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Economic trade-offs of novel forage use in livestock production systems: insights from Australia

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Introduction

Globally, livestock are a major component of agricultural systems and natural resource management, as well as an important contributor to nutrition and livelihoods, but are often undervalued (Herrero *et al*., 2009). In Australia, livestock production systems occupy half of the available land and contribute to ~50% of gross agricultural production. The main livestock systems are beef cattle grazing at low intensity in the arid and semi-arid regions of northern and central Australia; and sheep flocks integrated in crop-livestock systems in the temperate zone of southern Australia (Bell *et al*., 2014). Despite increased physical productivity (changes in outputs relative to inputs) in both sectors, real incomes have declined due to adverse terms of trade (Ash *et al*., 2015). Pressures are compounded by increasing public scrutiny on environmental performance and need to develop sustainable production practices. This situation has renewed the focus on improving the efficiency of current livestock systems, and coupling improvements in profitability to improvements in the natural resources. Diversifying feeding systems to overcome deficiencies in energy or nutrient supply can increase productivity and profitability, along with resource-use efficiency (Ash *et al*., 2015). In the north, irrigated forage crops have been identified as an avenue for promoting productivity through faster finishing of cattle, increased beef quality and reduced pressure on rangelands. In the south, plantings of forage shrubs have the potential to improve animal performance, economic returns and environmental management. With better understanding of the economic trade-offs and riskiness involved in the use of novel forages in livestock production systems, there is the opportunity to better design and deliver diversification options.

Materials and Methods

Two case-studies from Australia are presented to explore the economic trade-offs of novel forage use in livestock production systems. Case-study 1 is for the semi-arid tropical region (~500 mm/year) of north-west Queensland, with extensive grazing of unimproved native pastures with high levels of intra- and inter-seasonal variability. Animal growth is constrained by the limited quantity and quality of forage in the late dry season. Irrigation of a forage crop could potentially increase the availability and quality of dry-season feed and improve productivity by securing higher prices, or accessing different markets via a combination of accelerated animal growth and altered finishing periods. A bio-economic model (NABSA) was employed to consider irrigated forage scenarios (forage sorghum, *lablab*, *Bambatsi panic*) and development scales (100 - 1000 ha) based on off-stream storages and investment in infrastructure (Monjardino *et al*., 2015). Case-study 2 is located across the low-rainfall regions (250-350 mm/year) of southern Australia involving cereal cropping and Merino-based sheep producing wool and meat, grazing a mixture of pastures and crop residues. The incorporation of forage shrubs, such as Chenopod species including old man saltbush (*Atriplex nummularia Lindl*.), can diversify the farming system and increase resilience by persisting on poor soils under dry conditions, while providing feed when crop residues decline in quality and before the opening rains initiate annual pasture growth. Extra benefits to animal health and performance may result from plant compounds in shrub species. Deep-rooted, perennial plants promote sustainable water use, year-round ground cover and C sequestration. Conversely, shrubs have relatively low nutritional value, carry a high salt load that limits intake, and incur establishment and opportunity costs. A bio-economic model (MIDAS) was used to explore how key attributes of forage shrub systems (*i.e*. shrubs with a pasture under storey) can make forage shrubs economically more attractive in a whole-farm context (Monjardino *et al*., 2014).

Results and Discussion

The case-study results offer new insights into the economic trade-offs involved in improving livestock enterprises within risky decision-making contexts. The inclusion of novel forage species, such as irrigated forage crops and forage shrubs, allows livestock to be carried over the dry months (*i.e*. the tropical dry season in the north, and late summer). Consequently, producers are able to increase animal numbers and/or reduce supplementary feed costs to achieve gains in productivity and profitability.

Case-study 1 showed improvements in key productivity indicators, such as beef turnoff and enterprise profitability for some forage-based irrigation scenarios (*e.g.* 200 ha of *Bambatsi panic*). However, the costs of providing irrigated forage outweighed the economic gains as a result of the capital costs of the irrigation development (Table 1). The challenge is to find ways to make forage irrigation more cost-effective, or explore new combinations of water infrastructure and grazing options to achieve an economically viable outcome.

Table 1: Simulation results for scenarios 1 to 5 for the North Queensland case-study based on 15-year NABSA model runs (1996 -2010).

Key results	**Unit**	**Scenario 1 (baseline – no irrigation)**	**Scenario 2 (100 ha sorghum grazing)**	**Scenario 3 (200 ha Bambatsi grazing)**	**Scenario 4 (500 ha lablab for hay)**	**Scenario 5 (1000 ha sorghum for hay)**
Average total animal equivalents carried	AE	3,558	3,847	3,707	3,785	3,936
Average total head turnoff	head	1,002	909	1,034	1,012	973
Average total beef turnoff	kg	366,441	409,803	506,481	502,404	474,934
Average total gross margin per animal	A$/AE	110	104	151	103	35
NPV of net profit	A$	1,248,651	-2,175,544	-1,936,095	-6,480,504	-10,855,681
Net value of irrigation	A$/ha	-	-57	-53	-129	-202

Case-study 2 results indicate a niche role for forage shrubs in mixed farming systems, with profit being greatest for relatively small areas (~10% of farm area) on the less productive soils. For farms both with and without shrubs, the optimal whole-farm profit peaked at over 80% of the farm area used for cropping (Figure 1). However, at lower cropping areas the farm with forage shrubs was the most profitable, mostly due to the value of extra feed to sustain livestock over the summer months. Changes in commodity prices and improved nutritional quality of shrub-based systems were shown to substantially increase profitability and the recommended extent of plantings.

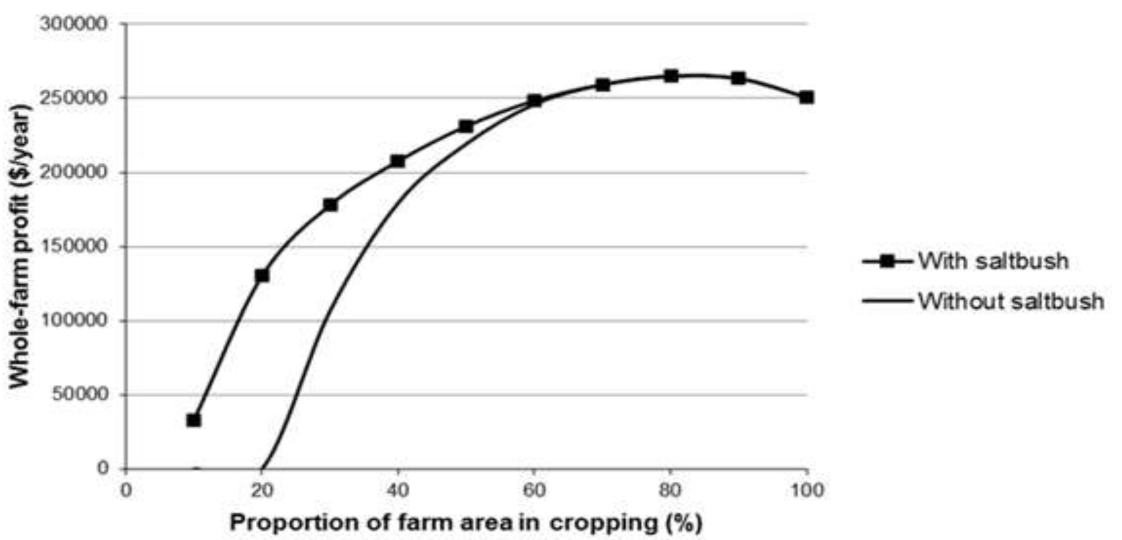

Fig. 1: Whole-farm profit for an increasing area of cropping on a standard southern Australian farm, with and without saltbush shrubs.

Conclusion

Bio-economic modelling is used to explore the role of novel forage options in boosting the productivity and profitability of Australian beef and sheep enterprises. Limited uptake of irrigated forage crops would be expected by individual beef producers, but the analysis highlights some important issues for the economic prospects for irrigation development applications across northern Australia, and possibly beyond. In the southern region of Australia, perennial forage shrubs offer a major prospect to enhance economic returns, decrease farm risk, and help address environmental challenges. Overall, the growing demand for food, including animal products, along with the need to increase resource-use-efficiency, provide strong incentives for adding alternative forages to bridge feed gaps and cope with a variable climate. Bio-economic models that capture the systemic nature of whole-farm operations are suited to exploring trade-offs in livestock systems around the globe.

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