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Does it pay to integrate irrigated forages in a beef cattle breeding operation in north Queensland?

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Abstract

The northern Australian beef industry accounts for approximately half of the national beef herd. It is currently challenged by a range of factors including decline in beef prices, limited live export trade, large farm debt levels, and low return on assets managed. Access to irrigation has been identified as one factor with potential to contribute to growth of the northern Australian beef industry. The development of irrigation for growing pasture and forage crops could extend the ability to sustain cattle through the dry season, a period when forage quality and quantity often limits cattle performance. We used a bio-economic model (Northern Australia Beef Systems Analyser) to investigate the farm-scale impacts of integrating forage crops into an existing cattle breeding operation in the Gilbert catchment of north Queensland. We assessed the feasibility of a range of forage crop types and irrigated areas with consideration of the capital costs of irrigation investment, price movements, and water reliability. This analysis highlights some of the key conditions under which beef producers are likely to benefit from an irrigation development at the farm scale.

Keywords: irrigation; tropical systems; bio-economic modelling; NABSA model, FGARA project, Gilbert catchment.

Introduction

The dominant beef production system that is used across most of northern Australia is centred on a cow–calf breeding operation, with several variations in the post-weaning management and marketing of male animals produced by the breeding herds (Gleeson et al., 2012). Breeding operations typically run a specialist breeder herd and transfer young and often newly weaned animals of both sexes to other holdings outside the region for growing out for live export, backgrounding for feedlots or finishing for slaughter. While many holdings retain a proportion of their own-bred heifers to maintain breeding herd numbers after culling or mortalities, others source their replacement breeders from other regions where they have already been grown out to a suitable weight and condition for mating. If suitable conditions prevail – and especially if forage supplies are adequate – many breeding holdings may finish cull breeders and older steers to heavier weight classes for slaughter (Bortolussi et al., 2005a; Schatz, 2012). The final choice for any single holding is largely determined by the interplay of land resource endowments, local climate and market opportunities.

The forage base for cattle enterprises is largely comprised of unimproved native pastures with only limited areas of sown grasses and legumes. These pastures generally provide a plentiful supply of herbage for grazing in the wet season, although there is considerable year-to-year variation in the total quantity and quality of available pasture due to seasonal rainfall variability. Herbage quality declines rapidly with the onset of the annual dry season during which feed shortages are also prevalent. As a result, annual animal growth patterns typically follow a sequence of seasonal weight gains and weight losses which affects the ability of stock to reach different market weight-for-age specifications, as well as breeder reproductive performance (Figure 1). Dry-season feeding of energy- and protein-enriched supplements (e.g. urea and molasses; cottonseed meal) to some or all stock classes is commonly practised. Some enterprises also feed hay to stock, especially in very dry seasons (Gleeson et al., 2012). This hay may be produced locally by cutting and baling dryland pastures or from sown pasture with limited irrigation, or it may be trucked in from other regions.

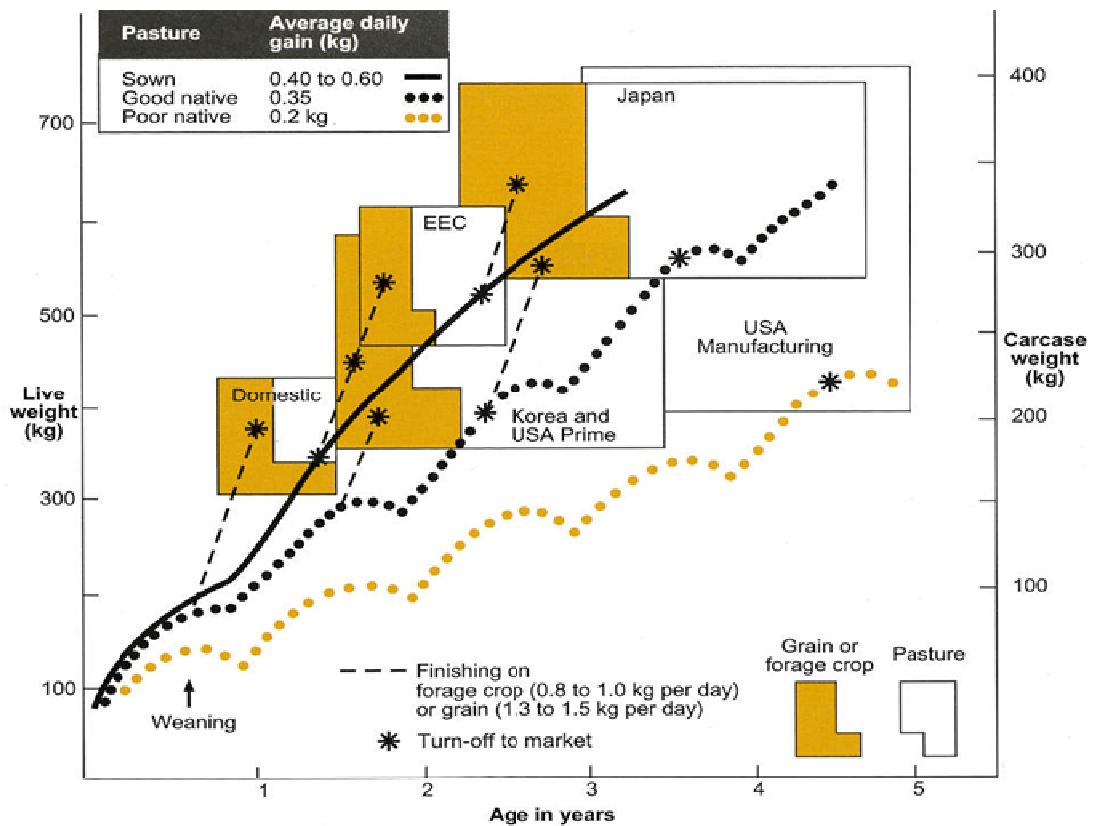


Figure 1 Growth patterns of beef cattle in northern Australia. Plot shows the effects of different pastures and the finishing options for various markets. Source: Gramshaw and Lloyd (1993). Reproduced by permission of the State of Queensland (acting through the Department of Agriculture, Fisheries and Forestry) 2013.

Although a range of factors – such as genetic makeup, physiological state, health, ambient temperature, stress, distance to water and general husbandry – affect beef reproductive efficiency and animal growth, a key driver remains the availability and intake of digestible dry matter. It is in this regard that the opportunities for irrigation to directly affect the productivity and profitability of existing beef enterprises in northern Australia are best considered.

The prospective markets available for a particular class of cattle in a herd (e.g. weaner steers, three-year-old bullocks, cull breeding cows, etc.) are largely determined by the pattern of growth of those animals relative to their age, which is significantly influenced by the type of pastures on which they are grazed and the extent to which high-quality forages and grain might be employed to supplement their diet (Figure 1). The capacity of different types of pastures, forage crops and grain to produce liveweight gain in beef cattle is well understood. Most beef enterprises will use that knowledge and their available pasture resources to develop feeding regimes to produce cattle that meet particular targeted market requirements in terms of weight and age (Gramshaw and Lloyd, 1993; Bortolussi et al., 2005a; 2005b). Figure 1 illustrates general growth patterns of beef cattle grazing on different pasture types in northern Australia and the finishing options for livestock that are targeted at various beef markets.

Irrigation developments may offer beef enterprises opportunities to alter feeding management strategies to exploit different market categories and to seek price premia for out-of-season turn off of suitable animals by providing high quality forages when the quantity and quality

of native pastures is limiting. In this analysis, a bio-economic simulation model (Northern Australia Beef Systems Analyser) is employed to assess the production and financial impacts of incorporating irrigation into beef production systems using a case-study enterprise centred on cattle breeding in the Gilbert catchment of north Queensland. The study is part of a larger initiative to assess the viability of irrigated agriculture in north Queensland (Petheram et al., 2013).

Irrigation has been identified as one of the critical factors determining future growth of the northern Australian beef industry (Gleeson et al., 2012). Improving cattle nutrition through improved pasture or forage crops leads to faster finishing of cattle and increased beef quality. This addresses a key risk factor identified by Gleeson et al. (2012) – that is, export market risk – and allows producers to move from operating ‘breeding’ enterprises to ‘fattening’ enterprises necessary to supply meat processors with slaughter-ready cattle. Such a shift would need to be supported by development of irrigation for growing pasture and fodder crops, extending the ability to fatten cattle through the dry season. Finished beef production might then occur in areas where livestock are now mostly shipped out either in the northern live export trade or to southern feedlots as ‘store’ (unfinished or not ready for slaughter) stock.

Methods

This study focuses on a case-study property located in the Georgetown area of the Gilbert catchment of north Queensland. The catchment has a hot and dry semi-arid climate, characterised by a highly seasonal climate with an extended dry season and occasional severe cyclones. Average annual rainfall is 850 mm/year, 93% of which falls during the wet season. Mean daily temperatures and potential evaporation are high relative to other parts of Australia, with potential evaporation over 2000 mm/year, on average (Petheram and Yang, 2013). A mix of sandy granite and duplex soils predominate in this region. Irrigable alluvial vertisols make up a smaller area of the properties (Bartley et al., 2013).

To examine the impact of irrigated forages on the performance of a Georgetown beef enterprise, selected irrigation developments based on surface water-harvesting opportunities were examined. The analysis used the Northern Australia Beef Systems Analyser (NABSA) (McDonald, 2012), a tool that integrates data about animal, pasture and crop production with labour and land requirements; accounts for revenue and costs; and allows the user to evaluate these against existing land, labour and financial resources.

The analysis was undertaken for four irrigation scenarios (scenarios 2 to 5), which were compared with a nil-irrigation baseline scenario (Scenario 1). The scenarios outlined in Table 1 focus on three crop types, viz. a cereal (forage sorghum - *Sorghum* spp.), a grass (Bambatsi panic - *Panicum coloratum*) and a legume (lablab - *Lablab purpureus*), which are agronomically feasible to grow in this region for grazing and hay-making for either on-property feeding or sale (Webster and Poulton, 2013). The areas of irrigation development range between 100 and 1000 ha, assumed to be realistic for the catchment.

Given the predominance of sandy soils in the Gilbert catchment, a spray irrigation system was assumed because a surface irrigation system, while having lower capital and pumping costs, would have high water losses.

A cattle breeding enterprise in Georgetown typically relies on grazing of native grass and feed supplements. As a result, in the baseline scenario (Scenario 1), it is assumed that there is an insufficient feed base to sustain the growth of weaners past the age of 6 to 8 months. The weaners are sold at that age, weighing 180 to 200 kg, and are assumed to be worth \$2.00/kg, for a total of \$360 to \$400/head. In the irrigation scenarios, the key assumption is that having a proportion of the property with improved forage for in-situ grazing (scenarios 2 and 3) or hand-fed hay (scenarios 4 and 5) allows weaner steers to remain on the property for around 12 to 14 months until they reach approximately 300 kg (live export weight) through extra feeding. These steers sell for an average \$1.80/kg, or \$540/head. While younger weaners fetch a higher price per kilogram in the marketplace, because they are young and in demand when cattle are scarce, heavier steers get slightly lower value per kilogram, but make up for it in the higher sale weights (38% increase in price per head relative to Scenario 1) (Table 1). In addition, there is a potential benefit from the sale of hay under scenarios 4 and 5.

Model output was converted into net present value (NPV), used to facilitate comparisons between development options over a 15-year period (1996 to 2010).

Table 1 Key features of the baseline (no irrigated pasture) and four irrigation scenarios for the Georgetown area.

Feature	Unit	Scenario 1 (Baseline)	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Farm irrigated area	ha	0	100	200	500	1000
Irrigated forage type		-	Sorghum (grazing)	Bambatsi (grazing)	Lablab (hay)	Sorghum (hay)
Length of crop growing season	months	-	6	Perennial	3	4
Water allocation *	ML/ha	-	4	10	6	4
Total water demand	ML	-	400	2,000	3,000	4,000
Water storage efficiency **		-	0.58	0.24	0.78	0.72
Water conveyance efficiency #		-	0.86	0.86	0.86	0.86
Water application efficiency ##		-	0.85	0.85	0.85	0.85
Total irrigation efficiency		-	0.42	0.18	0.57	0.52
Effective water volume to meet irrigation demand	ML	-	944	11,381	5,277	7,642
Selected water storage size	ML	-	1,000	12,000	6,000	8,000
Total annual capital and overhead costs of irrigation investment	\$/y	-	341,839	1,026,253	806,646	1,139,973
Available feed options		Native pasture Supplements	Native pasture Grazed fodder Supplements	Native pasture Grazed fodder Supplements	Native pasture Forage hay Supplements	Native pasture Forage hay Supplements
Selling age	months	6–8	12–14	12–14	12–14	12–14
Selling weight	kg	180–200	300	300	300	300
Selling price	\$/kg [^]	2.00	1.80	1.80	1.80	1.80

*Excludes losses; **After evaporation and seepage over the growing season; # Includes river to storage efficiency (0.90) and storage to field efficiency (0.95); ## Centre pivot (spray) irrigation system; [^]Liveweight

Finally, a multi-factorial sensitivity analysis, combining four key commodity and input prices that are subject to uncertainty and/or fluctuation over time (price of beef, price of hay, purchase price of urea fertiliser, and cost of pumping irrigation water via a centre pivot system), was conducted for each irrigation scenario for the period between 1996 and 2010.

The design of the complete factorial experiment involved varying four parameters over three levels for the relevant scenarios (Table 2). These parameters were assumed to be distributed independently. Benefits of irrigation were calculated as the difference between the farm average net profit of each irrigation-based scenario for each parameter combination and the farm average net profit of the baseline scenario for the default parameter levels.

Table 2 Key economic parameters for multi-factorial analysis in Georgetown, including values of uncertain parameters (model default values in bold) and probability of occurrence for each parameter value

Parameters	Unit	Relevant scenarios	Low		Standard		High	
			Value	Prob.	Value	Prob.	Value	Prob.
Liveweight sale price of steers	\$/kg	2, 3, 4, 5	1.60	0.15	1.80	0.7	2.00	0.15
Sale price of hay	\$/t	4, 5	50	0.2	100	0.6	150	0.2
Purchase price of urea fertiliser	\$/t	2, 3, 5	400	0.2	600	0.6	800	0.2
Pumping costs of irrigation for centre pivot system	\$/ML	2, 3, 4, 5	0*	0.1	38**	0.3	59 #	0.6

*Gravity-fed irrigation system (proposed by some producers); ** Electricity-generated; # Diesel-generated (default)

Results & Discussion

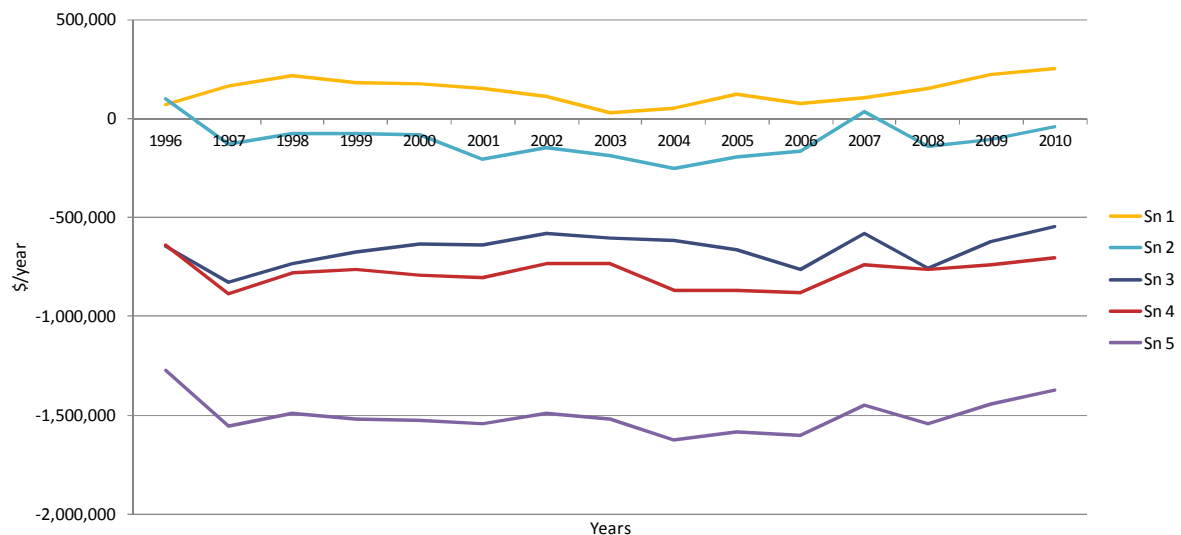
The results from the simulations show that integration of irrigated forages into the prevailing production system negatively affected enterprise profitability (Table 3). That is, under the assumed price and technology regime underpinning the scenarios, an investment in irrigation development to augment a beef enterprise would not be viable.

The poor overall outcome for irrigation scenarios 2 and 3 was despite improvements in most of the key performance indicators relative to the baseline scenario, including increased stocking rates and greater animal and beef turnoff (Table 3 and Figure 2). The projected negative net profit outcome is largely due to the substantial capital and overhead costs that are associated with the on-property irrigation development (Table 3 and Figure 2).

Table 3 Modelled results for scenarios 1 to 5 for Georgetown from 1996 to 2010. Key features of the five scenarios are summarised in Table 1.

Key results	Unit	Scenario 1 (baseline)	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Total animal equivalents carried	AE*	3,161	3,310	3,685	3,597	3,357
Total head turnoff	head	1,349	1,453	1,677	1,649	1,500
Total beef turnoff	kg	331,493	413,411	564,037	456,857	400,909
Average total gross margin per animal	\$/AE	111	136	161	78	16
Net present value of net profit	\$	1,423,830	-1,113,592	-6,897,313	-8,090,577	-15,555,503
Net value of irrigation	\$/ha	-	-72	-238	-272	-485
Payback period**	years	-	13	15	15	15

*Animal equivalents = 450 kg steer/dry cow at maintenance; **Within the considered 15-year period (1996-2010), i.e. 15 years means no payback

**Figure 2** Change in annual net profit between 1996 and 2010 for the five Georgetown scenarios

The multi-factorial analysis explores the outcomes that result from applying different combinations of economic parameters, focusing on the question of whether the scale of an irrigation development introduced to the property will increase whole-enterprise net profit. Assigning probabilities to the individual outcomes of the modelled scenarios (Table 2) and assuming that these also approximate the full range of possible outcomes, the results can be presented as a probability distribution, presented in Figure 3 for each irrigation scenario.

The net value of integrating irrigation with the existing beef cattle enterprise was negative for all of the scenarios under consideration, even when the cost of pumping water in the pivot spray system was assumed to be nil (consistent with an assumed gravity-fed irrigation system proposed by some local beef producers). All options in Scenario 2 and 50% of options

in Scenario 3 had a net value greater than -\$100/ha. In Scenario 4, approximately 60% of all investigated options had a net value of irrigation less than -\$200/ha and all options exceeded -\$300/ha. Scenario 5 was the worst performing scenario with net values of irrigation between -\$380/ha and -\$480/ha. The distribution mean varied between -\$61 and -\$428 per hectare of irrigated land and the median varied between -\$61 and -\$433 per hectare of irrigated land from Scenario 2 to Scenario 5, respectively.

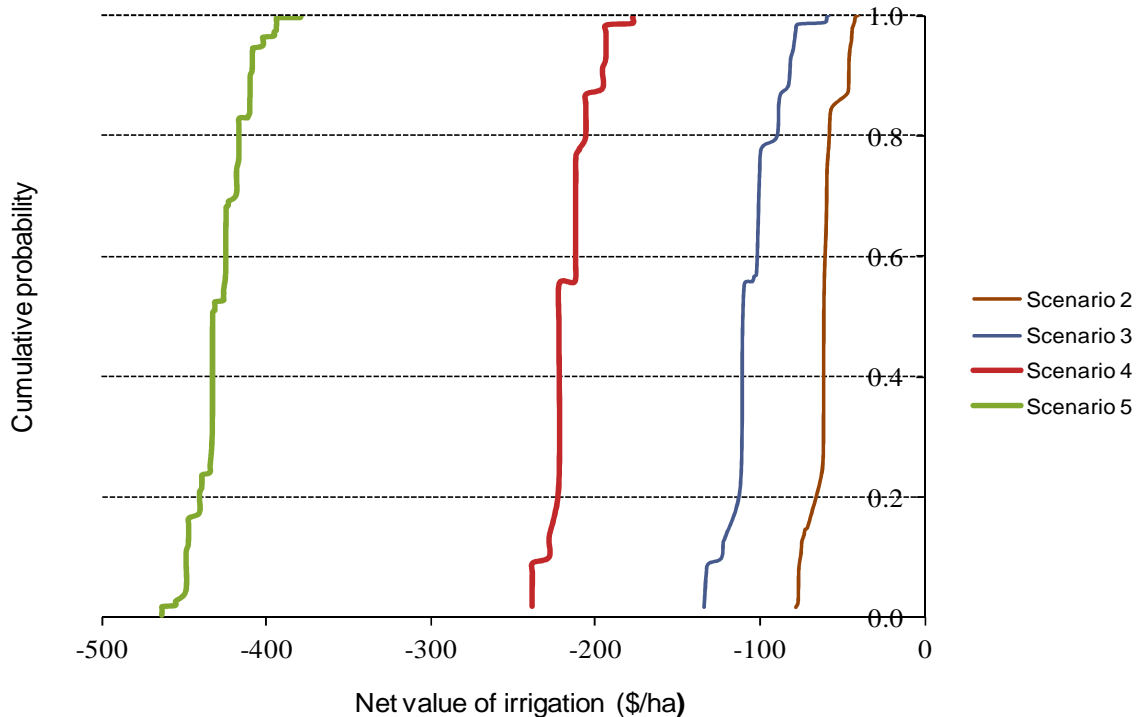


Figure 3 Cumulative distribution functions (CDFs) for the net value of irrigation of the four irrigation scenarios in Georgetown

A critical factor that underlies these results is the predominance of sandy soils in the Gilbert catchment, which results into very significant field efficiency losses and the need to install a more expensive spray irrigation system than what would otherwise be required (e.g. surface irrigation system). No scenario is more negatively affected by these circumstances than bambatsi, which produces the lowest total efficiency of all the scenarios given the perennial nature of the crop. The low value of irrigation for this scenario is despite bambatsi being a source of year-round, high-quality feed supply to the cattle, which is captured in the relatively high average total gross margin (per animal) result. Overall, grazing in situ was a more economical option than making and feeding hay, regardless of the crop, partly due to the high costs of cutting, raking, baling and storing of hay, and partly due to the fact that more biomass is potentially harvested over the whole growing season in a grazing situation.

Importantly, this analysis was based on the assumption that the forage crops are grown with 100% reliability of water supply, which is not likely to occur in reality. Therefore, results that might be obtained for a more likely 80% level of water reliability would be even less compelling than those presented here.

Conclusion

The utilisation of irrigated forage increased the productivity of the representative cattle herd modelled in this analysis through the provision of more and better quality feed. Under the parameters of this analysis, however, the costs of providing irrigated forage outweighed the gains. This is due to the large capital costs associated with irrigation development at the property scale. Nevertheless, the results of this study could provide encouragement to explore the value of irrigation when targeting different classes of animal, such as to improve weaning percentages in first calf heifers or weaning rates overall.

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