciding with peak crop water demand for growth and flowering/grain filling. In our case this flows from the drier winter months through summer and into the next year, from July to June.

The median monthly rainfall (Figure 8) for the Ingham growing season illustrates the possibility of an amount of rainfall in each month and reinforces the view of a dominant summer rainfall pattern. This does not necessarily mean that median rainfall for one month will be followed by the median rainfall for the next month. The graph shows clear seasonality with a range from 36mm in July to 438mm in February. Over a thirty year period the wettest years (2010-11) show pronounced rainfall peaks in December and March, corresponding to strong convergence along the monsoon trough. In the driest years (2002-3) rainfall peaked in February and May, with a range from 4 to 150mm, and a weak monsoon trough and southeast gradient flow.

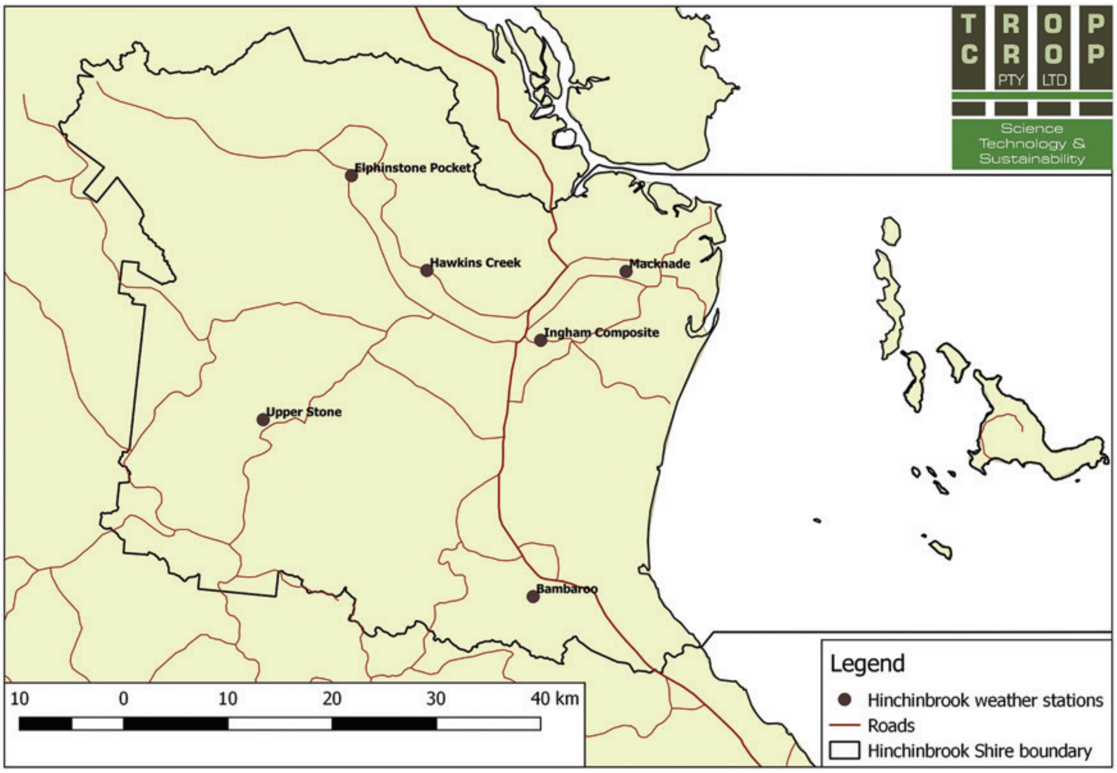


Figure 7: Location of weather stations used in this study. Data from Bureau of Meteorology, Melbourne.

For agriculture, rainfall probability needs to be considered at various stages in the crop cycle. Five stages are important: dry enough for cultivation and seedbed preparation, sufficient moisture at planting/sowing for germination and plant establishment, sufficient follow-up rain for vegetative growth, sufficient moisture but not excessive rainfall for flowering and grain filling, and dry conditions at harvest to avoid water-logging and produce spoilage. Thus, any consideration of the planting window needs to take rainfall probabilities into account. A good understanding of the long-term rainfall record and the seasonal climate forecast is very important. For Ingham and the Herbert in general, it is important to note variations in the occurrence of rainfall throughout the growing season in years with a wetter or drier outlook as this could have a marked effect on the timing of cropping operations.

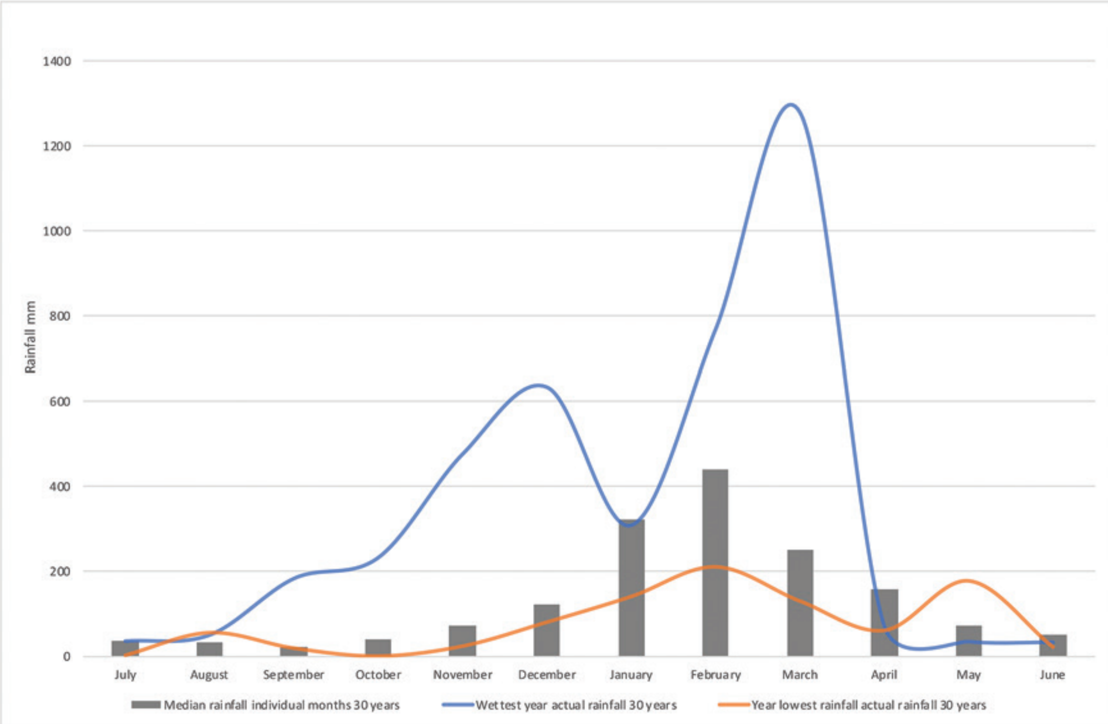


Figure 8: INGHAM - median rainfall total received for individual months in the growing season (grey bars,) and actual monthly total rainfall for the wettest (blue 2010 2011) and driest (orange 2002 2003) growing season in the 30 year period 1988 to 2018 (Source BOM http://www.bom.gov.au/climate/data/).

The probability of rainfall and number of wet days is explored in Table 1. At a frequency of 5 years in 10 (effectively the median rainfall) monthly rainfall ranges from a minimum of 36mm in July to a maximum of 438mm in February, with the onset of the wet season in December. The number of wet days correspondingly ranges from 5 in September to 19 in March. One year in 10 exceptionally wet conditions prevail with a monthly minimum in September (68mm) and maximum in March (939mm). In these years the number of wet days per month ranges from 13 to 26 and both waterlogging and flooding would be likely in summer. Nine years in ten at least 2-4mm of monthly rainfall can be expected from July to September and wet season monthly rainfall of between 100 and 150mm is likely to occur. In dry years, wet days range from 1 in August to 10-12 from January to April. This probability of variation in both rainfall and wet days can be used to inform decisions about the timing of cultivation, planting and harvesting. The analysis in Figure 8 and Table 1 is repeated for the seven other weather stations in Appendix 2.

Frequency	Rainfall mm and number of wet days recorded	July	August	September	October	November	December	January	February	March	April	May	June
1 year in 10	Rainfall	95	82.6	68.4	109.5	412	287.9	625.7	903	939.4	467	178.2	83.2
	Wet days	14	13	16	15	22	19	23	25	26	24	21	14
5 years in 10	Rainfall	36	34.8	22.3	39.6	74.2	121.4	322.1	438.6	251.6	159.8	73.2	50
	Wet days	7	7	5	7	11	13	16	17	19	17	13	9
9 years in 10	Rainfall	4	2	4.4	11.9	14.6	45	98.3	150	99.4	71.4	32.4	12.6
	Wet days	3	1	2	2	4	6	10	12	10	12	7	3

Table 1: Ingham Composite - Pattern of monthly rainfall (1987 - 2018) showing the frequency of rainfall received in at least 9 years out of 10, 5 years out of 10, and 1 year out of 10 and the corresponding number of wet days for each month. Rainfall is monthly average in mm and wet days are days with any record above 0 mm (Source: Bureau of Meteorology climate data on-line - Ingham Composite).

Throughout this analysis data have been used for the last thirty-two years (1987 - 2018). There is a perception that the seasonality of rainfall may have changed in recent times, with a later onset of the wet season which persists into May. This possible trend is overlain on a rainfall regime with some monthly and annual variability.

Any change in climate patterns will be important to note in rain-fed agriculture. To test this assertion, the number of wet days per month was aggregated for five-year cohorts (Figure 9).

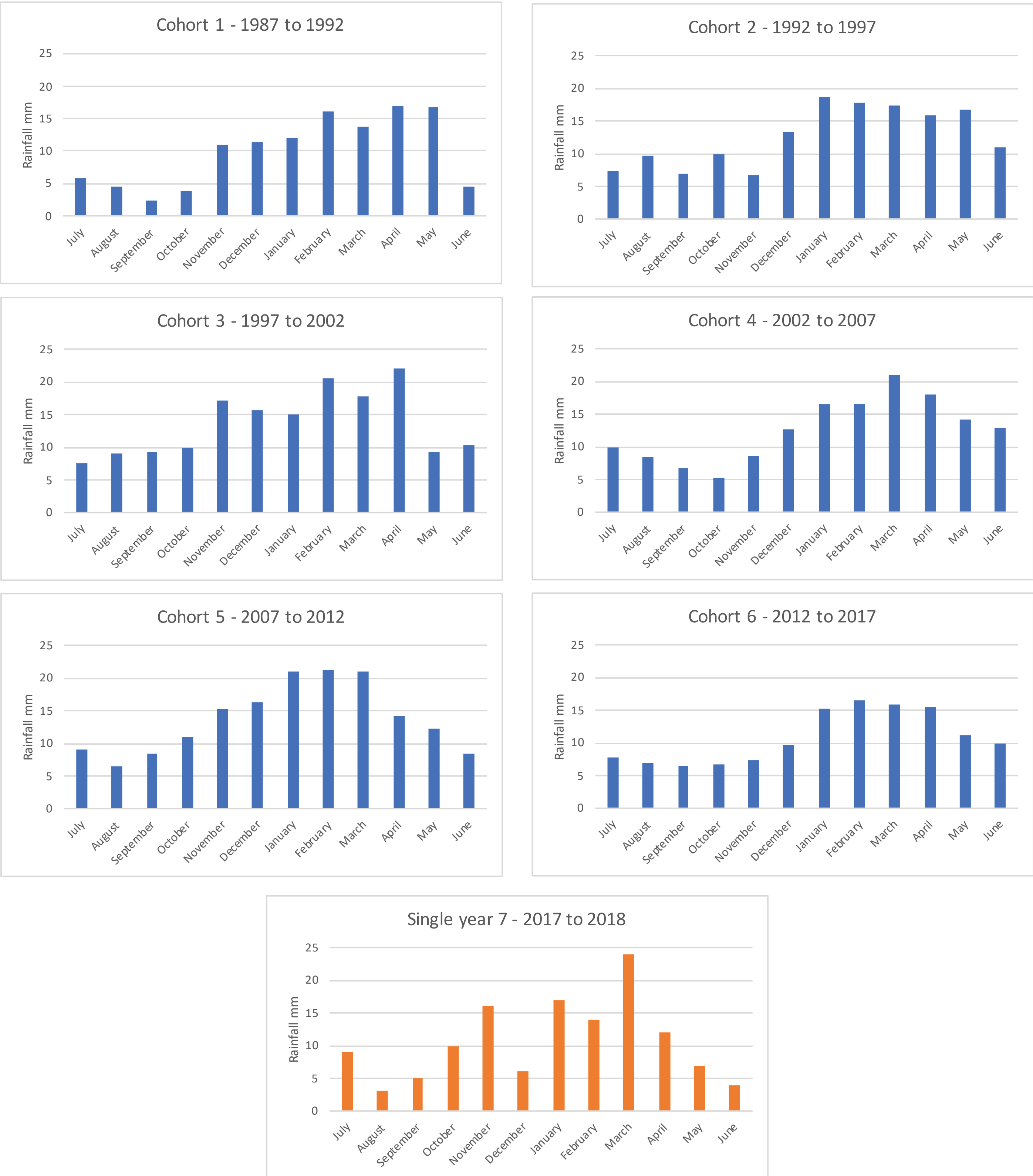


Figure 9: Monthly wet days by five-year cohorts 1987 to 2017 plus 2018. Data from Bureau of Meteorology. This can be considered statistically. A pairwise Chi –squared test on each cohort showed no significant difference between any of the monthly distributions (Chi2 range 5.9 to 15.8, df=11, P range 0.146 to 0.878).

Although there is considerable variation between five-year cohorts, the overall shape of the distributions through the year is very similar, and there is no evidence that there are increased monthly wet days from April onwards over the thirty-year period.

Data for air temperature at Ingham are presented in Figure 10. Monthly maxima range from 25 to 33° C with extremes up to 35°C. Monthly minima range from 13 to 23° C with extreme minima down to 10° C in July. Frosts are rare in Ingham and daily minima less than 2° C are less than two per year. However frosts are more common further west such as in the Stone River and Abergowrie areas.

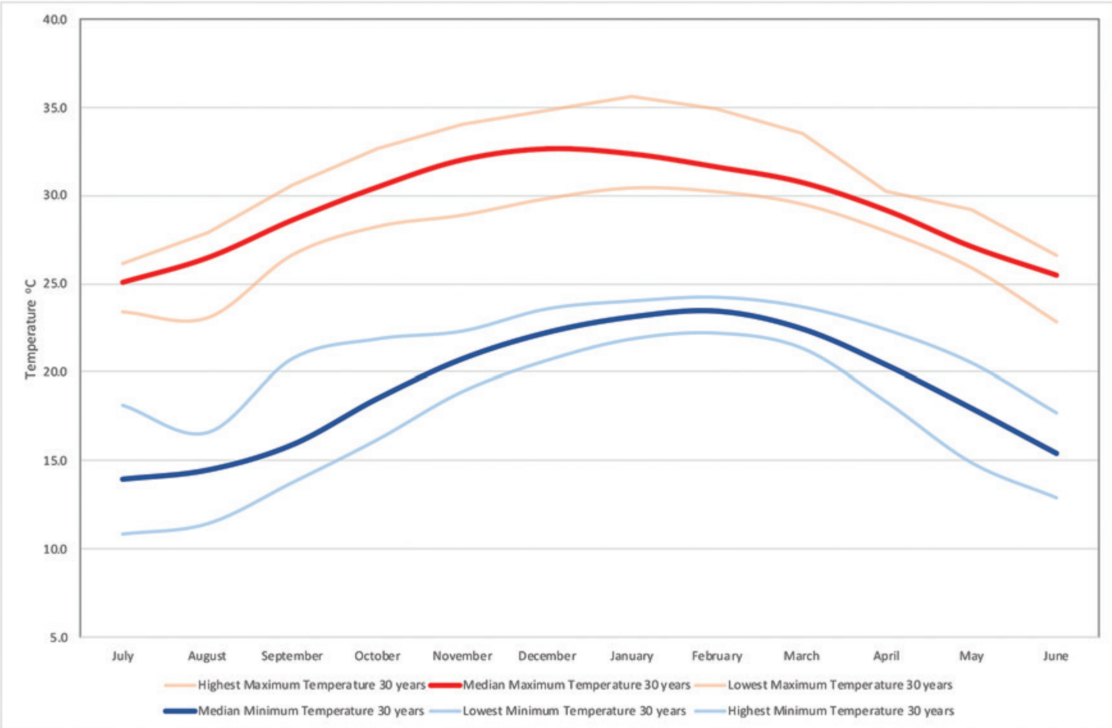
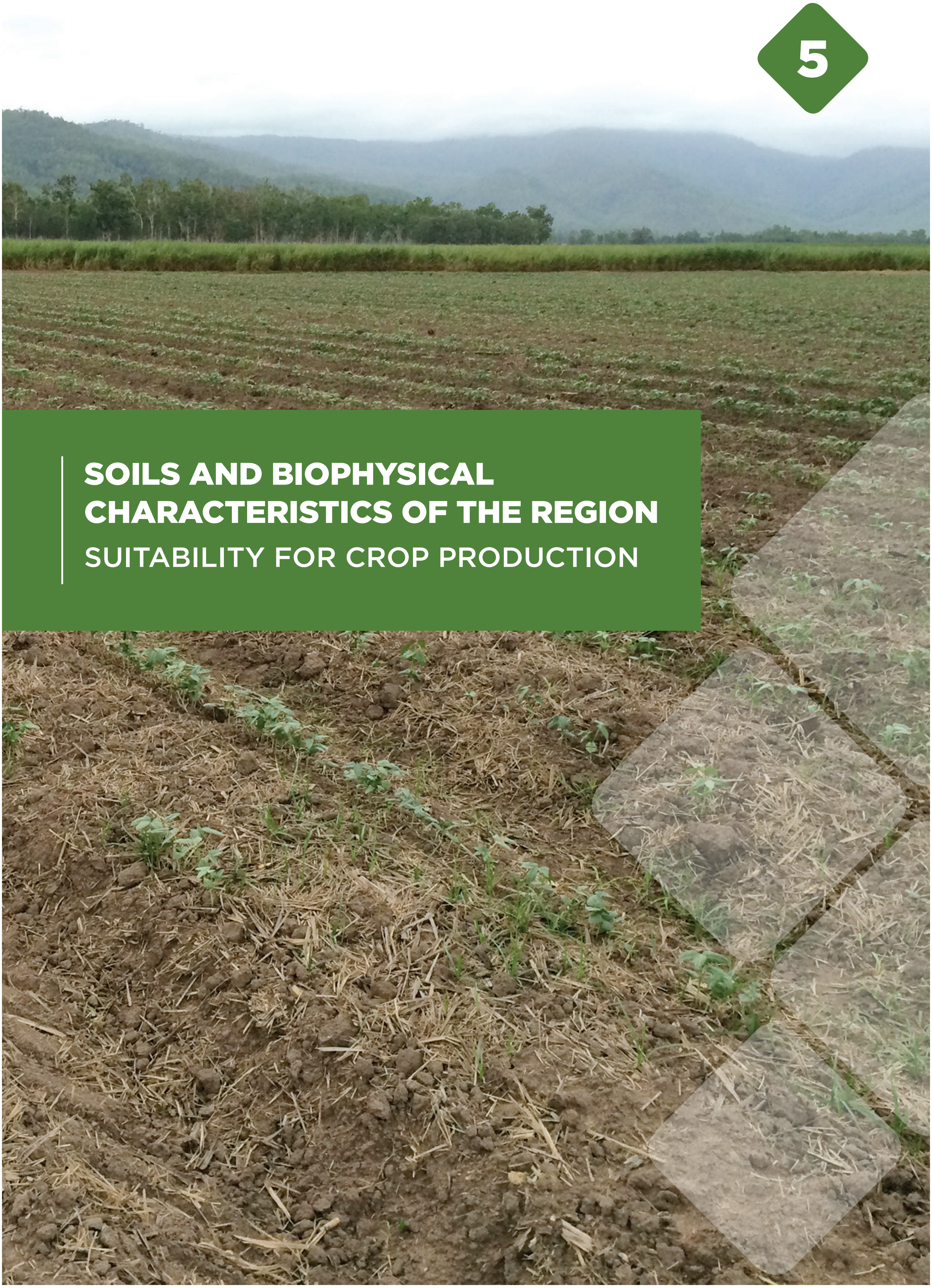


Figure 10: INGHAM - profile for air temperature showing maxima (red) and minima (blue) as a monthly average for the growing season July to June in the most recent 30 years period 1988 to 2018. Lighter lines show the upper and the lower range of the monthly average (Source: Bureau of Meteorology climate data on-line - Ingham Composite).



5

SOILS AND BIOPHYSICAL CHARACTERISTICS OF THE REGION

SUITABILITY FOR CROP PRODUCTION

5. SOILS AND BIOPHYSICAL CHARACTERISTICS OF THE REGION

SUITABILITY FOR CROP PRODUCTION

5.1 Soil types and soil mapping

Most soils in the Herbert River Valley have formed on alluvial deposits from the major river and tributaries and coastal flowing streams. These soils were surveyed at 1:100,000 scale in the 1980s. Peter Wilson and Dennis Baker's report 'Land Resources Bulletin – Soils and Agricultural Land Suitability of the Wet Tropical Coast of North Queensland: Ingham Area' is a comprehensive treatment of the area, the first major study to be done. The land resources were described in terms of climate, geology, geomorphology, hydrology, natural vegetation and soils.

Forty-seven soil types and seven variants were identified across 1626 unique mapping units (UMAs) on 160,270 ha of coastal lowlands. Of these, ten soil types were dominant and accounted for 61% of the lowland area in the region. Each mapping unit was assessed against 11 soil and land attributes and limitations for cropping suitability. Crop limitations were assessed against climate, water availability, soil nutrient supply, salinity, wetness, flooding, landscape complexity, soil physical condition, topography, rockiness and water erosion.

The Wilson and Baker survey is illustrated in Figures 11 and 12. The map legend (Figure 12) provides detail on the classes and characteristics of the broad range of soils.

5.2 Updating to the GDA94 datum and Albers mapping projection

The Wilson and Baker survey was created using the GRS80 datum and WGS84 projection. We converted to the Australian standard datum GDA94 to facilitate integration with other datasets and to the Albers projection which provides a more accurate measurement of areas than the one originally used. In simple terms this means the techniques used to bring the irregular curved earth's surface onto a flat map sheet or computer screen.

Regrettably in this process we encountered evidence of numerous errors in the soils database constructed from the original Wilson and Baker survey. These comprised numerous topological errors in the geometry of the mapped polygons and a significant number of attribute errors in the database. These led to unacceptable inconsistencies in representing soil types and their distribution. For the current study these data were checked manually and all corrected.

5.3 Adopting a simplified construct for Herbert soils

Herbert Valley farm soils were surveyed at a much finer scale (1:5000) by the CSR Technical Field Department through the 1980s and up to the early 2000s (Wood et al 2003). In this work the objective was to provide soil specific management guidelines for sugarcane production, improve crop nutrition, correct low soil pH and sodicity and improve sugar yields. This work was confined solely to sugarcane land. Additionally, it did not cover the whole district as the southern part of the sugarcane area had not been mapped when funding stopped, and it remains unmapped. In the remainder of the district, soil mapping for sugarcane growers for their individual farms is available from the sugar miller.

The delineation of soil type by location in Figure 11 (Wilson and Baker) presents a complex picture. There is a large number of soil types and an assessment of crop suitability based on the individual soil mapping units would be difficult to interpret. Consequently, a simpler system to identify suitable areas for various crops is desirable.

For this study we have adopted a simpler approach following on from the earlier work. We grouped the 47 soils recognised by Wilson and Baker into 10 groups based on the similarity of their characteristics, method of formation and position in the landscape (Table 2). The use of the 10 groups provides ease of understanding and interpretation when assessing crop suitability for a particular soil.

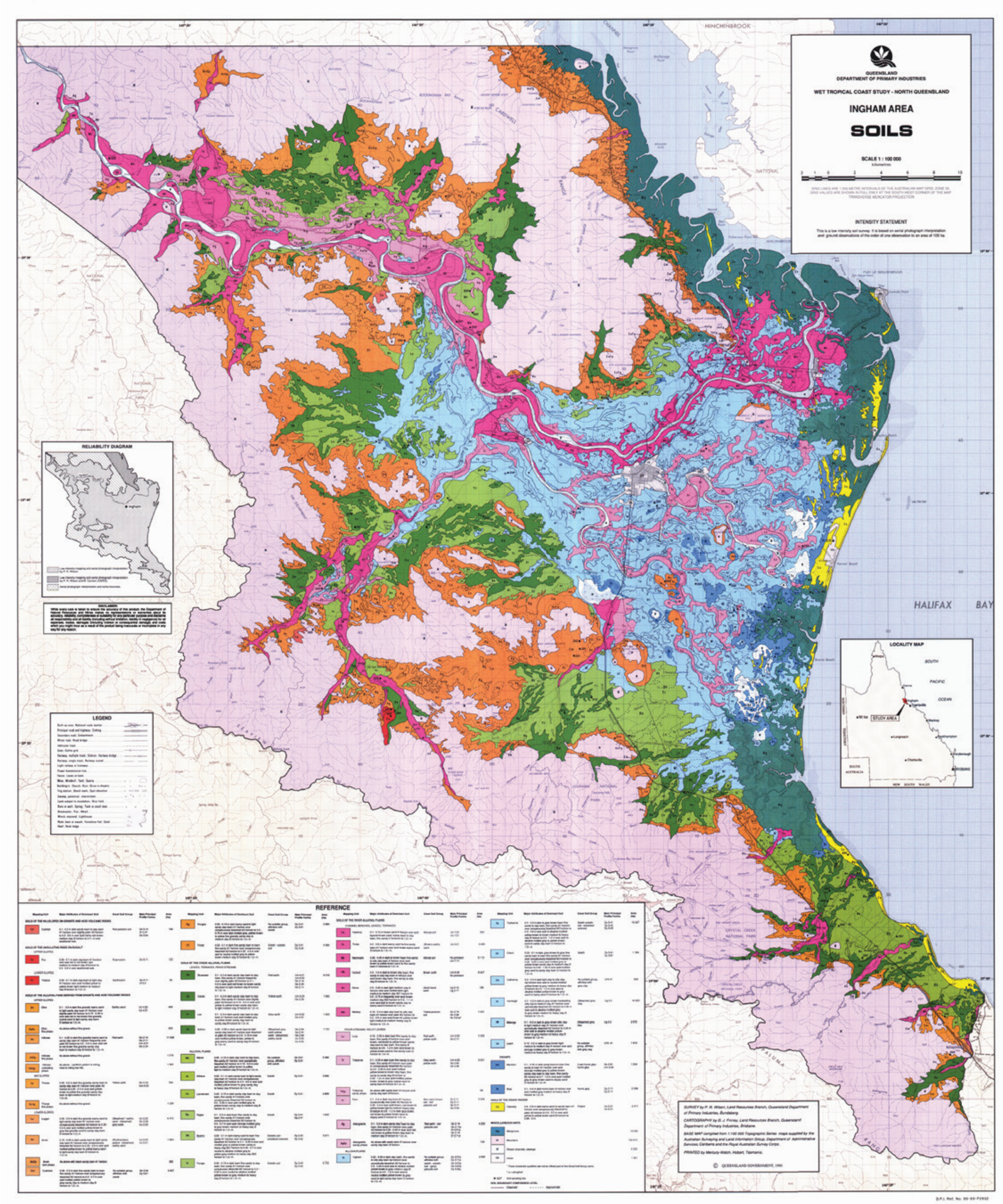
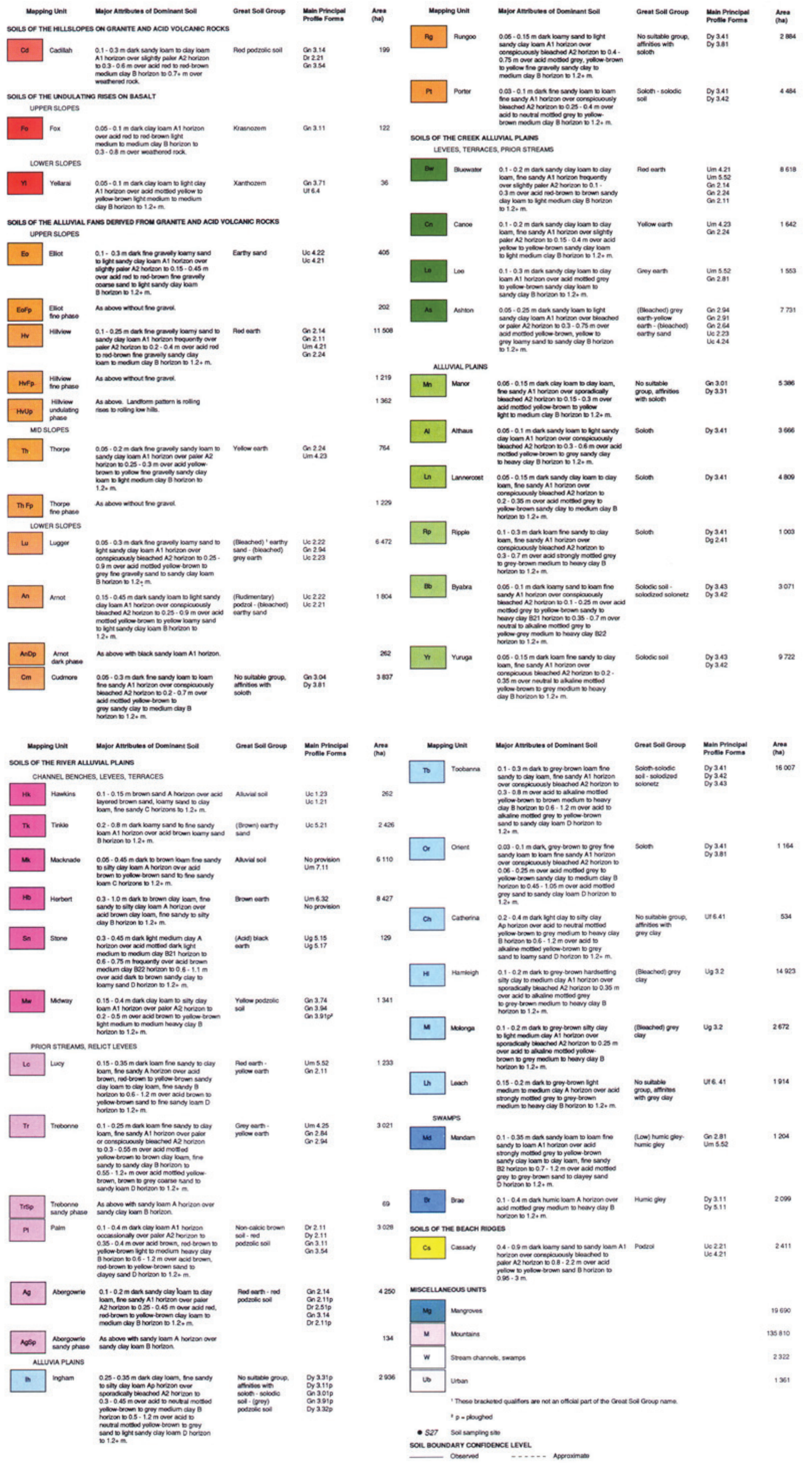


Figure 11: Ingham Area Soils. Wilson and Baker identified 47 soil types and an additional 7 variants. Legend detail is expanded in Figure 12. Survey by P.R. Wilson, cartography by G.J. Finney, Land Resources Branch, Queensland Department of Primary Industries. © Queensland Government 1990.



Code	Mapping Unit	Major Attributes of Dominant Soil	Great Soil Group	Main Principal Profile Forms	Area (ha)
SOILS OF THE HILLSLOPES ON GRANITE AND ACID VOLCANIC ROCKS					
Cd	Cadillah	0.1 - 0.3 m dark sandy loam to clay loam A1 horizon over slightly paler A2 horizon to 0.3 - 0.6 m over acid red to red-brown medium clay B horizon to 0.7+ m over weathered rock.	Red podzolic soil	Gn 3.14 Dr 2.21 Gn 3.54	199
SOILS OF THE UNDULATING RISES ON BASALT					
UPPER SLOPES					
Fo	Fox	0.05 - 0.1 m dark clay loam A1 horizon over acid red to red-brown light medium to medium clay B horizon to 0.3 - 0.8 m over weathered rock.	Krasnozem	Gn 3.11	122
LOWER SLOPES					
Yl	Yellarai	0.05 - 0.1 m dark clay loam to light clay A1 horizon over acid mottled yellow to yellow-brown light medium to medium clay B horizon to 1.2+ m.	Xanthozem	Gn 3.71 Uf 6.4	36
SOILS OF THE ALLUVIAL FANS DERIVED FROM GRANITE AND ACID VOLCANIC ROCKS					
UPPER SLOPES					
Eo	Elliot	0.1 - 0.3 m dark fine gravelly loamy sand to light sandy clay loam A1 horizon over slightly paler A2 horizon to 0.15 - 0.45 m over acid red to red-brown fine gravelly coarse sand to light sandy clay loam B horizon to 1.2+ m.	Earthy sand	Uc 4.22 Uc 4.21	405
EoFp	Elliot fine phase	As above without fine gravel.			202
Hv	Hillview	0.1 - 0.25 m dark fine gravelly loamy sand to sandy clay loam A1 horizon frequently over paler A2 horizon to 0.2 - 0.4 m over acid red to red-brown fine gravelly sandy clay loam to medium clay B horizon to 1.2+ m.	Red earth	Gn 2.14 Gn 2.11 Um 4.21 Gn 2.24	11 508
HvFp	Hillview fine phase	As above without fine gravel.			1 219
HvUp	Hillview undulating phase	As above. Landform pattern is rolling rises to rolling low hills.			1 362
MID SLOPES					
Th	Thorpe	0.05 - 0.2 m dark fine gravelly sandy loam to sandy clay loam A1 horizon over paler A2 horizon to 0.25 - 0.3 m over acid yellow-brown to yellow fine gravelly sandy clay loam to light medium clay B horizon to 1.2+ m.	Yellow earth	Gn 2.24 Um 4.23	764
Th Fp	Thorpe fine phase	As above without fine gravel.			1 229
LOWER SLOPES					
Lu	Lugger	0.05 - 0.3 m dark fine gravelly loamy sand to light sandy clay loam A1 horizon over conspicuously bleached A2 horizon to 0.25 - 0.9 m over acid mottled yellow-brown to grey fine gravelly sand to sandy clay loam B horizon to 1.2+ m.	(Bleached) [1] earthy sand - (bleached) grey earth	Uc 2.22 Gn 2.94 Uc 2.23	6 472
An	Arnot	0.15 - 0.45 m dark sandy loam to light sandy clay loam A1 horizon over conspicuously bleached A2 horizon to 0.25 - 0.9 m over acid mottled yellow-brown to yellow loamy sand to light sandy clay loam B horizon to 1.2+ m.	(Rudimentary) podzol - (bleached) earthy sand	Uc 2.22 Uc 2.21	1 804
AnDp	Arnot dark phase	As above with black sandy loam A1 horizon.			262
Cm	Cudmore	0.05 - 0.3 m dark fine sandy loam to loam fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.2 - 0.7 m over acid mottled yellow-brown to grey sandy clay to medium clay B horizon to 1.2+ m.	No suitable group, affinities with soloth	Gn 3.04 Dy 3.81	3 837
Rg	Rungoo	0.05 - 0.15 m dark loamy sand to light sandy clay loam A1 horizon over conspicuously bleached A2 horizon to 0.4 - 0.75 m over acid mottled grey, yellow-brown to yellow fine gravelly sandy clay to medium clay B horizon to 1.2+ m.	No suitable group, affinities with soloth	Dy 3.41 Dy 3.81	2 884
Pt	Porter	0.03 - 0.1 m dark fine sandy loam to loam fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.25 - 0.4 m over acid to neutral mottled grey to yellow-brown medium clay B horizon to 1.2+ m.	Soloth - solodic soil	Dy 3.41 Dy 3.42	4 484
SOILS OF THE CREEK ALLUVIAL PLAINS					
LEVEES, TERRACES, PRIOR STREAMS					
Bw	Bluewater	0.1 - 0.2 m dark sandy clay loam to clay loam, fine sandy A1 horizon frequently over slightly paler A2 horizon to 0.1 - 0.3 m over acid red-brown to brown sandy clay loam to light medium clay B horizon to 1.2+ m.	Red earth	Um 4.21 Um 5.52 Gn 2.14 Gn 2.24 Gn 2.11	8 618
Cn	Canoe	0.1 - 0.2 m dark sandy clay loam to clay loam, fine sandy A1 horizon over slightly paler A2 horizon to 0.15 - 0.4 m over acid yellow to yellow-brown sandy clay loam to light medium clay B horizon to 1.2+ m.	Yellow earth	Um 4.23 Gn 2.24	1 642
Le	Lee	0.1 - 0.3 m dark sandy clay loam to clay loam A1 horizon over acid mottled grey to yellow-brown sandy clay loam to sandy clay B horizon to 1.2+ m.	Grey earth	Um 5.52 Gn 2.81	1 553
As	Ashton	0.05 - 0.25 m dark sandy loam to light sandy clay loam A1 horizon over bleached or paler A2 horizon to 0.3 - 0.75 m over acid mottled yellow-brown, yellow to grey loamy sand to sandy clay B horizon to 1.2+ m.	(Bleached) grey earth-yellow earth - (bleached) earthy sand	Gn 2.94 Gn 2.91 Gn 2.64 Uc 2.23 Uc 4.24	7 731
ALLUVIAL PLAINS					
Mn	Manor	0.05 - 0.15 m dark clay loam to clay loam, fine sandy A1 horizon over sporadically bleached A2 horizon to 0.15 - 0.3 m over acid mottled yellow-brown to yellow light to medium clay B horizon to 1.2+ m.	No suitable group, affinities with soloth	Gn 3.01 Dy 3.31	5 386
Al	Althaus	0.05 - 0.1 m dark sandy loam to light sandy clay loam A1 horizon over conspicuously bleached A2 horizon to 0.3 - 0.6 m over acid mottled yellow-brown to grey sandy clay to heavy clay B horizon to 1.2+ m.	Soloth	Dy 3.41	3 666
Ln	Lannercost	0.05 - 0.15 m dark sandy clay loam to clay loam, fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.2 - 0.35 m over acid mottled grey to yellow-brown sandy clay to medium clay B horizon to 1.2+ m.	Soloth	Dy 3.41	4 809
Rp	Ripple	0.1 - 0.3 m dark loam fine sandy to clay loam, fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.3 - 0.7 m over acid strongly mottled grey to grey-brown medium to heavy clay B horizon to 1.2+ m.	Soloth	Dy 3.41 Dg 2.41	1 003
Bb	Byabra	0.05 - 0.1 m dark loamy sand to loam fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.1 - 0.25 m over acid mottled grey to yellow-brown sandy to heavy clay B21 horizon to 0.35 - 0.7 m over neutral to alkaline mottled grey to yellow-grey medium to heavy clay B22 horizon to 1.2+ m.	Solodic soil - solodized solonetz	Dy 3.43 Dy 3.42	3 071
Yr	Yuruga	0.05 - 0.15 m dark loam fine sandy to clay loam, fine sandy A1 horizon over conspicuous bleached A2 horizon to 0.2 - 0.35 m over neutral to alkaline mottled yellow-brown to grey medium to heavy clay B horizon to 1.2+ m.	Solodic soil	Dy 3.43 Dy 3.42	9 722
SOILS OF THE RIVER ALLUVIAL PLAINS					
CHANNEL BENCHES, LEVEES, TERRACES					
Hk	Hawkins	0.1 - 0.15 m brown sand A horizon over acid layered brown sand, loamy sand to clay loam, fine sandy C horizons to 1.2+ m.	Alluvial soil	Uc 1.23 Uc 1.21	262
Tk	Tinkle	0.2 - 0.8 m dark loamy sand to fine sandy loam A1 horizon over acid brown loamy sand B horizon to 1.2+ m.	(Brown) earthy sand	Uc 5.21	2 426
Mk	Macknade	0.05 - 0.45 m dark to brown loam fine sandy to silty clay loam A horizon over acid brown to yellow-brown sand to fine sandy loam C horizons to 1.2+ m.	Alluvial soil	No provision Um 7.11	6 110
Hb	Herbert	0.3 - 1.0 m dark to brown clay loam, fine sandy to silty clay loam A horizon over acid brown clay loam, fine sandy to silty clay B horizon to 1.2+ m.	Brown earth	Um 6.32 No provision	8 427
Sn	Stone	0.3 - 0.45 m dark light medium clay A horizon over acid mottled dark light medium to medium clay B21 horizon to 0.6 - 0.75 m frequently over acid brown medium clay B22 horizon to 0.6 - 1.1 m over acid dark to brown sandy clay to loamy sand D horizon to 1.2+ m.	(Acid) black earth	Ug 5.15 Ug 5.17	129
Mw	Midway	0.15 - 0.4 m dark clay loam to silty clay loam A1 horizon over paler A2 horizon to 0.2 - 0.5 m over acid brown to yellow-brown light medium to medium heavy clay B horizon to 1.2+ m.	Yellow podzolic soil	Gn 3.74 Gn 3.94 Gn 3.91p[2]	1 341
PRIOR STREAMS, RELICT LEVEES					
Lc	Lucy	0.15 - 0.35 m dark loam fine sandy to clay loam, fine sandy A horizon over acid brown, red-brown to yellow-brown sandy clay loam to clay loam, fine sandy B horizon to 0.6 - 1.2 m over acid brown to yellow-brown sand to fine sandy loam D horizon to 1.2+ m.	Red earth - yellow earth	Um 5.52 Gn 2.11	1 233
Tr	Trebonne	0.1 - 0.25 m dark loam fine sandy to clay loam, fine sandy A1 horizon over paler or conspicuously bleached A2 horizon to 0.3 - 0.55 m over acid mottled yellow-brown to brown clay loam, fine sandy to sandy clay B horizon to 0.55 - 1.2+ m over acid mottled yellow-brown, brown to grey coarse sand to sandy loam D horizon to 1.2+ m.	Grey earth - yellow earth	Um 4.25 Gn 2.84 Gn 2.94	3 021
TrSp	Trebonne sandy phase	As above with sandy loam A horizon over sandy clay loam B horizon.			69
Pl	Palm	0.1 - 0.4 m dark clay loam A1 horizon occassionally over paler A2 horizon to 0.35 - 0.4 m over acid brown, red-brown to yellow-brown light to medium heavy clay B horizon to 0.6 - 1.2 m over acid brown, red-brown to yellow-brown sand to clayey sand D horizon to 1.2+ m.	Non-calcic brown soil - red podzolic soil	Dr 2.11 Dy 2.11 Gn 3.11 Gn 3.54	3 028
Ag	Abergowrie	0.1 - 0.2 m dark sandy clay loam to clay loam, fine sandy A1 horizon over paler A2 horizon to 0.25 - 0.45 m over acid red, red-brown to yellow-brown clay loam to medium clay B horizon to 1.2+ m.	Red earth - red podzolic soil	Gn 2.14 Gn 2.11p Dr 2.51p Gn 3.14 Dr 2.11p	4 250
AgSp	Abergowrie sandy phase	As above with sandy loam A horizon over sandy clay loam B horizon.			134
ALLUVIA PLAINS					
Ih	Ingham	0.25 - 0.35 m dark clay loam, fine sandy to silty clay loam Ap horizon over sporadically bleached A2 horizon to 0.3 - 0.45 m over acid to neutral mottled yellow-brown to grey medium clay B horizon to 0.5 - 1.2 m over acid to neutral mottled yellow-brown to grey sand to light sandy clay loam D horizon to 1.2+ m.	No suitable group, affinities with soloth - solodic soil - (grey) podzolic soil	Dy 3.31p Dy 3.11p Gn 3.01p Gn 3.91p Dy 3.32p	2 936
Tb	Toobanna	0.1 - 0.3 m dark to grey-brown loam fine sandy to clay loam, fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.3 - 0.8 m over acid to alkaline mottled yellow-brown to brown medium to heavy clay B horizon to 0.6 - 1.2 m over acid to alkaline mottled grey to yellow-brown sand to sandy clay loam D horizon to 1.2+ m.	Soloth-solodic soil - solodized solonetz	Dy 3.41 Dy 3.42 Dy 3.43	16 007
Or	Orient	0.03 - 0.1 m dark, grey-brown to grey fine sandy loam to loam fine sandy A1 horizon over conspicuously bleached A2 horizon to 0.06 - 0.25 m over acid mottled grey to yellow-brown sandy clay to medium clay B horizon to 0.45 - 1.05 m over acid mottled grey sand to sandy clay loam D horizon to 1.2+ m.	Soloth	Dy 3.41 Dy 3.81	1 164
Ch	Catherina	0.2 - 0.4 m dark light clay to silty clay Ap horizon over acid to neutral mottled yellow-brown to grey medium to heavy clay B horizon to 0.6 - 1.2 m over acid to alkaline mottled yellow-brown to grey sand to loamy sand D horizon to 1.2+ m.	No suitable group, affinities with grey clay	Uf 6.41	534
Hl	Hamleigh	0.1 - 0.2 m dark to grey-brown hardsetting silty clay to medium clay A1 horizon over sporadically bleached A2 horizon to 0.35 m over acid to alkaline mottled grey to grey-brown medium to heavy clay B horizon to 1.2+ m.	(Bleached) grey clay	Ug 3.2	14 923
Ml	Molonga	0.1 - 0.2 m dark to grey-brown silty clay to light medium clay A1 horizon over sporadically bleached A2 horizon to 0.25 m over acid to alkaline mottled yellow-brown to grey medium to heavy clay B horizon to 1.2+ m.	(Bleached) grey clay	Ug 3.2	2 672
Lh	Leach	0.15 - 0.2 m dark to grey-brown light medium to medium clay A horizon over acid strongly mottled grey to grey-brown medium to heavy clay B horizon to 1.2+ m.	No suitable group, affinites with grey clay	Uf 6. 41	1 914
SWAMPS					
Md	Mandam	0.1 - 0.35 m dark sandy loam to loam fine sandy to loam A1 horizon over acid strongly mottled grey to yellow-brown sandy clay loam to clay loam, fine sandy B2 horizon to 0.7 - 1.2 m over acid mottled grey to grey-brown sand to clayey sand D horizon to 1.2+ m.	(Low) humic gley-humic gley	Gn 2.81 Um 5.52	1 204
Br	Brae	0.1 - 0.4 m dark humic loam A horizon over acid mottled grey medium to heavy clay B horizon to 1.2+ m.	Humic gley	Dy 3.11 Dy 5.11	2 099
SOILS OF THE BEACH RIDGES					
Cs	Cassady	0.4 - 0.9 m dark loamy sand to sandy loam A1 horizon over conspicuously bleached to paler A2 horizon to 0.8 - 2.2 m over acid yellow to yellow-brown sand B horizon to 0.95 - 3 m.	Podzol	Uc 2.21 Uc 4.21	2 411
MISCELLANEOUS UNITS					
Mg	Mangroves				19 690
M	Mountains				135 810
W	Stream channels, swamps				2 322
Ub	Urban				1 361

[1] These bracketed qualifiers are not an official part of the Great Soil Group name.

[2] p = ploughed

● S27 Soil sampling site

SOIL BOUNDARY CONFIDENCE LEVEL

——— Observed - - - - - - Approximate

Figure 12: Map legend of soil mapping units with their principal characteristics, taken from 'Ingham Area Soils' survey by P.R Wilson, cartography by G.J. Finney, Land Resources Branch, Queensland Department of Primary Industries. © Queensland Government 1990.

Soil group	Principal characteristics (2018)	Wilson and Baker soil mapping units (1990)	Sugarcane soil groups (Wood et al 2003)	Texture	Drainage	Friability	Root depth	Water Holding Capacity	Position in landscape
1	Shallow soils	Cadillah Hillview undulating		light	well	moderately friable	limited	low	high
2	Deep sandy soils	Cassidy Ashton Bluewater	Beach Sand Ridge Sand ridge Coarse Sandy Loam	light	well	moderately friable	moderate	low	high
3	Recent alluvial soils close to Herbert and Stone Rivers	Macknade Herbert Hawkins Tinkle Stone Midway	River Bank	intermediate	well	friable	deep	moderate	high
4	Older alluvial soils on terraces, old levees and prior streams	Abergowrie + sandy phase Palm Trebonne + sandy phase Canoe, Lucy, Lee	Red Loam Terrace Silty Loam Clay Ridge	intermediate	well	moderately friable	deep	moderate	high
5	Granitic hillslope soils	Hillview + fine phase Lugger Elliot + fine phase Thorpe + fine phase	Red Sand Grey Sand	light	well-imp	moderately friable	moderate	low	high-intermediate
6	Basaltic soils	Fox Yellarai		intermediate	well	friable	deep	moderate	high
7	Seymour soils	Arnot + deep phase Cudmore Porter Rungoo Ripple	Fine Black Sand Fine Grey Sand Pale Brown Sandy Loam Grey Brown Loam Coarse Sandy Clay, Ripple Alluvial	intermediate - heavy	poor	moderately friable -massive	limited	moderate	low
8	Seasonally wet soils with intermediate texture	Lannercost	Sandy Clay Fine Sandy Loam	intermediate	imperfect	moderately friable -massive	moderate	moderate	intermediate
9	Seasonally wet soils with heavy texture	Hamleigh Molonga Leach Catherina Toobanna Orient, Ingham Manor, Althaus Byabra, Yuruga	Clay Clay Loam Silty Clay Heavy Clay	heavy	poor	moderately friable -massive	moderate	moderate	low
10	Poorly drained swamp soils	Brae Mandam	Black Organic Clays	heavy	poor	moderately friable -massive	limited	moderate	low

Table 2: Broad groupings of soils based on their characteristics, formation and position in the landscape.

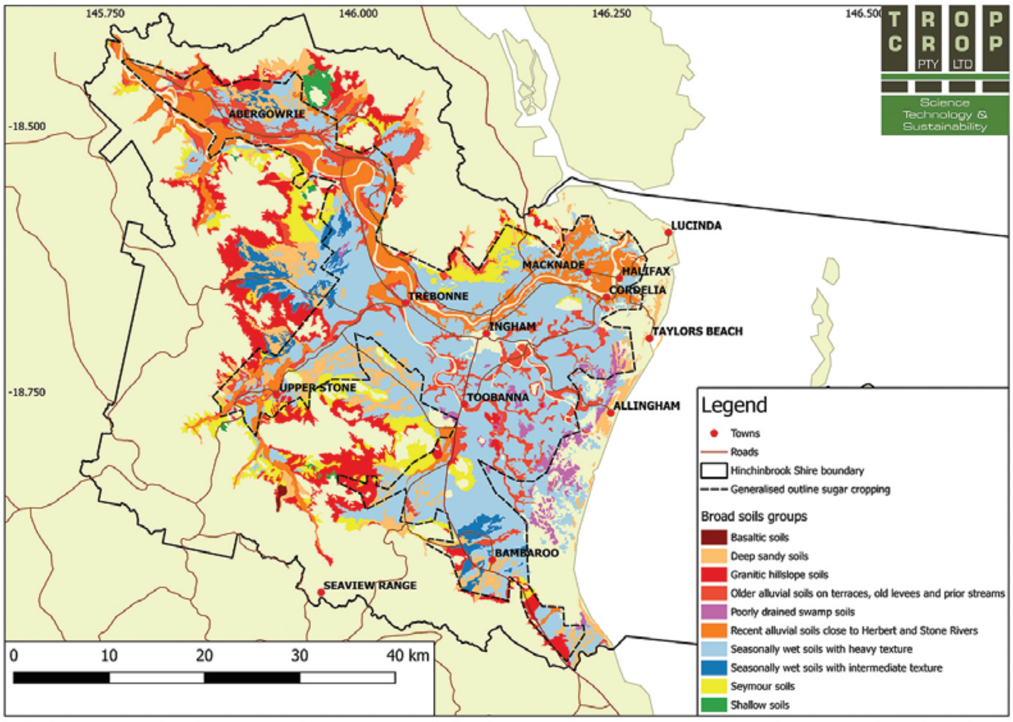


Figure 13: Distribution of Herbert River district soil groups as used in this study.

Based on local experience and building on the previous work of Wilson, Baker, and Wood et al, we feel that these revised soil groups based on their principal characteristics (Table 2) offer a practical classification of the cropping environment and likely suitability of a particular area for a candidate crop. The ten groupings also reflect the Herbert soil characteristics as we know them from an agronomy perspective.

5.4 Land suitability for agriculture

In the time elapsed since the Wilson and Baker survey, many of the inherent characteristics of agricultural soils have been modified through farming practice in an attempt to improve productivity. This will be especially evident in sugarcane soils. Fertilising, improved fertiliser application technology, judicious use of mill mud, liming to address low soil pH, drainage and laser levelling, and more recently controlled traffic farming and raised beds have all contributed to soil modification and management. Cooperative drainage and flood mitigation have also changed the farming environment (mentioned later).

To assess land and soil type suitability for future alternative crops that might be considered, Table 2 uses six soil characteristics to differentiate suitability. These principal characteristics are:

Texture	The proportion of clay, silt, sand and gravel in a soil, the soil composition by particle size.
Drainage	The aeration of a soil shown by its colour and its ability to allow water to pass through it so as not to become waterlogged. Dependent on the depth to water table, texture, porosity and structure.
Friability	The characteristic of the soil to break down to stable aggregates when cultivated and not to lose structure, and to maintain a stable aggregate size through wetting and drying.
Root depth	The depth in a soil profile to which plant roots are able to grow to take up water and nutrients and not be prevented by a compacted or massive subsoil.
Water Holding Capacity	The ability for the soil profile to hold water under gravity, and to release that water to plant roots; the difference between field capacity and wilting point.
Position in landscape	Relates to elevation and method of soil formation. Describes the height relative to surface water flow and likelihood of flooding.

The seasonal climate and rainfall and the variation in the rainfall pattern continue to be major factors in the predominately rainfed cropping system in the Herbert.

Cropping suitability and consideration of specific candidate crops across the 10 soil groups and assessment against the six suitability characteristics is continued in the section Assessing Crop Suitability.

5.5 Flooding in the Herbert

Spatial data on the extent of flooding have been sourced from the Queensland Department of Natural Resources and Mines (Qld DNRM). These include coverages showing the flooding resulting from different flood stages in the Herbert River and its tributaries (Figure 14). Note that levels above 12m constitute major flooding.

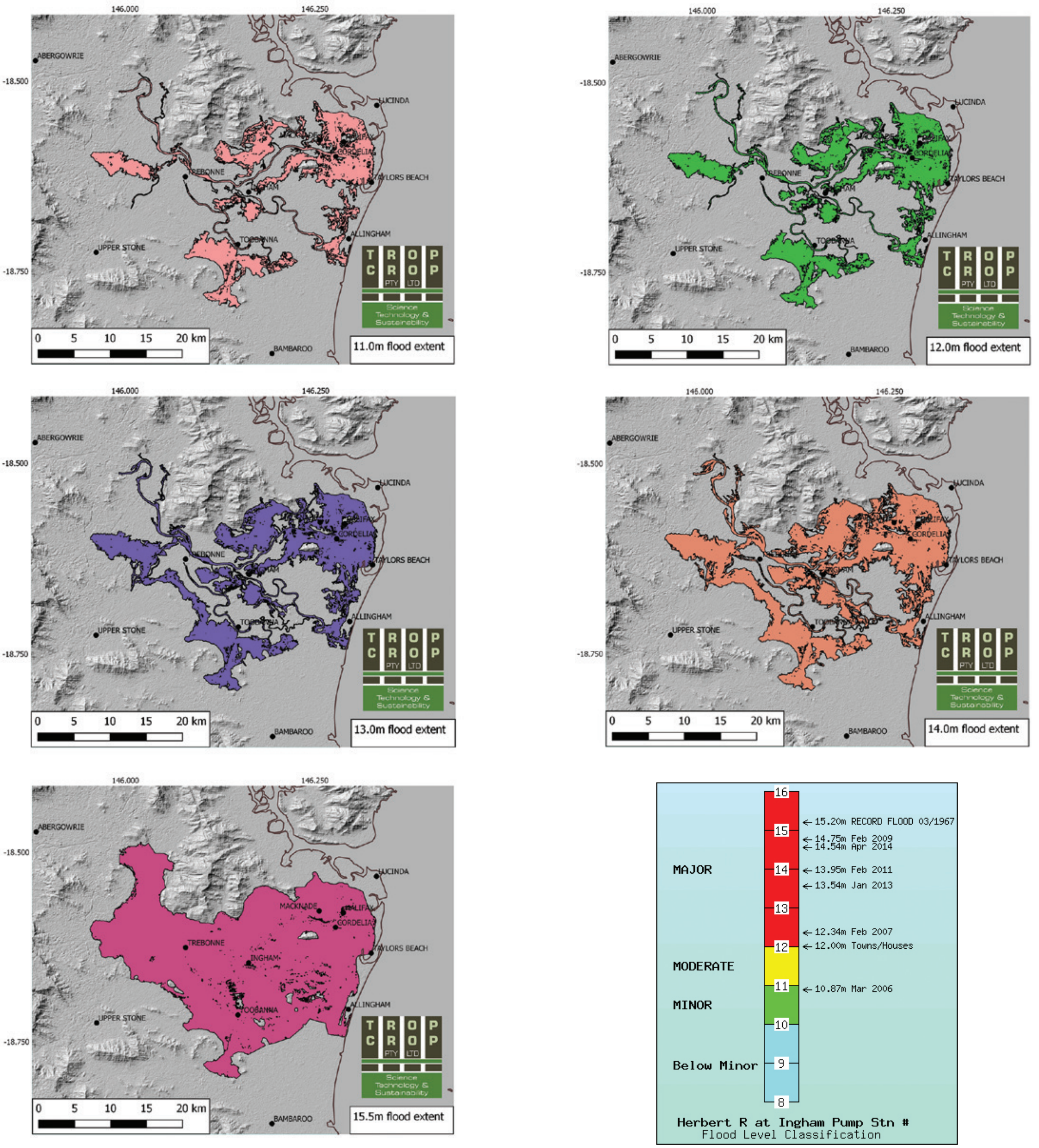


Figure 14: Extent of flooding for different flood stages in the Herbert River.

Recent modelling of flood levels in the Herbert (Table 3) suggests that a major flood stage of 14m could have a recurrence interval of five years, implying major inundation across the floodplain and cultivated areas.

Gauge height (m) Ingham Pump Station	Modelled discharge $m^3\ s^{-1}$	Modelled recurrence interval (years)
11	3000	2
12	3999	3
13	4900	4
14	6003	5
15	9900	20
15.2 (1967 flood)	14629	70

Table 3: Modelled discharge and recurrence interval for floods in the Herbert River at Ingham (from South & Leister 2015)

5.6 Drainage improvement in the Lower Herbert

Efforts have been directed at improving the drainage of sugarcane farms in the Herbert for many years. It was found that substantial losses in sugarcane yields occurred when the regional water table was less than 0.5m below the soil surface (Chardon and Rudd, 1978). Yield losses with other crops are likely when water tables are high unless they are grown on raised beds.

Whilst many growers have graded their fields and established drains to remove excess water from their properties, the need for an integrated network of drains was recognised by the establishment of a number of Drainage Boards in the 1960s and 70s. Their main purpose was to coordinate the construction and maintenance of drains, pumps and other works to remove water from low-lying areas (Horsley et al, 1982) and in some cases these works qualified for government subsidies.

Completion of the Lower Herbert Rural Drainage Plan in 1983 produced a framework for the effective integration of all drainage work and eventually resulted in the amalgamation of the Drainage Boards into a single authority, the Lower Herbert Water Management Authority which still exists. Best practice guidelines for improving surface drainage for low-lying sugarcane areas in the Herbert have been developed and are available in a technical extension manual (Reghenzani and Roth, 2006).

5.7 Groundwater and irrigation in the Lower Herbert

Irrigation would strengthen the region's reliability to finish off crops and meet market obligations. The region remains a predominantly rainfed cropping area with large seasonal variation between wet and dry seasons. With mild winters there would be a market opportunity to produce mid-year through to early spring if crops could be watered with supplementary irrigation.

Despite indications of available groundwater with the documentation of four aquifers (Cox 1980, Lait 1993). Demand for irrigation has remained low with sugarcane as the principal crop and its tolerance to relatively short spells of dry conditions.

The lack of demand for irrigation water has resulted in underutilised water entitlements and little or no demand for water trading. A limited amount of irrigation is occurring throughout the district in the growing of commodities mainly watermelon, pumpkin and sweet potato. Several growers have mentioned interest in smallscale poly-houses as practiced in the Bundaberg region for production of higher-value horticultural produce. This production technology would add to the diversity of crops and revenue, and not risk encroaching on mainstream sugarcane farmland.

Part of the Lower Herbert is located in the Lower Herbert Groundwater Management area (Figure 15). This is regulated under the Water Plan (Wet Tropics) 2013, managed under the Wet Tropics Resource Operations Plan 2015 administered from Qld DNRM Ayr office.

Information on groundwater resources has been sourced from Qld DNRME and includes spatial data on location of bores, the groundwater management areas, alluvial boundaries and groundwater zones. There may be water quality data available for each bore as well as information on water depths, yields and generalised geology. The boundary of alluvial groundwater (Figure 16) includes some tributary streams and the groundwater zones (Figure 17) reflect the salinity of source sediments and weathered rocks.

The Water Plan (Wet Tropics) 2013 regulates the taking of groundwater or construction of bores. Under the water plan, an owner of land with existing groundwater works in a prescribed groundwater management area should provide the chief executive with a notice of works on the approved form (Qld DNRM).

DNRM are currently working to finalise the Wet Tropics Resource Operation Plan towards the authorisation of existing groundwater works for licensing and finalisation of process for granting of water licences and establishment of a trading framework including temporary and seasonal assignments. Works installed prior to 20 June 2012 that take groundwater can continue to take water from existing works provided the works have been notified to the Department. (NB: stock and domestic use does not require notification, Qld DNRM).

The Lower Herbert Groundwater Management area can be located in Queensland Globe under the Inland Waters layer, which can be found be searching for groundwater management area within the layer's selection area.

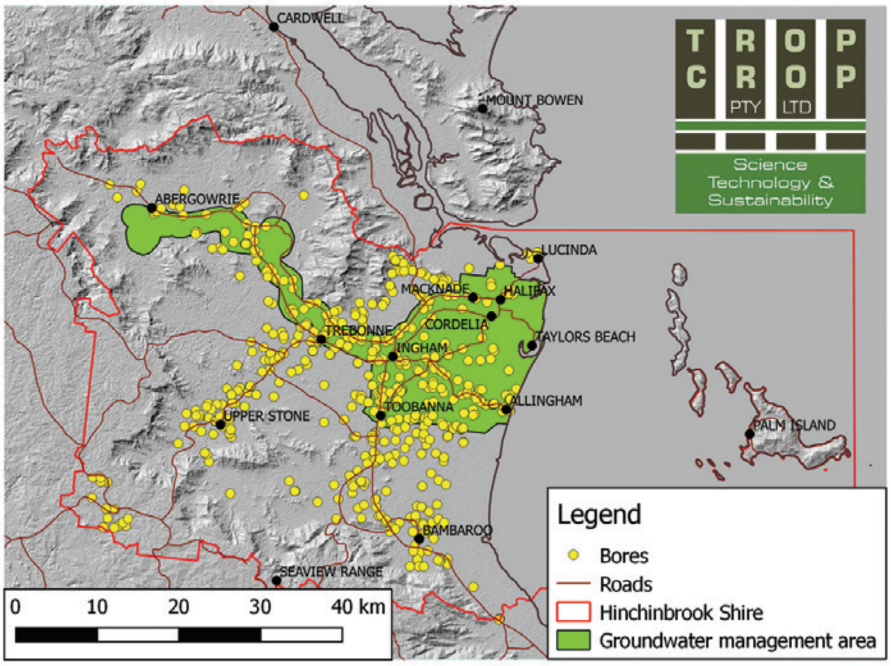


Figure 15: Location of bores and groundwater management zone in the Hinchinbrook Shire.

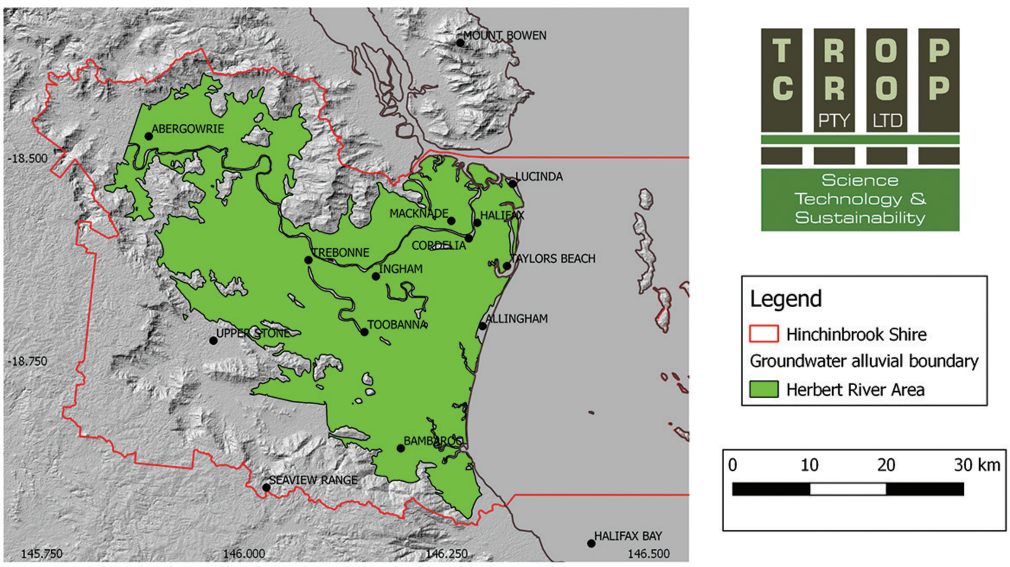


Figure 16: Groundwater alluvial boundary in the Hinchinbrook Shire

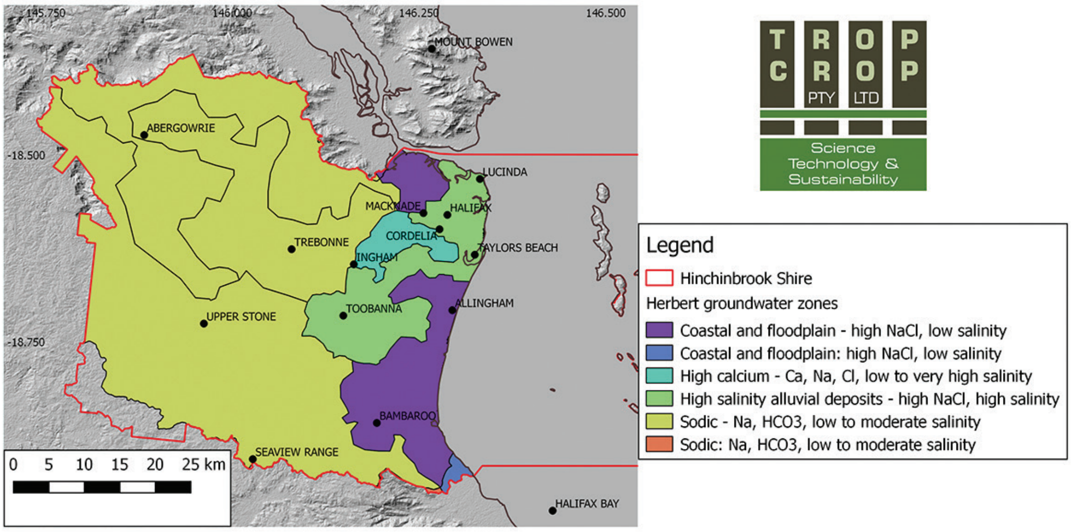


Figure 17: Groundwater zones and generalised chemistry in the Hinchinbrook Shire

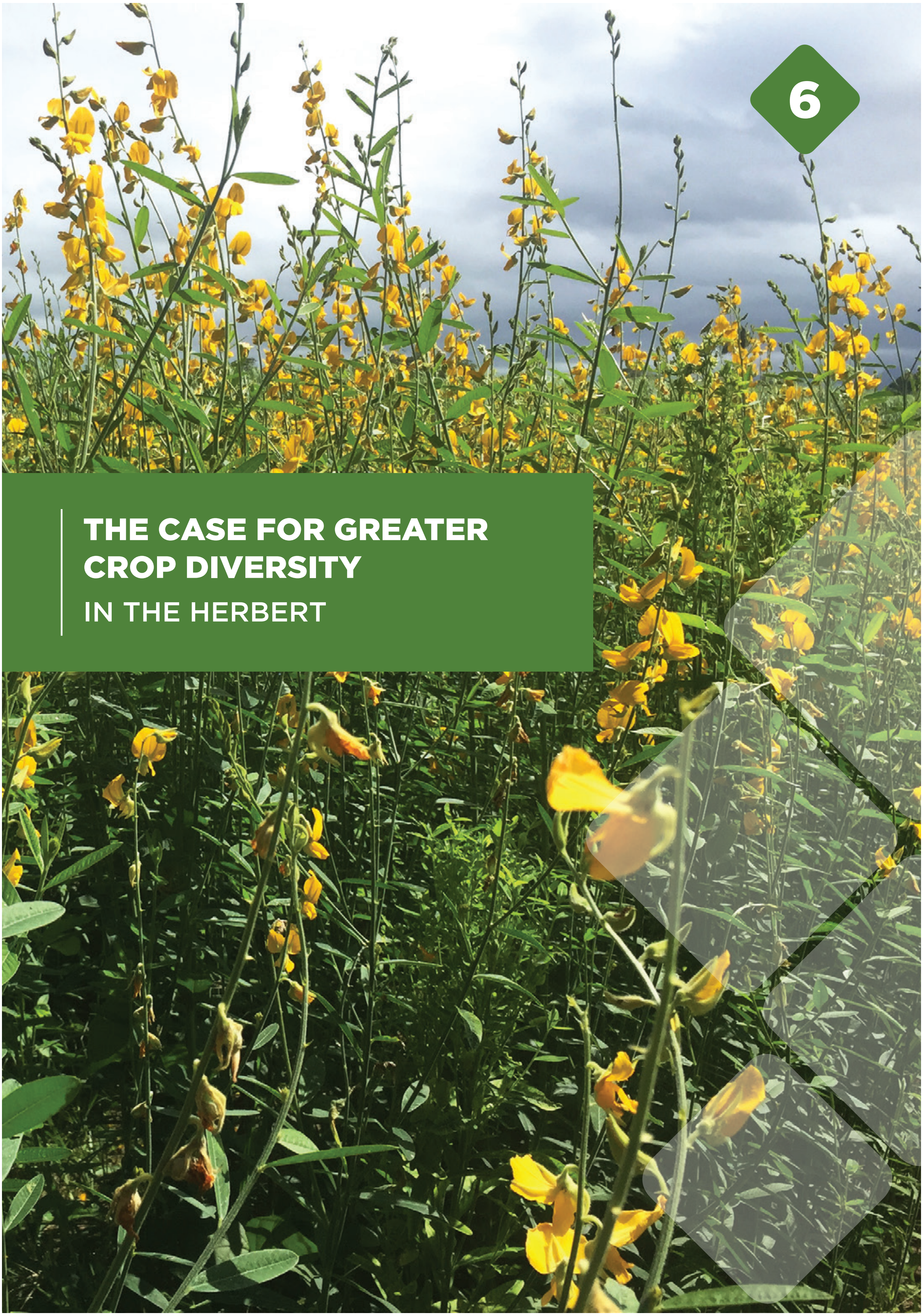
5.8 Vegetation Management and Natural Resource Management

Being an old farming area (dating from the 1870's) the majority of the cropping landscape is cleared and under cultivation. A key advantage for the Herbert is the lack of capital expenditure required in the establishment of suitable land and supporting infrastructure, roads, bridges etc. for the growing of crops.

The fact that farmland has been under cultivation for such a time does mean that steps are being taken to better manage the natural resource. It is important for agriculture to target improved environmental stewardship. For the Herbert River Valley this has a major bearing on downstream water quality draining from farmland and the water quality for the Great Barrier Reef Lagoon.

The coastal zone agriculture in Herbert River Valley agriculture is closely attuned to environmental stewardship. The region is well monitored and modelled, farming and land management decisions can be well informed. As before, many of the shifts in farming practices stand to lead to an improved environmental outcome.

It is important that any adjustment to the cropping regime is cognisant of environmental stewardship and sustainability and provides leadership in this area.



THE CASE FOR GREATER CROP DIVERSITY

IN THE HERBERT

6. THE CASE FOR GREATER CROP DIVERSITY

IN THE HERBERT

The economy of the Ingham area is highly dependent on a single crop, sugarcane, which is grown largely as a monoculture. On average, a plant crop and 4-5 ratoon crops are grown. Following the removal of the final ratoon crop, usually towards the end of the harvesting season, the land is left fallow and supports whatever grasses and weeds grow there. The planting of fallow crops is comparatively rare although this has increased in recent years. Most fallow crops are legumes such as cowpeas or soybeans and these are planted to enrich the soil providing organic matter and some/all of the nitrogen required by the next sugarcane plant crop.

6.1 Consequences of sugarcane monoculture

Most of the cane growing land in Queensland has been cropped for over 50 years. Wood (1985) analysed soils in the Herbert from 20 paired sites with adjacent areas of old cane land and non-cropped land and showed that the soils supporting old cane land had become clearly degraded. The old land was more compacted, had lower water infiltration rates, lower water holding capacity, lower levels of soil organic matter, was more acidic and had a reduced capacity to store and hold plant nutrients. These findings were supported by Bramley et al (1996) who conducted a similar study in other cane growing districts. Further investigations showed that soil biological degradation had occurred with old cane land having reduced microbial biomass, greater numbers of plant-parasitic nematodes and more root pathogens (Stirling et al, 2010).

In the early 1990s sugar industry statistics showed that productivity measured as tonnes of sugar harvested per hectare had hardly increased at all during the previous 20 years (Garside et al, 1997). The term “yield decline” was introduced and was defined as the loss of productive capacity of sugarcane soils under long-term monoculture. A major research program was established at this time to determine the causes of the problem and to develop solutions.

6.2 Major findings of the Sugar Yield Decline Joint Venture

The principal causes of yield decline were found to be:

- a lack of crop diversity with no fallow break crops;
- soil compaction caused by heavy harvesting and cultivation equipment operating over most of the field;
- a progressive decline in soil fertility and biological activity;
- an increase in sugarcane root diseases caused by various fungi.

Given that many of the components of the conventional sugarcane farming system were contributing to yield decline the challenge was to develop an alternative system that was not only productive and profitable but also sustainable. The suggested system involved a reconfigured row spacing to separate cropping and traffic zones, an alternative crop to break the sugarcane monoculture and reduce populations of sugarcane-specific root pathogens, and a substantial reduction in soil disturbance and tillage.

6.3 The likely benefits of the new farming system and crop diversification

The indications are that the new farming system, as outlined above, will lead to a progressive improvement in soil health (Stirling et al, 2010). However, any improvements will be relatively slow, soil health benefits will take time to be realised. There is no quick fix.

In recent times the district has actively investigated the benefits of rotation cropping and crop diversification to improve soil health and increase productivity.

6.4 Introducing new crops into the sugarcane farming system

Provided the basic principles of the new farming system are followed, it should be possible to incorporate a wide range of different crops into a rotation with sugarcane. The next sugarcane crop is established after a period of fallow, ideally including a short-season break crop to improve soil condition. Some crops may confer bigger benefits to sugarcane than others. Some may involve a break of at least one year. This is unlikely to have a significant impact on the supply of cane to a sugar mill as the increase in yield during the sugarcane crop cycle is likely to compensate for the loss of 1 year of sugarcane particularly as the crop that is sacrificed is the last ratoon which is almost always the lowest yielding crop.

6.5 How can it be done?

We have assessed recent years of sugarcane cropping cycle across the Hinchinbrook Shire/ Herbert River Valley, looking at the proportion of land being fallowed. Six geographic sub-regions in the Herbert region can be compared, based on differences in climate or soil type: Abergowrie, the Wet Belt, Stone River, Central Herbert, Lower Herbert, and Ingham Line.

Currently, there is little difference in the number of ratoon crops and length of the sugarcane cropping cycle between sub-districts. In our estimate, plant and up to 4th ratoon generally accounted for 90% of the sugarcane crop. On average 14% of sugarcane land is in fallow, circa 9,100 ha each year.

Cropping that is complementary to sugarcane will best fit in to this five to seven-year cycle as a fallow crop. The question is how to make the most opportune use of the fallow period? Can there be optimal utilisation of fallow to support diversified cropping? This fits with current short-season sugarcane fallowing, 3-5 months. Would a sequence of break crops over a 15 or 18-month fallow provide a greater soil health benefit to boost subsequent sugarcane production, and strengthen cash flow for growers?

6.6 A model for coordinating cropping on fallow land

On average, district cane farms are made up of a large number of smallish blocks. We estimate the median area of cane blocks to be between 2-4 hectares. The small size and spread of the individual blocks when in fallow may have a bearing on the feasibility of growing alternate break crops. Small disjunct areas may make planting, harvesting and specialist equipment movement less practical. Realistic commercial production requires a satisfactory scale for the district.

A model of cooperative land management among neighbouring or like-minded growers where the cropping rotation might bring a shared contiguous area into fallow at the one time could make alternate or complementary break cropping more feasible. Contiguous areas, or blocks in close proximity, farmed as one fallow may allow a scale of operation to suit timeliness of operations and equipment movement, and for harvested produce storage.

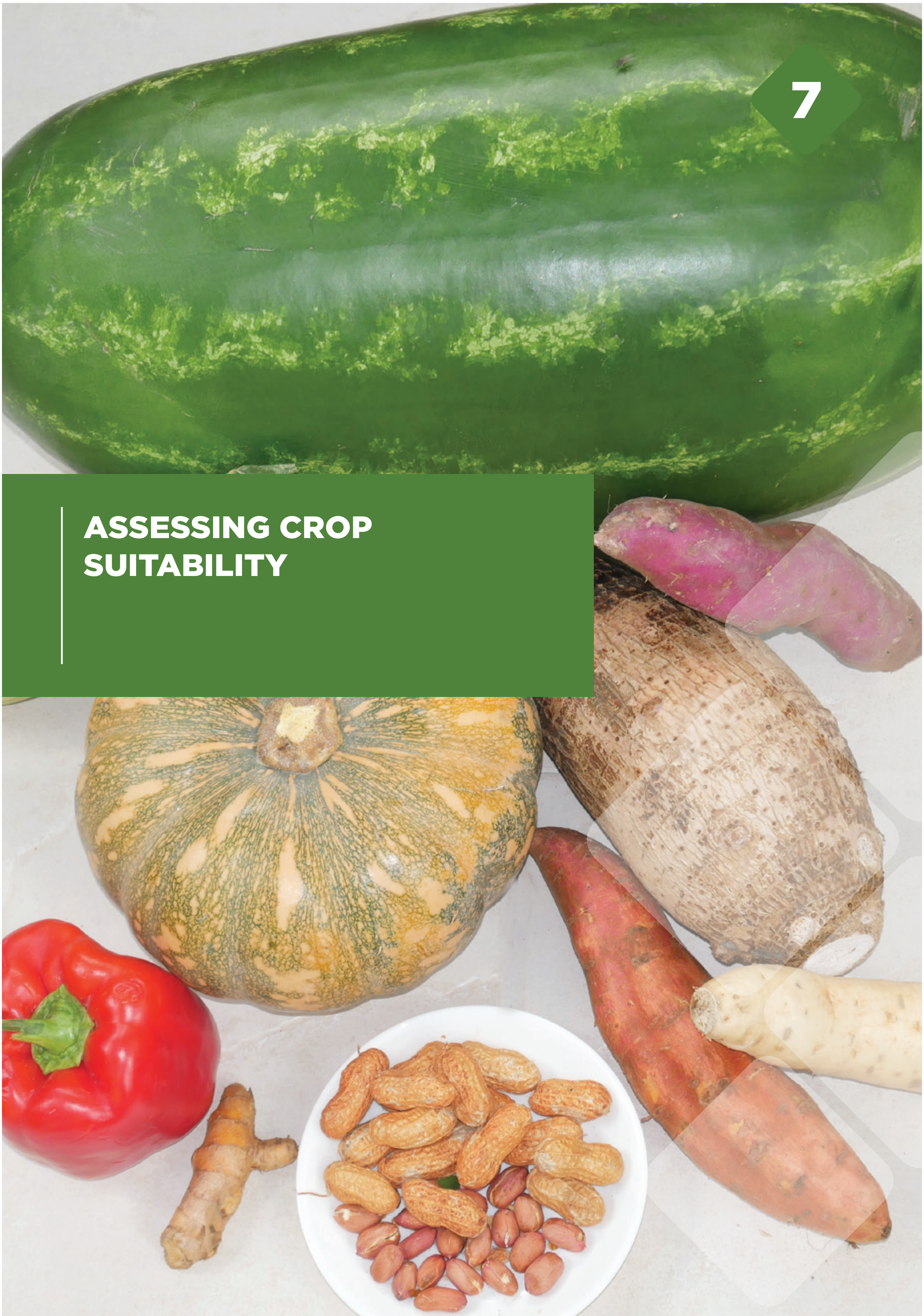
Additionally, management oversight by one or a few growers of a larger combined area across several farms can possibly achieve a higher level of management, timeliness of operations, and equipment availability. Such scale could mean the difference between success or otherwise for the alternate crop, with the benefit going to all of the participating landholders.

The details of the fallow farming model may vary from share-farming to short term lease, depending on the length of time. The benefit to the participating landowner would be improved weed control, liming to improve soil condition and nutrient status, break in pest and disease cycle and freedom from fallow management.

Key for the success of a contracting fallow cropper is to have a sufficient area of land in a manageable area, and control of operations and inputs to achieve a timely and uniform management of the crop.

With adoption of GPS guidance and precision agriculture, crop rows on raised beds positioned with A/B lines, and reduced tillage, it should still be feasible to have coordinated cropping during the sugarcane fallow.

The design is a win for landowner, the contracting fallow land sharefarmer and for the district agricultural revenue.



7

ASSESSING CROP SUITABILITY

7. ASSESSING CROP SUITABILITY

7.1 Wilson and Baker land resource and crop suitability assessment

Based on their survey of the Herbert River Valley land resources, Wilson and Baker (1990) considered the land suitability for 20 different crops as well as pasture and the growing of forestry pine. Crops included sugarcane, banana, pawpaw, mango, lychee, citrus, avocado, rambutan, tea, vegetables, cucurbits, pineapple, dry maize, wet maize, sorghum, sweet corn, soybean, peanut, sweet potato, and rice.

Their crop suitability assessment drew on significant resources of Department of Primary Industries agronomists and horticulturalists. Coming off a large initial survey area, 319,456 ha consisting of 1626 unique mapping areas, of which 160,270 ha was coastal lowland, and by examining soils only at undisturbed sites, large areas were mapped as suitable for many of the crops assessed.

7.2 Profile of Herbert Valley agriculture

In the 1990 survey sugarcane was the dominant crop. There were small areas of banana, avocado, pawpaw, mango, lychee, maize, forage sorghum, grain sorghum, sweet corn, soybean as green manure, rice, watermelon and pumpkin, and pineapple. Cattle grazing was the only substantial industry apart from sugarcane.

Irrigated cropping included 200 ha of rice annually, with the remainder limited to small areas of sugarcane, melons and pumpkins. Irrigation water was drawn mainly from streams. The lack of any dedicated water harvest or storage for irrigation was noted as limiting cropping options in the traditional winter dry season from June to November.

More recent figures (2015-2016) for agricultural production for the Hinchinbrook Shire show a similar picture (see table 4). There is a narrow range of agricultural pursuits. Sugarcane production is the only major crop land use, followed by grazing of beef cattle. While overall cropping area will have increased since 1990 the range of crops has decreased. There are small areas of legumes, probably included under the listing oilseeds. Small areas of rainfed rice are being grown each summer in heavier soils. Pineapple is grown near Crystal Creek however this production will sit in the statistics for the neighbouring Townsville City region.

Hinchinbrook Shire 2015-2016. ABS	Hectares
Sugarcane	49,371
Oilseed (recorded as canola, but presumably soybean, sunflower or other)	48
Grain crops (maize and sorghum)	22
Vegetable (melon and pumpkin)	25
Fruit and nut trees	51
Hay and silage	28
Livestock	
Beef cattle	13, 153 head
Pigs	228 head
Bees for honey	544 hives
Eggs free range	100 dozen

Table 4: Agricultural production from the Hinchinbrook Shire 2015 2016. Taken from ABARES statistics and compiled by QDAF Townsville.

This pattern of production for the Hinchinbrook Shire is shown in the land use surveys conducted by Queensland Department Agriculture and Fisheries in the Wet Tropics bioregion in 1999 and 2015, compiled at 1:100,000 scale (Figure 18).

This mapping uses the ALUM mapping scheme (Version 8, 2016), which is the Australian standard adopted by all States and which provides a three-tiered system of classification.

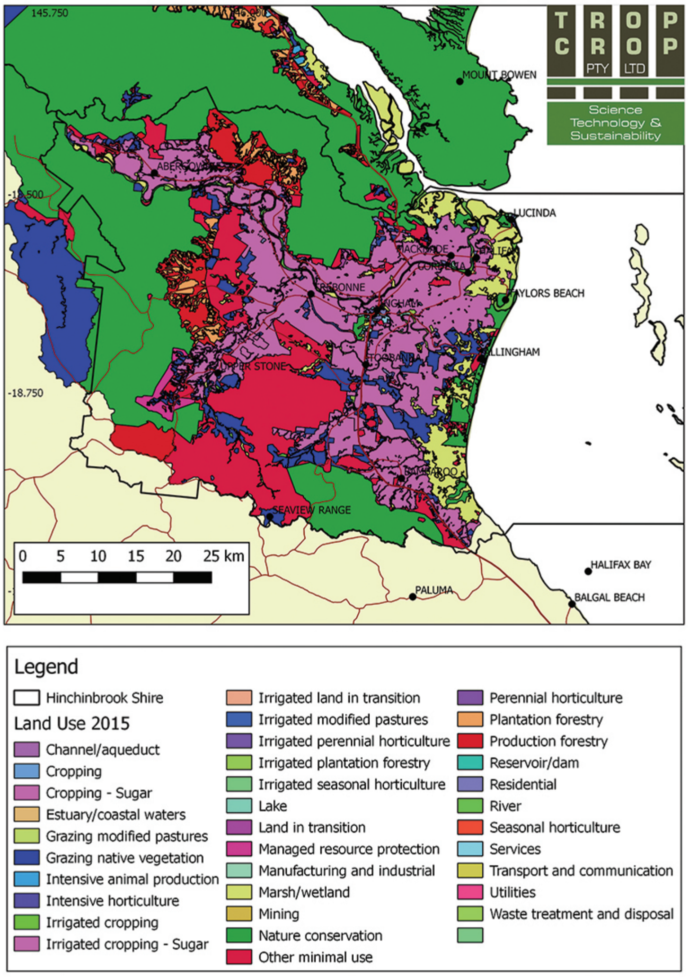


Figure 18: Land use (secondary categories) of the Hinchinbrook Shire in 2015. Source: Queensland Department Agriculture and Fisheries

7.3 Assessing suitability for crops today

We have not attempted to reassess or recreate the soil type by crop suitability formulated by Wilson and Baker (1990). There would be little to be gained in repeating or questioning the depth of work covered in their extensive study.

Adapting the Wilson and Baker 1990 classification and guided by the soil categories used by Wood et al (2003) we have grouped the 52 soils into 10 broad categories (Section 5.3 Table 2). The 10 categories are based on soil characteristics and likely agronomic responses in determining their suitability for crops. This is in a bid to simplify interpretation of the initial land resource and crop suitability survey and to increase access to this valuable catalogue of land resource information.

Based on local experience, we are confident that the proposed grouping does not contradict the original authors assessment but are mindful that since 1990 land has been modified by 25 years of improved farming practice, cropping inputs and amelioration. Soil conditions have been altered and improved. Soil constraints mapped previously may now not be so pronounced.

Table 5 summarises the suitability of crops considered in the 1990 survey, grouped according to the 10 soil groups adopted in this study. The areas are the total hectares falling into suitability class 1, 2 and 3. Class 1 suitable with negligible limitations, class 2 suitable with minor limitations, class 3 suitable with moderate limitations.

Suitability of soil types and locations across the study region as per the original survey will still hold and should continue to be used as a guide on the possibility of growing other crops. As noted above, constraints considered significant at the time may now diminished.

	1. Shallow soils	2. Deep sandy soils	3. Recent alluvial soils close to Herbert and Stone Rivers	4. Older alluvial soils on terraces, old levees and prior streams	5. Granitic hillslope soils	6. Basaltic soils	7. Seymour soils	8. Seasonally wet soils with intermediate texture	9. Seasonally wet soils with heavy texture	10. Poorly drained swamp soils
Avocado										
Banana		13,755	15,374	14,584	17,428	36	1,805			
Citrus	199	13,755		7,388	17,630	158				
Cucurbit			15,374	14,381	10,670	36	4,980	4,761	33,963	
Lychee	199	13,755	17,032	14,584	17,796	158	8,595		25,917	
Maize Dry		6,605	15,503	14,381	10,670	36	4,980	4,761	53,483	2,100
Maize Wet		13,755	15,374	14,584	6,298		253			
Mango	199	13,755	17,032	14,584	17,630	158	1,805			
Pawpaw	199	13,755		7,388	17,630	158				
Peanut				10,117	296					
Pineapple	199	13,755		13,281	17,630	36	2,059			
Rambutan										
Rice		13,755	15,374	14,584	16,673	36	12,571	4,761	37,435	
Sorghum		6,605	15,503	14,381	10,670	36	4,980	4,761	53,483	2,100
Soybean			15,374	14,381	296					
Sweet Corn		6,605	15,503	14,381	10,670	36	4,980	4,761	53,483	2,100
Sweet Potato			15,374	14,381	10,670					
Tea				4,359	296					
Vegetable		6,605	15,374	14,381	10,670	36	4,980	4,761	33,963	

Table 5: Land suitability for a range of crops as considered in the 1990 Wilson and Baker study, grouped according to the broad groupings of soils adopted in this 2018 study, based on their characteristics, formation and position in the landscape. The area is the sum of country considered as crop suitability class 1, 2 or 3 representing either negligible, minor, or moderate limitations. Suitable land is that located only within the Hinchinbrook Shire.

In line with the 20 crops previously assessed, and to bring new crops into consideration, we introduce a detailed assessment of six additional crops: capsicum, industrial hemp, kenaf, mung bean, safflower and taro. Our assessment is based on the modified soil groupings 1 to 10 (Table 6). In addition, we have included melons and pumpkin, peanut and sweet potato, crops that were considered in the previous study and the subject of current interest or in production in the district.

As before, suitability assessment is based on the land suitability five class system; class 1 -suitable with negligible limitations, class 2 - suitable with minor limitations, class 3 - suitable with moderate limitations, class 4 - marginal/presently unsuitable, and class 5 - unsuitable. For mapping purposes only land suitable for cropping is shown, class 1 to 3.

The 1990 authors noted that land has a wide range of properties that will affect crop establishment, costs of production, yield, and sustainability, and that the land classification system is a simplification of these complex interactions.

Table 6 summarises the perceived fit of nine crops into various soil types in the district. Assessment for melons and pumpkins, rice and sweet potato are based on the earlier study and we saw no reason to alter these. Capsicum is taken from the earlier vegetable suitability assessment. Mung bean has been based on the earlier assessment for soybean. Assessment for industrial hemp, kenaf, and taro is based on local soils knowledge and opinion and feedback from local growers. It was not possible to identify a range of soils for safflower and it will be necessary to do local trial work to assess suitability in Herbert soils and climate.

Following table 6, we present summary points on the agronomy for each of these candidate crops, followed by mapped areas of presumed suitability.

	1. Shallow soils	2. Deep sandy soils	3. Recent alluvial soils close to Herbert and Stone Rivers	4. Older alluvial soils on terraces, old levees and prior streams	5. Granitic hillslope soils	6. Basaltic soils	7. Seymour soils	8. Seasonally wet soils with intermediate texture	9. Seasonally wet soils with heavy texture	10. Poorly drained swamp soils
Capsicum		■	■	■	■	■	■	■	■	
Industrial Hemp		■	■	■	■					
Kenaf		■	■	■	■					
Melons & Pumpkins			■	■	■	■	■	■	■	
Mung Bean			■	■	■					
Peanut		■	■	■						
Rice		■	■	■	■	■	■	■	■	
Safflower	Unknown - no local trials or knowledge to date									
Sweet Potato			■	■	■					
Taro		■	■	■						

Table 6: Land suitability for a range of crops considered in the 2018 study and guided by the findings of the 1990 survey and report. Grouped according to the broad groupings of soils based on their characteristics, formation and position in the landscape adopted for this study. The area is land considered suitable with negligible, minor and moderate limitations, classes 1, 2 and 3. Suitable land is that located only within the Hinchinbrook Shire.

7.4 Capsicum (Capsicum annuum L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
Ten to 15 weeks.	Non-photoperiod-sensitive.	Wide range of soils, deep well drained such as loams. Avoid water logging.	Shallow.	Sensitive to salinity and to high EC irrigation water.	High water requirement, requires irrigation 30 to 40 mm per week.

Growing season

Late autumn through to spring. Optimum daily temperature 15-30° C.

Likely fit in Herbert River region soils and climate

Estimates of suitable soils are taken from the initial mapping of vegetable cropping.

Previous production experience in the Herbert River region

To our knowledge there has been no prior commercial scale production of capsicum in the Herbert. There has been small scale market garden production.

Particular crop requirements

Will require irrigation.

Advantage that the Herbert region offers

Proximity to local markets and to transport logistics. Can offer a product for the local northern market appealing to low food miles.

Avenues for marketing

The feasibility of commercial scale production of capsicum in the Herbert for major markets would depend on competing against supply from mainstream areas in the Burdekin, Gumlu, Bowen, and Bundaberg. Timing of product availability would be a crucial factor, is there a niche with seasonal availability that Herbert producers could fill? It may be feasible to procure local markets in Townsville and Cairns and the northern region.

Supply to a local market will depend on the relationship with a supply chain directly to the final point of sale: wholesalers, green grocers, and restauranteurs.

Herbert production would need to distinguish itself from market garden scale of supply located throughout the region. The Herbert would need to establish a brand and provenance loyalty throughout the region, akin to a paddock to plate model. Production may cater for niche capsicum and peppers varieties.

Where to from here

Capsicum production for supply to the fresh market in local centres will require establishing relationships directly with buyers at the final point of sale.

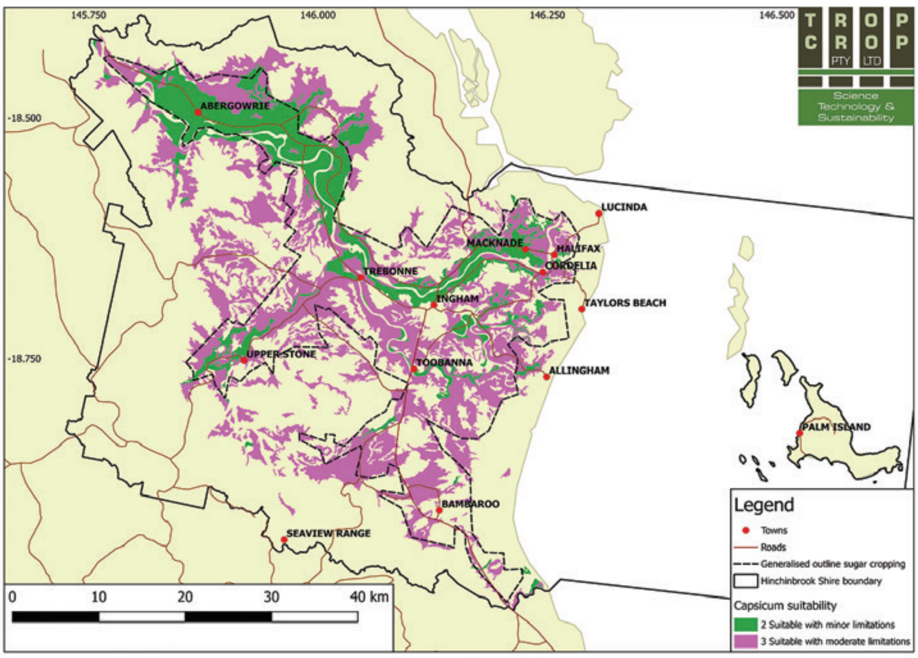


Figure 19: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing CAPSICUM. Land assessed as having a minor limitation (class 2) is plotted separately to land considered to have a moderate limitation (class 3). Adapted from Wilson and Baker (1990) – land for vegetables.

7.5 Industrial Hemp (Cannabis sativa L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
Hemp grows quickly and will flower 70 - 90 days after sowing. Fibre harvest is done before or at early flowering.	Sensitive, a short-day plant. Requires short daylength to initiate flowering.	Neutral to slightly alkaline, well drained, sensitive to flooding and waterlogging.	Medium	Moderately sensitive.	High, to support high growth rate. At least 600 to 700 mm rain a year. Requires soil with good water-holding capacity.

Hemp has a long history of cultivation for fibre and also for medical, oil, and illicit narcotic production. Originally from Asia, C. sativa is cultivated widely in China, Asia, Russia, India and SE Asia. Hemp was an important fibre alongside silk, producing fabric and clothing and being much less costly than silk.

Industrial hemp (hemp) refers to cultivar types that have a low THC drug content, which are the majority of C. sativa varieties, and do not serve any purpose for the illicit narcotics trade. Industrial hemp is grown for fibre. There are three products, the outer fibre of the stem (bast), the fibre of the inner stem (hurd), and the seed. Different varieties are grown either for seed or for fibre.

In Australia, any prospective grower of hemp has required a licence obtained from their respective State Government to acquire seed and produce the crop. Hemp crops must not exceed a threshold THC level set by State legislation.

Commercial crops are grown in most States. Hemp has been trialled in Mareeba, Mackay, Bundaberg, and Childers

Growing season

Hemp is a fast growing, herbaceous annual plant, growing to between 1.5 and 5 m tall.

Generally sown from October through to March/April. Presumably in the tropics, hemp would be sown into the wet season to grow on summer rains, and flowering would occur in the autumn to be ready for harvest. Earlier sowing would deliver higher crop growth for higher fibre yield.

Requires high sunlight during vegetative growth, therefore growth could suffer in cloudy days over summer.

North Queensland should be well suited to crop hemp, however this would need to be trialled.

Likely fit in Herbert River region soils and climate

Initial assessment of suitability for hemp production and trial production favours southern eastern Australia, and under irrigation.

Herbert soils would be suitable, however in many areas would require liming to raise soil pH to avoid acid soils.

Previous production experience in the Herbert River region

There is no known previous production of industrial hemp for fibre in the Herbert.

Particular crop requirements

Will favour fertile, deep well drained soils. Will not tolerate waterlogging.

There is no management system or agronomy established for hemp. Local trialling would be required to determine how well-suited hemp would be to sugarcane soils in the fallow period. High plant stand densities are reported, 250 plants /m2 is desirable. Presumably this is under irrigation.

Would likely require irrigation to fill gaps in seasonal rainfall. This would be significant in view of the rapid growth rate for the crop.

Despite a strong tap root, it is considered that hemp does not handle soil compaction well.

There are no registered herbicides. A wider row spacing between sugarcane hills would permit interrow spraying with knockdown herbicides if use permits could be obtained.

Growing for vegetative growth and fibre means that insect pests should not be a significant problem.

Root knot nematodes would be a carryover risk in sugarcane, however they would be a greater risk on sandy and lighter soils.

Efficient methods for harvesting and processing would need to be developed. The lack of specialised mechanical harvesting and processing equipment has been identified as limiting the uptake of industrial hemp cropping in Australia. The stem fibre strength means that machinery can be bound up during harvesting. Sickle-bar mowers, hay windrowers and hay balers have shown promise. Baled material needs to be stored under cover, out of the weather. Work needs to be done here.

Advantage that the Herbert region offers
Unknown at this stage. Trial plantings and assessment of product specifications for particular end uses will be required.

Avenues for marketing
Hemp requires the availability of long-term markets and contracts with specifications for an industry to be established. While there is commercial interest for local production, there is no value chain established for hemp.

There has long been a movement in the alternative culture to have hemp more accepted as a legitimate fibre. The bulk of fibre and textile products have been imported to meet initial demand. The level of acceptance in mainstream trade has grown and the range of opportunities for products increased.

The burgeoning hemp industry association would be the appropriate source of information on production and processing, market supply lines and on developments in harvesting equipment.

The recent debate and potential legalisation of cannabis oil in certain circumstances in Australia may add to the understanding of agronomy and production of hemp, although care is required to separate hemp for industrial purposes from requirements for medical products.

Where to from here
Hemp for fibre would be an innovative crop for the Herbert, potentially fitting into consideration for the sugarcane fallow alongside kenaf, safflower and sunflower as tap-rooted crops that might lessen the effect of compaction in the cropping system.

Local trials are required to assess planting times and configurations, growing seasons, the agronomy of the crop, and suitable harvesting techniques.

The developing hemp industry would be the prime source of information for potential growers.

Licencing to grow hemp remains in force in Queensland.

7.6 Kenaf (Hibiscus cannabinus L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
3 to 5 months in the literature, 6 months as a dry season crop in Burdekin	Flowers on a short day, however vegetative growth determines fibre yield	Deep and well drained. Will not tolerate waterlogging	Medium to deep, prominent tap root	Unkown	High water requirement, may be better suited to irrigation

Growing season
Kenaf is widely grown in Africa, Asia, India, SE Asia, USA and central America. Traditionally kenaf has been a source of fibre, rope and twine, bagging and rugs. It is grown as an industrial crop. The more recent interest in the USA and Australia has been with the potential for kenaf to be source of cellulose fibre for paper pulp production, and for non-wood renewable fibre and fibre-reinforced plastics for use in the industrial, building and motor vehicle industries.

Highest growth rates are in warmer climates when daytime temperatures are higher than 27° C.

In the literature varieties were noted to be photo-period sensitive. The plant requires increasing daylength to prolong vegetative growth, and a shortening daylength to initiate flowering. Highest fibre quality is when harvested at the early flowering stage, so the growing period ideally goes over the summer and into autumn.

Likely fit in Herbert River region soils and climate
The major benefit with kenaf could be the deep taproot which may work to break up compacted soils during the sugarcane rotation. Deep rooting pattern may also assist in scavenging for nutrients which have leached down the soil profile, removing

them and reducing the risk of movement into downstream water for a water quality benefit.

Kenaf is reported to be grown at high plant populations and narrow row spacings, to achieve a thin plant stem and tall erect growth to maximise the fibre yield. It would therefore be questionable if kenaf could be planted onto sugarcane hills in fallow to achieve sufficient crop stands. This effect of plant population and planting configuration would require trialling and experimentation.

Previous production experience in the Herbert River region

There is little local knowledge. To our knowledge kenaf has not been grown in the Herbert. Kenaf has only been planted in Australia in experimental plots. Trials were conducted under irrigation in the Burdekin in the 1980's and a further semi-commercial trial in the early 2000's.

Kenaf is reported to have a high water requirement, and it would need to be determined if it could be grown in the Herbert over the summer wet season as a rainfed crop and harvested in the late autumn. Sowing following sugarcane harvest and fallowing may be feasible.

Particular crop requirements

Requires medium textured soil with good drainage. As a rainfed crop it will have a high soil moisture requirement but will not tolerate waterlogging. Prolonged waterlogging and high temperatures will set back and risk killing the plant.

Heavier soils may be suited if planted on beds to assist with drainage. This could fit with sugarcane fallow.

Advantage that the Herbert region offers

Could processing be done in sugar mills? As an offshoot to sugar processing and pre-sugarcane harvest.

Harvesting might be feasible with modified sugarcane harvesting and transporting equipment.

Avenues for marketing

Considering Kenaf is somewhat theoretical. Interest would depend on the future demand for alternative sources of fibre and pulp to supply for manufacture of paper pulp, cardboard and fibre-reinforced plastics.

A viable kenaf production would require processing facilities to be close at hand. The light weight and high volume of dried kenaf stem would make transport of the raw product over a long distance unviable. This was noted as the major obstacle in the 1980's Burdekin trials.

Where to from here

Market research would be required to determine future demand for alternative and sustainable paper pulp supply.

Requirements would be markets with firm contracts and product specifications. It is not possible to comment on likely returns to growers

International trends in demand for newsprint and paper manufacture will determine potential for kenaf.

It is not known if there is a commercial source of kenaf seed in Australia.

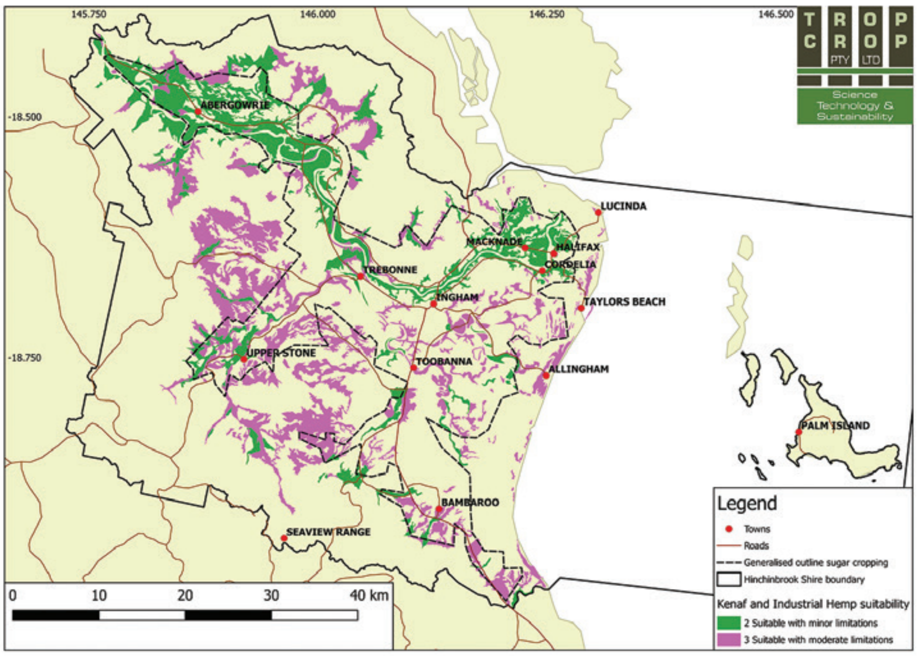


Figure 20: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing INDUSTRIAL HEMP and KENAF. Land assessed as having a minor limitation (class 2) is plotted separately to land considered to have a moderate limitation (class 3). Based on soil characteristics noted by Wilson and Baker (1990) and the current assessment of crop requirements and growing conditions.

7.7 Melon and Pumpkin (Citrullus spp. and Cucurbita spp.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
Melons 12 to 14 weeks and pumpkins 15 to 20 weeks - depending on seasonal temperature.	Indeterminate however temperature is more important factor.	Wide range of soil types, deep well drained such as loams. Avoid water logging.	Shallow.	Sensitive to salinity and to high EC irrigation water.	High water requirement, requires irrigation.

Growing season

Autumn through to spring, require long, warm growing periods. The growing season for melons and pumpkins is well understood in the Herbert valley.

Likely fit in Herbert River region soils and climate

Estimates of suitable soils are taken from the initial mapping for cucurbits. Favoured soils and locations in the district are well known and well tried. These crops are grown on a wide range of soils. Access to water for irrigation is a key factor.

Previous production experience in the Herbert River region

Melon and pumpkin production have a long history in the Herbert. Annual planting of these crops is in response to market feedback and in anticipation of production levels in other regions. It is very common to use fallow sugarcane ground for these crops. There is a widespread belief that melons and pumpkins improve sugarcane ground, probably with carryover of residual fertiliser.

Particular crop requirements

Will require irrigation. Melons are grown on plastic mulch and trickle tape. Pumpkins are grown on soil surface and will be watered occasionally with overhead irrigation.

Melon marketers will offer support with crop inputs, plant protection services, and chemicals. The industry is well serviced with laboratory analysis for sap, leaf and soil analysis ensuring a rapid turnaround on test results.

The nutrition program is a basal planting fertiliser and then regular fertigation at various growth stages according to sap testing results. Plant protection requirements are high and crops should be monitored regularly for insect, mite and fungal disease attack. Crops require pollination with bees.

Melons are a high input crop and hopefully a high-value return.

Advantage that the Herbert region offers

There is a history of consistent supply of melons

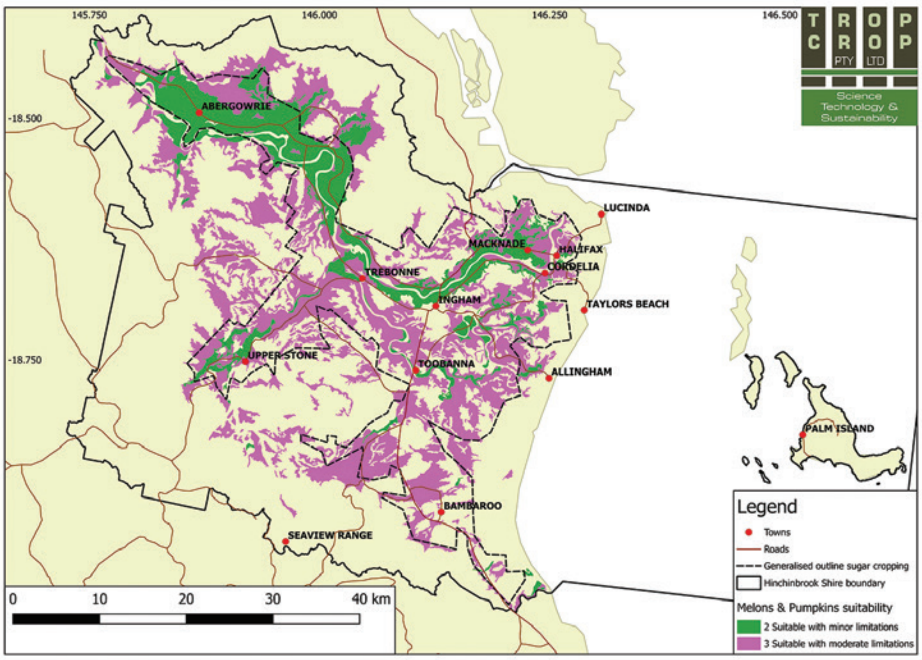


Figure 21: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing MELONS and PUMPKINS. Land assessed as having a minor limitation (class 2) is plotted separately to land considered to have a moderate limitation (class 3). Adapted from Wilson and Baker (1990) – land for cucurbits.

and pumpkins from the district and growers are regarded as reliable suppliers. Transport connections are well established with proximity to the national highway.

Avenues for marketing

Relationships with marketers are long standing and trusted. Pre-season feedback on market projections is important for melons. Pumpkins can experience wide price fluctuations, with seasons of oversupply meaning that surpluses may not reach market. Market intelligence is the key factor for intending producers.

Where to from here

Melon and pumpkin production is well established in the Herbert and has a long standing place in the market. Melon and pumpkin growers appear to have reliable access to water for irrigation. Production is expected to continue at the current level, albeit with seasonal fluctuations as have been historically experienced.

7.8 Mung Bean (Vigna radiata (green) and Vigna mungo (black))

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
10 to 15 weeks.	Non-photoperiod-sensitive.	Wide range of soils, deep well drained such as loams. Will not tolerate water logging.	Shallow to moderate, with a taproot. Can extract moisture from as deep as 90 cm in uncompacted and open textured soil.	Sensitive to salinity and to high EC irrigation water.	Requires soil moisture profile 80 to 100 cm in a dryland situation. Considered hardy and drought tolerant but often irrigated.

Growing season

A short season summer crop, approximately 90 days to maturity. Optimum daily temperature is 15-30° C. Darling Downs sow through summer from December to early February. Central Queensland February onwards, and then August and early spring, Burdekin sow August through to December.

It is considered a hardy plant and moderately drought tolerant.

In sugarcane rotations mung bean has been viewed as well placed to follow final harvest and plough-out. However, as dryland crop adequate soil moisture at sowing is critical.

Likely fit in Herbert River region soils and climate

Estimates of suitable soils are taken from the initial mapping for soybean. Alluvial soils and granitic hillslope are favoured, avoiding sodic subsoils. Would mung beans grow on raised beds in the heavier seasonally wet soils? These soils could expand the Herbert area considerably. Raised beds would require specific construction with flat surfaces and appropriate row spacing. Ridged and uneven surfaces make heading difficult and increase bean losses, the plants are short and pods close sit to the soil surface.

Previous production experience in the Herbert River region

In recent times there has been limited trialling of mung bean across the district in irrigated and rainfed plantings. Sowing was trialled as early as April and then in September and through to October. Unfortunately, low seasonal rainfall resulted in poor crop growth and yield. These efforts were not successful.

Growers reported the district needed a higher level of agronomic support to grow mung bean. The crop requires specialist technical and practical knowledge and skills.

Particular crop requirements

Grown as either irrigated or dryland crop. Pre-sowing soil moisture is key. Moisture profile of 80 to 100 cm is required. In the Herbert soil moisture profile is largely depleted after harvest. Seasonal rainfall and irrigation to establish plants will be beneficial.

Unblemished bean colour and smooth skin texture is a key factor in mung bean product quality. The high-priced food grade market demands both. Mis-matched rain and wet conditions at harvest and high bean moisture levels can downgrade quality, rendering beans suitable only as a manufacturing grade for milling and processing.

Inoculate seed using Group I inoculant (Rhizobium strain CB 1015). Be aware of potential weed problems as broadleaf herbicide options are difficult in mung bean. Also, be aware of previous paddock history of applied residual herbicides. Mung bean require regular insect pest monitoring from the late vegetative flowering initialisation stage onwards to ensure timely and effective control. May require desiccation before harvest.

Advantage that the Herbert region offers

The Herbert would benefit from a break crop that would fix some atmospheric nitrogen into the soil and contribute to soil organic matter. Despite a short growth-season a definite production fit for mung bean in the Herbert remains as unchartered territory.

Proximity to receival and shipping facilities is a plus. The handling facility at Brandon has lowered the cost of transport compared with previously shipping to Biloela and Kingaroy.

To be attractive to the market the Herbert will need to fill a gap in supply and demonstrate that we can produce a reliable quality. Are there seasonal conditions that suit this production timing? Can production for the Herbert be managed to fill a supply gap? This will have to be looked at across a range of seasons.

Avenues for marketing

All regions have challenges producing mung bean. Market demand remains high. It is an important food crop for Asia and fluctuations and shortfalls in supply often occur. Premium quality attracts a high price. Production from north Queensland is currently sold to the trader, graded and bagged in 25kg packages via subcontract at the Brandon facility and shipped for export from Townsville port.

Where to from here

Mung bean will remain as a high value market.
To consider mung bean for the Herbert further trialling is required to identify suitable soil types and seasonal conditions, and sowing times. Variety assessment may identify better suited types.
If they can be grown mung bean would be a useful adjunct to sugarcane rotation with the benefit of a short growing period.

As for other crops the it is likely the district would benefit from receival, handling and storage facilities and coordinated transport, to achieve economy of scale. However, for mung bean that complicates grading and quality assessment for individual consignments and this may require individual delivery to the Brandon facility.

Crops will need servicing from accredited agronomists to meet industry quality standards. The plant protection needs for mung bean would be higher than for other crops.

The Australian Mungbean Association (AMA) is the peak body representing growers and marketers and is the best source of information. AMA can also be contacted through Grains Research and Development Corporation (GRDC) northern division.

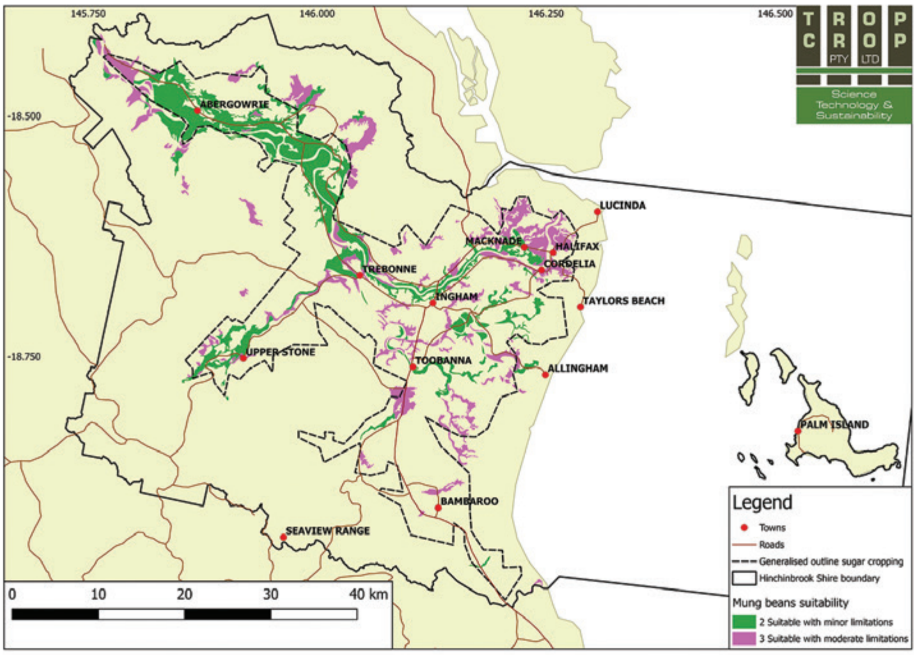


Figure 22: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing MUNG BEAN. Land assessed as having a minor limitation (class 2) is plotted separately to land considered to have a moderate limitation (class 3). Adapted from Wilson and Baker (1990) – land for soybean.

7.9 Peanut (Arachis hypogaea L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
100 to 150 days	neutral	pH 5.5 to 7.0 well drained friable soils	Medium	Moderately sensitive	Usually irrigated 500 – 700 mm

Growing season

Peanut is a summer growing legume. Frost sensitive. Grown from southern Queensland Burnett to the Atherton Tablelands and across to Katherine in the Northern Territory. Sown from October/November through to January in the Burnett and Bundaberg regions. December/ January sowing in north Queensland. Katherine has experimented with sowing as late as April.

Likely fit in Herbert River region soils and climate

Peanut will be suited to well drained and moderately textured soils. Key will be to have soil that will separate from the groundnuts once the crop is lifted, so heavier soil is not suitable.

Can possibly fit in to summer rainfall pattern to grow as a rainfed crop, plant November and harvest May. Irrigation if available would be an advantage.

Rainfall at harvest will be a problem. Has a high calcium requirement, soil will have to be limed prior to planting.

Previous production experience in the Herbert River region

Several growers have tried peanut in the past. There has been no production in recent years.

The results of the Sugarcane Yield decline Joint Venture indicated that peanut should be a good fit with sugarcane crop rotations.

Particular crop requirements

Control of foliar diseases in summer humidity requires regular and frequent spraying with protectant fungicide. Soil borne fungal diseases should not be a problem in a rotation with sugarcane. Old sugarcane ground may need to be checked for soil chemical residues. Requires specialised planting and harvesting equipment. Drying down peanut in the field once lifted is desirable, ideally to 12% moisture content. Silos available for storing and drying in Ingham would be an advantage to enable economy of scale for shipment to Tolga or to Kingaroy.

Advantage that the Herbert region offers

Avoid high temperatures above 32° to 33° C for crop stress and shutting down growth. Receival and drying facilities through Peanut Company of Australia are in close proximity at Tolga, Atherton Tablelands. Coordinated cropping of sugarcane fallow could offer feasible areas for peanut each year.

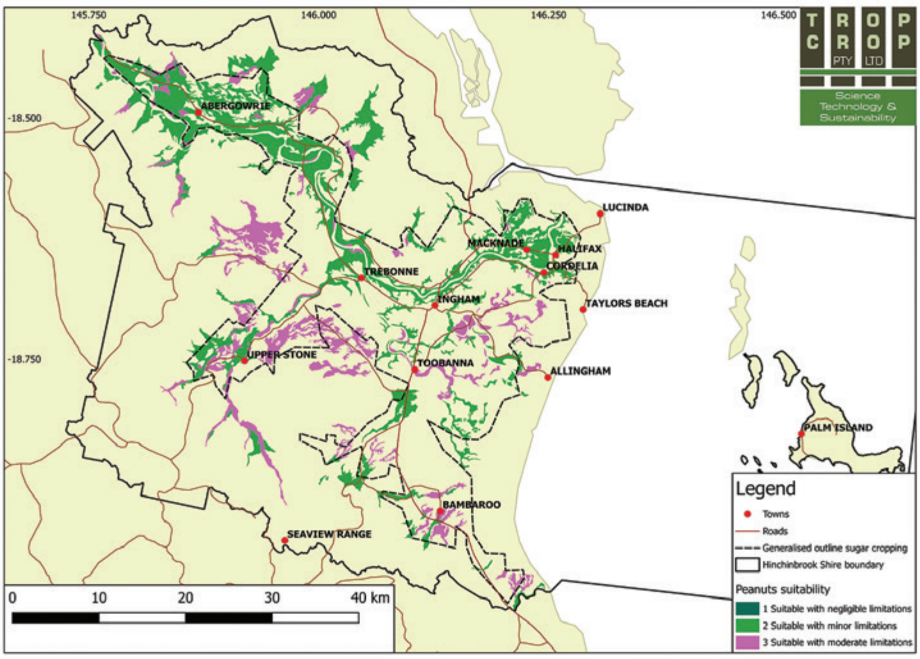


Figure 23: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing PEANUT. Land assessed as having negligible limitation (class 1), a minor limitation (class 2), or moderate limitation (class 3) are plotted separately. Based on soil characteristics noted by Wilson and Baker (1990) and the current assessment of crop requirements and growing conditions.

Avenues for marketing

Coordinated district production necessary, with market awareness prior to planting coupled with seasonal outlook for summer rainfall necessary information. Peanut Company of Australia is looking for expansion in north Queensland through seasonal contracts. Current domestic production is meeting 40% of domestic market demand.

Where to from here

Peanut production would need certified agronomy support for the district.

Cooperative ownership or management of planting, lifting, harvesting and storage/drying facilities would be an advantage.

PCA agronomy and production staff are willing to work with the district with advice on varieties and crop management. To be successful it is anticipated that the district will need to increase the crop knowledge and available agronomy support with dedicated local resources.

7.10 Rice (Oryza sativa L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
120 to 140 days, variable with rainfed conditions	Not sensitive, growth and grain fill will be affected by temperature and accumulated heat units	Heavy texture, self mulching, avoid sodic subsoil	Medium to allow extraction of soil moisture to greater depth than with irrigation	Moderately sensitive	High, but rainfed so rely on seasonal rainfall

Growing season

Rice is now grown in north Queensland as an upland crop, not flooded in the paddy with water to cover the ground surface as previously practised. In some areas the crop will be irrigated periodically, however in the majority of cases in the Herbert it is grown as a rainfed crop, not irrigated.

As a rainfed crop it is desirable to grow on the summer rainfall, planting in late December early January. This fits in well with land coming out of cane in the fallow. Rice harvest will occur from late April to June. The duration of rice to flowering and grain-fill will depend on sunlight and temperature. This equates to a requisite number of heat units. Given seasonal conditions there will always be some variability for rice in north Queensland, and crop management will always require careful monitoring of growth stages.

In earlier times in north Queensland rice has been grown as two crops a year, with a second sowing as a winter crop. This was only feasible where irrigation was available. In current cropping rotations the summer sowing on wet season rain is the best fit.

Likely fit in Herbert River region soils and climate

Rice is expected to be suited to a wide range of Herbert soils. In past production a soil that was impervious to water was best as the field was periodically ponded with water. Heavy clay subsoils or compacted soils, possibly with sodic soils at depth. With upland rainfed rice rooting depth is more important. Soils with high water holding capacity are needed so a wider range of probably better soils are suited.

Previous production experience in the Herbert River region

Rice was grown throughout the 1970's in the Herbert, working in with the north Queensland rice industry with receival and milling facilities operating from the late 1960's at Brandon and Home Hill in the Burdekin. Production ceased, and milling operations closed in 1992.

In 2011 receival and processing facilities were re-established at Brandon, followed by concerted efforts to re-establish commercial rice production throughout north Queensland. SunRice as one of Australia's leading branded food exporters and the principal commercial interest in the NSW rice industry purchased the Brandon facilities and have supported the north Queensland industry research and development program through Rice Research Australia and AgriFutures Australia.

North Queensland is strategically placed to produce Australian long grain rice types.

Since 2015, several Herbert River growers have trialled rice as a fallow rotation with sugarcane with mixed results. Industry development priorities have been identified. These efforts for industry development are expected to continue.

Particular crop requirements

Current production in the Herbert is based on an older long grain variety Doongara initially selected for the subtropical NSW industry. Results have been surprising however it is widely recognised that production will be improved with the selection of long grain varieties better suited to the tropics.

For rainfed rice, heavier self-mulching soils are suited with a higher water holding capacity. Ideally the plant will be deeper rooted than in irrigated paddy crops. Areas with sodic subsoils will not be as well suited.

Care with seedbed preparation and seeding is important when coming out of sugarcane. A fine soil tilth will enable accurate seed placement at appropriate depth. Seeding depth will vary according to seasonal conditions and soil moisture at sowing.

Crop nutrient management is not as fine-tuned as in NSW crops. There has been less research to date for the tropics. There is work to be done on balanced nutrition in the higher temperature and higher rainfall environment, on determining the optimal split between pre-sowing and sowing applications and on further nutrient requirements before panicle initiation.

Insect, plant disease and weed control requirements are high in the tropics. While stem and foliar diseases occur widely in all tropical rice production the use of fungicides is not economical. Varietal resistance will be the key for disease management. Herbert crops require frequent monitoring for insect attach and insecticide application can be required. Broad leaf and grass weeds require successive herbicide applications.

Advantage that the Herbert region offers

Rice fits well with sugarcane rotation and an alternate crop for the fallow break. Cane blocks are a convenient size for fallow cropping and inclusion of rice in the break should deliver soil improvement benefits.

Fitting into sugarcane rotation, modern farming practices and precision agriculture technology, paddock layout and laser levelling to improve drainage all assist in overcoming prior constraints to fallow break cropping.

The Herbert offers reasonable proximity to Brandon for transport and delivery. It will be important for local coordination of cropping and harvesting and for storage and transport. This would be facilitated by the availability of suitable storage, drying and loading facilities in Ingham.

North Queensland including the Herbert River valley should be well placed to produce long grain fragrant types, which will complement the mainstream medium grain production from NSW.

The Herbert as a growing region also offers a degree of risk management for overall Australian production. The spread of growing regions minimises production shortfalls in dry years where water can be in short supply for irrigation for some areas.

Avenues for marketing

There is strong world-wide demand for rice in many niche markets as a staple in many country's diets.

All north Queensland rice currently produced is acquired and sold through SunRice. Compared with other potential complementary crops, rice offers an established market pathway.

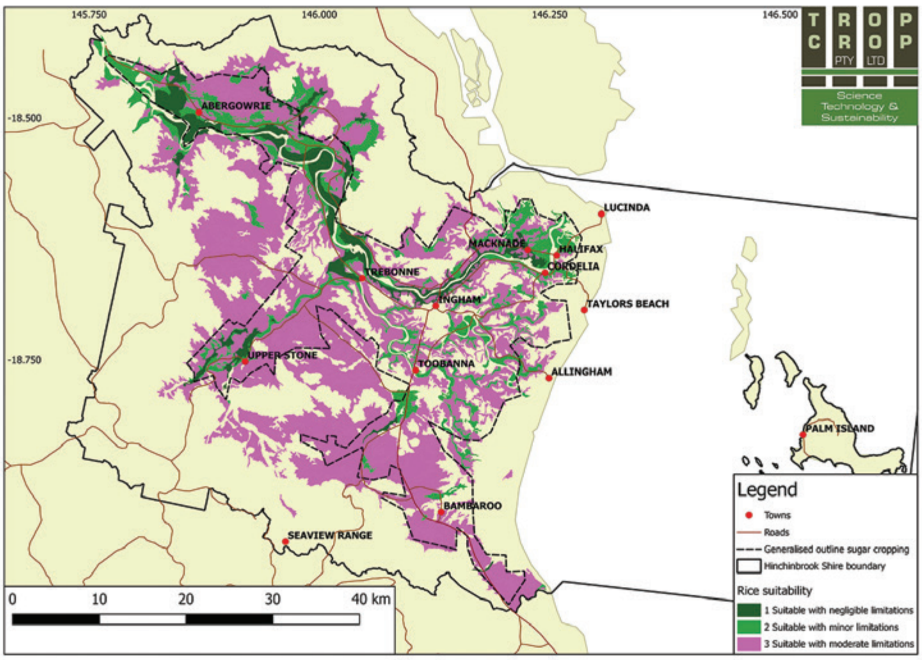


Figure 24: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing RICE. Land assessed as having negligible limitation (class 1), a minor limitation (class 2), or moderate limitation (class 3) are plotted separately. Adapted from Wilson and Baker (1990).

Where to from here

Establishment of delivery, storage and handling infrastructure in the district.

An operational model for local district coordination for production, farming operations, harvesting, storage, and delivery to market receival point.

Achieve critical mass to allow participation in the wider north Queensland industry research and development initiatives, addressing varietal selection, crop nutrition and plant protection needs.

Establishment of sufficient agronomy capacity in the district to service alternate crops.

7.11 Safflower (Carthamus tinctorius L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
Long season, in southern Australia may be from 26 to 31 weeks sowing to maturity	Responds to increasing day-length, winter and spring sowing	Neutral to slightly alkaline	Medium to deep, strong tap root to extract deep soil moisture	Moderately tolerant	High, at least 300 mm. Grown as dryland will require deep soil moisture profile.

Growing season

In southern Australia, safflower is planted as a winter or spring crop. The long growing season enables some flexibility with planting, as late as spring. Safflower can tolerate higher temperature and dry conditions with onset of summer due to the plants ability to draw on deep soil moisture.

In cereal-growing regions safflower is best adapted to higher rainfall areas with a dry climate during late spring and early summer, where water demands can be supplied from stored subsoil reserves.

If safflower was to be grown in the Herbert, it would require a full soil moisture profile at planting. Conceivably it would be sown in autumn after the summer wet season. The soil moisture profile is seen as a key requirement for rainfed safflower.

Likely fit in Herbert River region soils and climate

The suitability of Safflower as a rainfed crop in the Herbert soils and climate is unknown. However, as a rotational crop, the deep-rooted growth habit with a strong taproot could be useful in breaking up compacted soils after sugarcane, opening up soils and improving aeration and access to soil moisture. Drawing on deeper soil moisture might also benefit cropping land and water quality by taking up leached nitrogen fertiliser from depth.

Note that we have not attempted to map soil suitability for safflower. Local trials will be required to determine the fit into local soils and climate.

Previous production experience in the Herbert River region

Nil, not known to have been trialled previously. No regional data available. Safflower is currently being trialled in mixed crop assessments in far north Queensland.

Particular crop requirements

Deep soil moisture.
Soil with high water holding capacity.
Soil with low broadleaf weed pressure as there are no selective broadleaf herbicides available.
No knowledge on suitability of either linoleic or oleic fatty acid types.

In southern Australia, at flowering and through to maturity and harvest, heavy rainfall may reduce yield and oil quality by inhibiting pollination, discolouring seed, promoting disease and cause ripe seeds to sprout in the heads. The same risk could exist in north Queensland crops.

Advantage that the Herbert region offers

It is not known if the growing season in north Queensland with an earlier planting might offer earlier maturity and harvest than crops in southern Australia. This might be attractive to processors.

Avenues for marketing

Would require a pre-season contract for supply.
Would need to build a relationship with processors.

Main market contracts would be for oil seed.
Possible market for supply for pet food birdseed.
Advice from GRDC on access to markets.

Where to from here

Explore options and assess interest from processors to see if a market niche can be developed.

Would require some experimental planting in the district. Need advice from seed companies and processors on likely varietal suitability.

Investigations should examine the fallow soil improvement and soil health benefits, reducing compaction, perhaps reducing carryover nematode and soil disease pressure.

Assess risk of carryover effect of herbicides from previous sugarcane crops and determine what safe plant-back periods might be.

GRDC is a useful site for information.

7.12 Sweet Potato (Ipomoea sp. L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
20 to 22 weeks	Considered neutral to short-day, of no consequence as a vegetative harvest	Well drained soil, not tolerant of waterlogging, affects tuber quality, pH 6.0 and above	Medium 30 cm	Moderately sensitive	Will not persist for long periods of drought; requires irrigation 20 mm / week first 4-6 weeks, 40 45 mm / week during root development

Production and the growing season

Generally planted from autumn to early Spring. In the Herbert planting late March would meet a gap in market supply in early Spring, reaching the market earlier than supply from colder regions. This would utilise the drier cooler winter months for the growing season, however, irrigation would be necessary.

Four principal types of sweet potato grown. The majority of Queensland production is for the fresh market: Gold (Beauregard), Red (Northern Star), Purple and White (Kestle) types. Gold/Beauregard is the main type and accounted for 90% of fresh market in 2015.

Across Queensland, there are seasonal differences between these types in harvest and availability for market.

Likely fit in Herbert River region soils and climate

Should be suited to grow on a wide range of soils; deep, light, and well drained. Well drained sandy loam with clay subsoil is considered ideal. Sweet potato will not tolerate waterlogging or low pH soils.

Previous production experience in the Herbert River region

Assessed by Wilson and Baker 1990 as being widely suited to Herbert Valley, 15,900 ha of land being highly suitable.

Locally, there is limited experimental planting of sweet potato. There has been no mainstream market supply.

Particular crop requirements

Will require irrigation. Trickle tape irrigation is considered best. Trickle tape wetting pattern in the formed seed bed in the field indicates the spacing for planting. Irrigation is important throughout the crop. Root development for yield commences shortly after transplanting.

Nutrition is important. Excessive fertiliser nitrogen supply will promote vegetative growth at expense of yield.

It is important to source planting stock from a disease-free supply. There are several virus diseases in Australia. The Queensland industry employs innovative virus diagnostic and detection methods for planting stock. This is from tissue-cultured plants that have been screened and proven free of virus disease infection. Growers purchase plant stock from a sweet potato seed scheme from tissue cultured sources. Pre-ordering is necessary with 12 months lead time.

On-farm nursery seedbeds to supply cuttings and runners need to be carefully maintained, ideally located away from commercial or garden plantings and free of broadleaf weeds that will harbour aphids, whiteflies and other sap-sucking insects. Insect attack risks infestation of seed-stock with many of the virus diseases. Nursery plants are usually cut 4-5 times to supply runners for field planting.

Root Knot nematodes infest sweet potato and are the main plant protection problem. There are several nematode species. Nematodes are more of a problem on lighter sandier soils. Bare fallowing and choice of non-host (forage sorghum) or trap rotational crops, combined with increased soil organic carbon are the management strategies. The availability and reliance on chemical nematicides has lessened in recent years.

Soil testing and nematode counts can provide an assessment of likely pest problems. South Australian Research and Development (SARDI) can provide a DNA extraction and soil profile for soil-borne pathogens.

Broad-leaf weed control is difficult in sweet potato. There are few registered herbicide options.

Production is labour intensive. Planting is manual, weed control is manual, and harvest picking is manual, with a high labour requirement for each task. Backpacker labour sources are used in each of the main production areas.

Advantage that the Herbert region offers

The Herbert could capture a gap in the early market supply during August and September.

Avenues for marketing

Widely grown in Bundaberg and on the Atherton Tablelands. Market can face glut with over supply. Market has increased in recent years with healthy food trend. Sold through supermarket chains.

Where to from here

Horticulture Innovation Australia (HIA) supports sweet potato industry via an industry levy. Since 2016 HIA Sweet Potato Strategic Investment Advisory Panel has set an industry direction for research and development.

Timing for the market is important as currently there is an oversupply of product onto the fresh market. However, there is increasing demand for sweet potato with the product gaining support in our diet with evidence of health benefits.

Suitable irrigation would be required for sweet potato in the Herbert Valley. It would be a high-value crop for a relatively small area. Current state-wide production sits between 1500 and 2500 ha. To meet a market demand, the Herbert would deploy a portion of the overall suitable soil types in any one cropping season.

The advantage is that this type of cropping would fit in with the sugarcane rotation and the paddock size, but would require a longer fallow period.

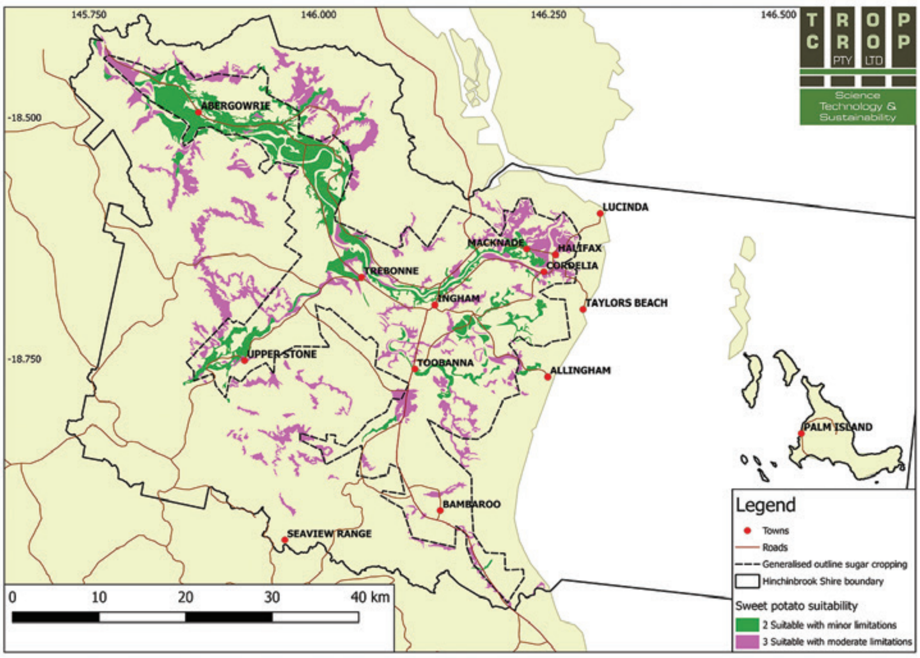


Figure 25: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing SWEET POTATO. Land assessed as having a minor limitation (class 2) is plotted separately to land considered to have a moderate limitation (class 3). Adapted from Wilson and Baker (1990).

7.13 Taro (Colocasia esculenta L.)

Crop physiology and soils at a glance

Crop length	Photoperiod daylength response	Soil type	Rooting depth	Sensitivity to salinity	Water requirement
9 to 12 months, favours daytime temperature range 25° C to 35° C	Unknown – does not flower	pH 5.5 to 6.5 friable and well drained, good water holding capacity, not suited to acid pH	Medium	Moderately sensitive	High water requirement – requires supplementary irrigation

Growing season
Year-round planting. Crop takes from 9 to 12 months to reach adequate corm size for market. Regular planting of small areas will allow progressive harvesting to meet ongoing market demand.

Likely fit in Herbert River region soils and climate
Taro could fit into a wide range of soils. To date most experience is with older alluvials. Planting in raised beds on heavier alluvial soils has worked. A lower row profile would be suited on lighter loams and clay loams that are free draining. Favour soils with a higher water holding capacity. Above all, taro grows best in a humid environment. While wet season rain would suit, taro has a high water-requirement and irrigation is required outside of the wet season. Requires daily irrigation. Trickle irrigation can supply sufficient water volume but lacks the advantage of increasing humidity throughout the plant stand.

Soils that have been used for prolonged sugarcane production are likely to suffer low soil pH and this would require addition of lime. Taro tolerates waterlogged soils, however from a management and machinery access point of view well drained soils are a more practical proposition.

Taro production is high value and would require small areas of land. Small pockets of country not suited to cane paddock layout may be suited.

Previous production experience in the Herbert River region
Limited production in the Herbert. Two growers in recent times. Most production traditionally has been in the Tully, El Arish and Silkwood regions.

Particular crop requirements
Planting is by vegetative propagation. Depending on market requirement, the lower stem and upper part of the corm can be cut at harvest and replanted. If the lower stem and upper corm are left intact to maintain shelf life, mini corms or pups are taken off mother plants at harvest and planted.

Start-up would require getting quality nursery stock from a willing supplier. Herbert soils likely to require liming to address acid pH, and production may respond to the application of mill ash. Taro appears to be a luxury feeder and requires soils with higher potassium and magnesium supply. Care is required to arrive at an appropriate nutrient management program.

Washing and scrubbing equipment is required in the packing shed. Transport required to nearest transport shipment hub.

Plant protection problems experienced; cane grubs, parasitic nematodes (Rhidophilus stimulus), armyworms and other leaf-eating caterpillars, cluster caterpillars. Local production will require investigation into appropriate management and control measures.

Advantage that the Herbert region offers
With irrigation taro fits well with Herbert soils and climate. It may find a niche in heavier and wetter soils that are less suited to sugarcane. Land that can produce taro could benefit from being part of a longer-term rotation with sugarcane to help break pest cycles.

Production in the Herbert would fit in with transport supply chains to both local and southern markets.

Avenues for marketing
Taro is a fresh market crop. Markets are mainly in east coast capital cities and local. At present there is a constant market demand with Pacific Islander and Asian community preference. Currently local suppliers do not access supermarket chains, product sold here is sourced from overseas. Local production would benefit from Freshcare TM accreditation to open up access to supermarket chains.

While taro has a good shelf life, product presentation might be improved with a protective wrapping to minimise drying, packaged with suggestions for preparation and cooking methods is seen as a positive.

Taro is considered a low GI food and is reputed to contain a natural steroid and beneficial to cattle for good growth rates where used as stock feed overseas.

Where to from here

Production is based on individual farms supplying market agents. The market demand suggests that there is some room for increased production to reach a sustainable scale. Increased local production volume could attract improved coordinated transport facilities and collective industry effort will be required to stimulate plant protection product development and Freshcare TM accreditation for market access.

Market supply chain development may reach into supermarkets.

Taro production has a high manual labour input. Mechanisation wherever possible will help lower the cost of production.

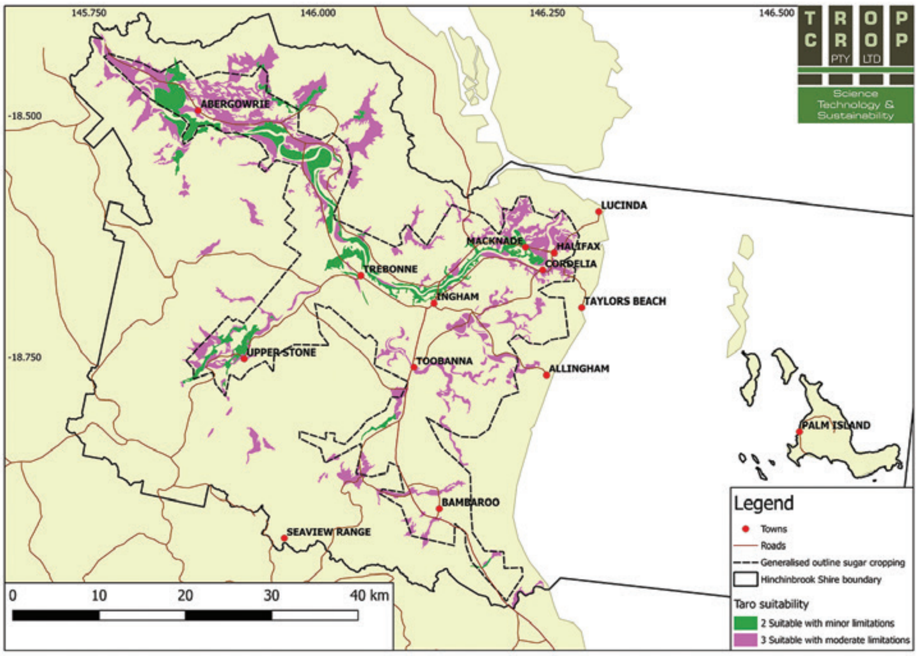


Figure 26: Area and location of land in the Hinchibrook Shire estimated to be suitable for growing TARO. Land assessed as having a minor limitation (class 2) is plotted separately to land considered to have a moderate limitation (class 3). Based on soil characteristics noted by Wilson and Baker (1990) and the current assessment of crop requirements and growing conditions..

8

MARKET ACCESS AND SUPPLY CHAIN CONSIDERATIONS

8. MARKET ACCESS AND SUPPLY CHAIN CONSIDERATIONS

Expanded production and increased diversity of agricultural production in the Hinchinbrook Shire will require considerable work in some areas to develop market access, establish supply chains and to identify supply chain and transport logistics.

For all produce, speciality and commodity, there will be common requirements. Taking a high-level view, this can be broken into three market areas. These views are general and not specific to the crops considered as candidates in Assessing Crop Suitability.

8.1 Local regional markets – fresh food and produce

There is a long history of producing melons and pumpkins in the Herbert. For the state and interstate markets supply chain logistics are well established, albeit on a relatively small scale. The supply chain is a supported loop, with the option for mainstream market agents and buyers to supply seed, plant protection products and advice and at the same time promote a level of seasonal production to meet expected market demand.

Other fresh produce could fit into a similar model to supply southern markets. North Queensland is well serviced with road transport logistics to southern capitals servicing mainstream fruit and vegetable production from Tablelands, banana from Tablelands, Lakeland, and Wet Tropics coast, and vegetable and sweet corn from the Burdekin, Gumlu and Bowen areas. Two crucial questions; the scale of production that could be achieved in the Herbert to supply and be attractive to market agents, and a niche for seasonal availability to supply product and quality to fill a market gap.

The local and regional market for fresh produce is also significant and should be an attractive option for regional production. Most regional centres will have fresh produce retailers. There are several major outlets in Townsville and Cairns procuring large portions of their throughput from local growers. This appeals to consumer preference for a local brand, fresh, longer shelf life, and low food miles. Variation in seasonal production and quality means that market prices fluctuate and that for the consumer supply is seasonal. However, relationships built on trust between grower and retailer are strong and once established are serving both parties well.

Local and regional markets are also well supported by local transport networks, often providing backloading opportunities to carry produce from farm to retail outlet.

The bottom line for fresh produce, fruit and vegetable production in the Herbert will be achieving an effective and reliable scale of production and building a relationship with the local wholesaler or retailer.

8.2 Grain, oilseed and other non-food commodities

Grains and oilseeds will be destined either for supply into the grain trade or oilseeds market. Other non-food crops will go into other specialty markets such as fibre or bioenergy.

Several seed companies have offered advice on varieties that may be best suited to the Herbert and would be a useful source of information for market location and demand.

Contracts should be pursued with traders however spot selling into the grain and stockfeed market is an option. Successful local production of corn has been sold into the regional stock feed market for many years.

The situation for peanuts handling has improved considerably for north Queensland production. The Peanut Company of Australia has established receival, drying and shelling facilities at Tolga. There has been a push to increase domestic production and favourable consideration given to northern areas. Southern Queensland has been afflicted with water shortages and soil disease issues. Any product coming out of the Herbert could be transported to Tolga. Ready access to drying facilities may give more flexibility to field moisture content at harvest. This was an issue that downgraded quality in earlier plantings when nuts were shipped directly to Kingaroy.

If safflower can be shown to grow successfully in the district it would be supplier into a speciality high-value vegetable oil market for specific industrial uses, including biofuels, bioplastics and biolubricants and cosmetics. Market development and establishment of supply contracts should be discussed with the holders of plant variety rights. Grains Research and Development Corporation is a useful source of information. The initial requirement is to trial the crop in Herbert climate, soils and growing season.

The basis of a rice supply chain is already established. Rice is grown under contract to Sunrice with receival and processing facilities already in place at Brandon, two hours by road south of Ingham. Currently all rice produced is supplied to Sunrice and is integrated into the broader national and international marketing program. Sunrice favours north Queensland to grow and become a significant source of fragrant long grain product. Long grain rice does not do so well in the temperate production in southern NSW, Australia's major rice growing area.

With the lack of established industries for other crops in the Herbert it would seem preferable for growers to collaborate and combine resources. This might be possible on a share-farming or a cooperative basis. A coordinated production model would deliver uniform and optimum soil testing, seed bed preparation, sowing times, crop and plant protection management, and harvest. Achieving optimum timeliness for crop management operations would increase product quality and provide surety to buyers. In turn this may help the district achieve a workable economy of scale for production and avoid overcapitalisation on machinery. It may also optimise the use of fallow land. Such a model could be replicated to accommodate growth in productive capacity.

For grain and oilseed, the district will need to invest in infrastructure for product handling and storage. Conceivably this will be receival and storage bins with drying and loading facilities to hold and maintain product quality. Coordinated shipment of product from a centralised storage and handling facility will improve economies of scale and strengthen a supply chain. Product might be shipped to a regional processor, the port of Townsville, or further afield to other trade destinations. The availability of handling facilities would be an important step for the district.

With the industrial crops, the question is raised on the feasibility of local processing facilities for kenaf and industrial hemp. This is topical. Currently there are no known processing facilities for kenaf and we have not obtained any information on processing requirements for industrial hemp. Indeed, it is not clear as to the extent that either industry has developed. However, should these industries advance and processing facilities become available long-distance transport of a high-volume light-weight material to processing would be costly.

Local processing would be attractive for economic development. Jobs and value-adding would benefit the district. For now, the primary requirement is to determine the market trends and expectations for these fibre products, and to see if these crops can be grown successfully in the Herbert climate, soils and growing seasons.

8.3 Export markets - food trends in Asia

Export markets are a key driver for much of the interest in agricultural development in northern Australia. Southeast Asia, India, and China feature in this discussion.

China is reported to have some 300 million people moving from rural to urban living which will also introduce changes to food habits associated with changes to real income and lifestyle (IMF report). The Australian Bureau of Resource Economics and Science (ABARES) has published a series of research papers about "What Asia Wants", updated in 2017, with modelled projections to 2050. The paper on "What China Wants" predicts a 100% increase in food demand in China by 2050, with shifts away from "staples" towards more western diets with demands for processed foods as well as dairy products, meats, fruit and vegetables as well as continued demand for oilseed crops.

The ABARES report also stated China's ambitions towards self-sufficiency in protein sources, supported by research by ABARES' Hyde and Sayed 2014 research on "China's Self-sufficiency Policy" from 1996 onwards with the aim of 95% self-sufficiency for rice, wheat, coarse grains, soya beans and potatoes. However, the authors point out that the policy may be relaxed or rejected in some parts as imported soybean accounted for 80% of consumption in 2013. The Chinese Government also operated extensive grain reserves which are released through auction and maintains floor prices for most of these commodities to support domestic production.

A report on "The E-Commerce Market in China 2017" prepared by the Chinese E-Commerce Research Centre states that on-line sales of fresh produce into China has increased by 80% annually, albeit from a small base. This trend is also being followed for processed food. The report also stated that fresh foodstuffs also faced the highest barriers to entry because of logistics within the supply chain, guaranteed financial arrangements, "user" operations, which are interpreted to mean distribution networks, scale of supply and quality issues.

An AUSTRADE report on "Food and Beverage to China" lists essential components for successful commerce to include safety, brand quality, taste, nutritional and functional food benefits, quality packaging, freshness and convenience. The opportunities for trade include products associated with milk powder, seafood, fresh fruit, oats and breakfast cereals, processed foods, baby food, fresh juice and wines and craft beers.

The ABARES report on Indonesia "What Indonesia Wants" models that Indonesian food demand will quadruple between 2009 and 2050 with significantly changed and increased demand for meat, dairy and fruit and vegetable products. The report also states that Indonesian internal capacity for food production is significant but will continue to be compromised by the competition for resources by non-food producers such as oil palm.

Given the likely scale of production in the Hinchinbrook region, stand-alone bulk shipments by sea are unlikely. A report by Nguyen, Hogan et al (2013) "Infrastructure and Australia's Food Industry" made the argument that privatisation of Australia's major airports had resulted in a shift from cargo to passenger traffic in many cases. Most foodstuff air freight occurred out of Melbourne with supply from Victoria, Tasmania and South Australia. However, Cairns airport has long term plans to expand its foodstuff export hub and has the benefit of proximity to the Herbert and increased Asian flights. No information is available on any recent moves by Townsville airport to increase or change cargo export facilities.

There are a range of service providers to assist in food exports. Web searches list brokers that will undertake internal and external customs, quarantine, food standards and other regulatory requirements. Australian Government agencies such as ABARES, AUSTRADE and the Department of Agriculture and Water Resources all provide export advice. Further, most direct export businesses need to develop effective partnerships and networks within the host country to effect the supply chain logistics.

Trade via E-Commerce will increase and is expected to be a significant factor in trade between northern Australia and China. E-commerce and block chain market mechanisms will mean a more direct pathway to the overseas buyer for Australian producers. The result will be stronger feedback on market demand and product quality. E-Commerce was highlighted at the July 2018 James Cook University Asian Market Forum 2018 – China Update in Townsville. The Asian market forum has been a regular feature for several years and provides updates on the workings of export markets.

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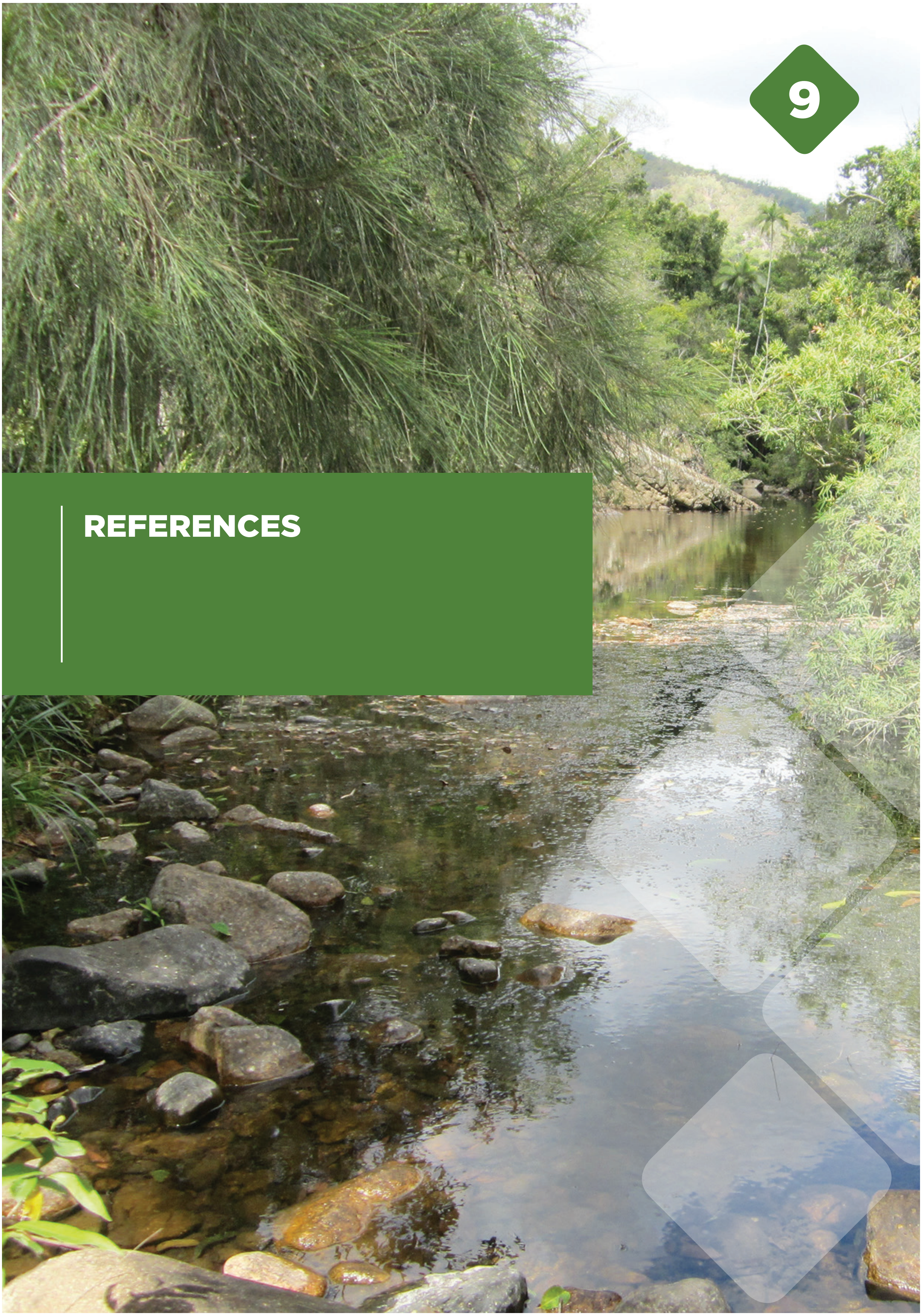

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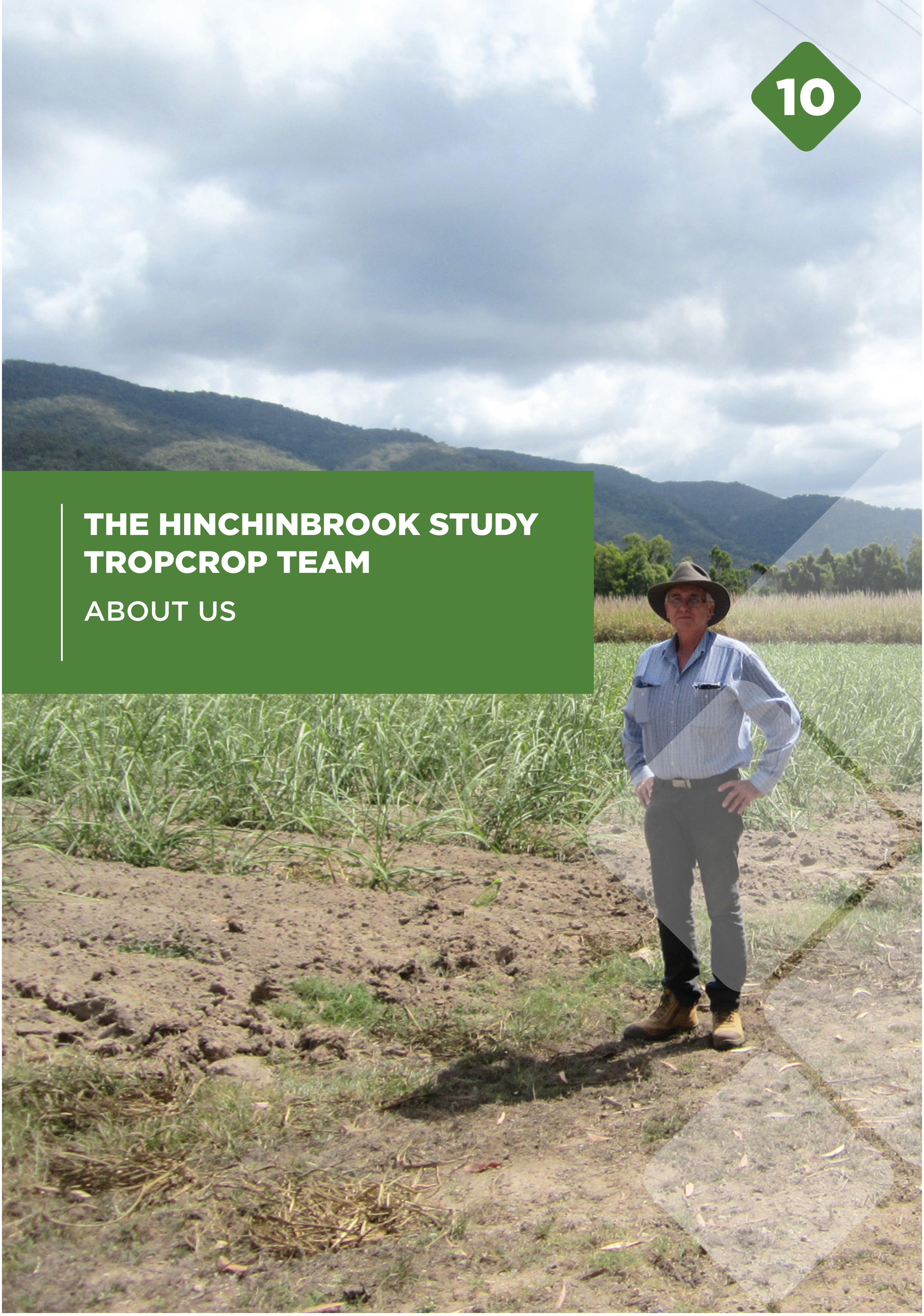

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THE HINCHINBROOK STUDY TROPCROP TEAM

ABOUT US

10. THE HINCHINBROOK STUDY TROPCROP TEAM

ABOUT US

Our small team brings an extensive background of experience in agricultural science and agricultural policy development and interpretation to address the Hinchinbrook Shires question on the Capability and Feasibility Study into the potential growing of crops in the Herbert River District. Collectively many years of cropping and industry experience.

DONALD POLLOCK
Agronomist.

Twenty-five years' experience in tropical agricultural precision agriculture, project management, market product analysis, soils management, and field research in addressing soil management issues. Prior to this, ten years in plant protection research and development in temperate winter cereal and sub-tropical rice.

DR ANDREW WOOD
Agronomy and soil science.

Thirty years lived and worked in the Herbert as a sugarcane agronomist, research leader, productivity specialist and farm manager. Examined the causes and possible remedies of declining sugarcane productivity. Co-ordinated detailed mapping of much of the soils in the Herbert used for cane production. Co-ordinated the conversion of land from timber production back to sugarcane production.

PROFESSOR DAVID GILLIESON
GIS design and analysis.

Over thirty years in applied research has focussed on using GIS and remote sensing to support natural resource management in tropical Australia and adjacent regions. Experience in vegetation mapping and assessment using aerial photography, airborne videography and satellite imagery. Recently been developing integrated satellite and aerial imagery environmental monitoring systems for the resources sector, specifically in Papua New Guinea and Northern Australia.

JOHN POLLOCK
Policy analysis and industry development.

Now moderately retired. Forty years in agriculture-related policy analysis, formulation and industry development. This has included: Executive Director, Qld Department of Primary Industries and Fisheries; Executive Director Fisheries; Executive Director Strategic Policy; General Manager, Policy Services, Qld Department of Primary Industries; Director Policy, Qld Department of Lands; Principal Policy Officer, Office of the Cabinet and Principal Executive Officer, Premier's Department and Department of the Premier, Economic and Trade Development; Director, Sugar Research and Development Corporation.

Initial career Research Officer/Senior Research Officer – sugarcane plant breeding and genetics, Bureau of Sugar Experiment Stations.

Left to right: The TropCrop team, Don Pollock, John Pollock, Dr Andrew Wood and Professor David Gillieson

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