Integration of cattle and irrigated cropping in northern Western Australia: Opportunities and challenges

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Abstract
The beef industry contributes about $1B annually to the economy of Western Australia (WA), with 50% of the value coming from the northern rangelands. The Kimberley region has about 70% of the northern cattle herd. Its tropical climate, characterised by distinct wet and dry seasons, extreme seasonal variability, low population density, and large property sizes pose significant operational challenges. During the dry season, livestock production is constrained by low-quality forage, resulting in weight loss. The integration of cattle production and irrigated cropping, particularly with an expanding cotton industry in northern WA, offers an opportunity for a step-change in the efficiency of beef production, through improved feeding and finishing. This strategy could mitigate risks in the beef supply chain and reduce greenhouse gas emissions intensity. Our study aimed to review and identify the potential opportunities and challenges for the increased use of irrigated crops and co-products in the northern WA beef industry. Key findings of our review were: 1) market diversification is essential for a sustainable cattle industry where supply chain disruptions can be mitigated; 2) ensuring consistent meat supply requires a systematic, integrated approach, as abattoirs face viability challenges due to supply fluctuations; 3) the cost of cropping infrastructure is a significant challenge, and the case for investment needs support from rigorous economic analysis and 'trial-by-doing'; and 4) the bioeconomic model Crop Livestock Enterprise Model provides a suitable platform for evaluating a range of options for the sustainable intensification of the supply chain in northern WA. Our review provides a framework to assess economic and sustainability outcomes for changes in the beef supply chain in northern WA (e.g., new forage options, animal genetics, markets and animal management) that may be required to meet evolving needs of cattle markets.

Keywords
Beef cattle; northern Western Australia; irrigated cropping; opportunities; challenges; modelling

Introduction
Western Australia (WA) has a beef herd of about 2 million head that has remained relatively stable over the last 20 years. The gross value of production for WA beef cattle disposals (slaughter and live export) peaked at $1.03 billion in 2021-22. Cattle turnoff typically ranges between 700-800 thousand head annually, with 200-300 thousand head (35-45%) going to live export markets. This represents about half of all live exports from Australia. The northern rangelands of WA hold about half the cattle herd and contributes nearly half the value of beef production. The Kimberley region dominates production with about 70% of the northern cattle herd (The Western Australian Beef Industry, 2015). Competitive advantages of the northern Australia beef industry include its adapted production systems, low-cost base and geographic positioning that allows efficient access to South-East Asian markets. However, inherent low productivity, high capital costs and overreliance on a small number of markets make the industry vulnerable to market shocks (Chilcott et al. 2020). Beef production in WA is particularly reliant on live exports and alternative markets to help reduce exposure to volatility in this trade. There is some north-to-south movement of cattle for domestic markets; however, if this supply chain proves inadequate to meet supply, northern producers may need to consider growing out cattle locally. Therefore, there is a need to support the northern Western Australian beef industry to find options to derisk alternatives to business as usual.

In addition to the market issues, beef production in northern Australia faces two main challenges regarding natural resource management. First, the distinct wet-dry (tropical) conditions reduce forage availability and quality during the dry season, leaving markets vulnerable to variability in both inter and intra-seasonal conditions and prone to supply chain disruptions. These conditions are becoming difficult to withstand

financially in an industry experiencing declining terms of trade (Chilcott et al. 2018). Relatively small changes in pasture growth rates and quality can significantly affect the available feed, and therefore intake and livestock performance, and the number of animals that achieve target liveweights (cited in Snow et al. 2014). Second, the industry relies on water from the natural environment and predominantly uses intact native pastures for feed, which has the potential for environmental risks, such as land degradation. Extensive beef cattle production occupies a significant portion of the land mass in northern Australia and the beef industry's role as a primary land manager is crucial for sustainable environmental management and maintaining social license.

Currently in the northern beef industry, optimal calving occurs during the wet season, and animals are managed so they are weaned and mustered during the dry season. Rainfall and the resultant road closures across northern Australia limit the ability to muster and truck cattle during the wet season, which can result in extended shutdown periods for abattoirs. In recent years, producers in northern WA have experienced variable access to nearby abattoirs, which results in cattle often being transported thousands of kilometres, facing issues such as high transport costs, weight loss, and animal welfare concerns (ACCC, 2017). During the dry season, high supply of cattle has also led to a significant drop in lightweight beef prices, reducing farm profitability.

There is an opportunity to address these challenges through the integration of feed products from local irrigated cropping industries to provide alternative feeding strategies for intensification of production. An emerging opportunity in the Kimberley is the expansion of irrigated cotton production and local processing of cotton seed may provide new, affordable sources of energy and protein, particularly for use in feeding systems during the dry season. Providing high-quality forage for cattle, available from irrigated crops, allows them to accelerate their growth trajectory and achieve turn-off weights at an earlier age, ultimately resulting in higher productivity. There are also benefits for reducing greenhouse gas (GHG) emissions and emission intensities because higher quality forages will reduce methane output per kg of beef produced.

Despite the benefits of supplying improved forage, several challenges persist, including capital costs associated with infrastructure, approvals regulation and legislation, logistics of seasonal feed supply and ration formulation, determining the optimal method of utilization (e.g., grazing, feedlots, silage or hay production), determining the class of livestock and target market(s), and establishing the ideal scale of irrigation for maximizing the utilization of irrigated crops. In addressing these challenges, employing an economic model to simulate the entire farm enterprise can offer insights into the comparative advantages of different scenarios vs. business as usual. Factors such as forage utilization, livestock management, and environmental sustainability can be considered concurrently. This study aimed to evaluate and identify the opportunities and challenges of utilising irrigated crops and their associated by-products within the beef industry of northern WA. We introduced a bio-physical and bio-economic modelling framework that allowed representation of the entire farm enterprise and beef supply chain.

Methods

Figure 1 illustrates the literature review process for this study. The first step was a systematic approach to collate existing literature, focusing on articles that addressed identified challenges, and included models for economic evaluation of northern WA beef cattle enterprises. Based on this review, feedback from industry advisors was collected, and possible alternative scenarios to improve the profitability of beef cattle industry in northern WA were described.

Any change scenarios need to be compared with the current state to determine their profitability. The second step was therefore to develop a suitable modelling framework for assessing the potential advantages and disadvantages of alternative scenarios compared to the current state. Various supply chain scenarios were evaluated that incorporated different interventions such as alternative forage options and livestock management, as well as considering any impact on GHG emissions.

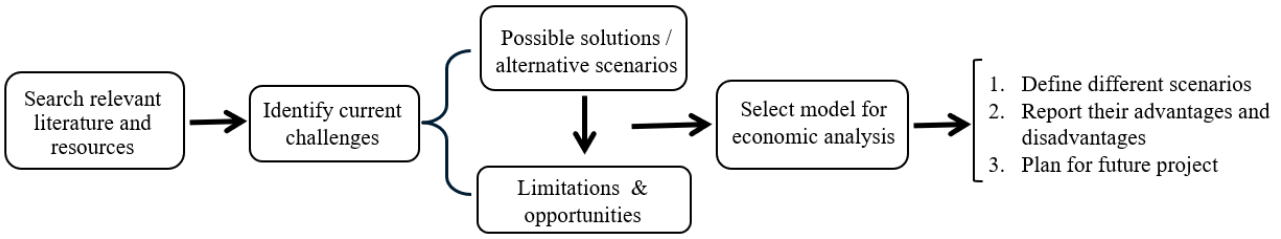

Figure 1. The diagram of review process in this study.

Results and discussion

An overview of the current challenges facing the beef industry in northern WA and potential alternatives to enhance profitability of cattle businesses are presented in Figure 2. Several key challenges were identified, including a high reliance on live export markets, weather-related disruptions leading to supply fluctuations during dry seasons, and emissions of GHG through enteric methane production (Figure 2A). The primary challenges for profitable finishing strategies were the considerable economic value of live export, the cost of feedlot infrastructure and finishing rations, potential for increased GHG emissions in the supply chain and the lack of available protein sources for finishing strategies. In response, an alternative approach is proposed, involving the utilization of irrigated crops (conserved as fodder and/or grain) as a sustainable protein source for finishing systems (Figure 2B). This strategy not only addresses the methane emission issue by reducing turn-off age but also offers potential advantages such as reduced fluctuations in meat supply. Integrating cattle production with irrigated cropping presents an opportunity for efficiency enhancement and emission reductions with feedlot finishing, because this strategy can maintain increased control over both nutrition and the environment (Greenwood, 2021).

Based on the review, we prioritised scenarios for the integration of irrigated crops and beef production, as follows: 1) a short-fed finishing system to grow out animals (from approximately 300-330 kg to 400-450 kg) that provides a continuous supply chain for local abattoirs and decreases transportation costs; and 2) backgrounding and feedlot finishing strategies for selected lightweight animals to achieve an acceptable selling weight and more continuous supply to the market out of season when prices are high to improve profitability. Additionally, there is a baseline scenario representing business as usual, in which steers were sold at a minimum live weight of 280 kg at two mustering events during the dry season.

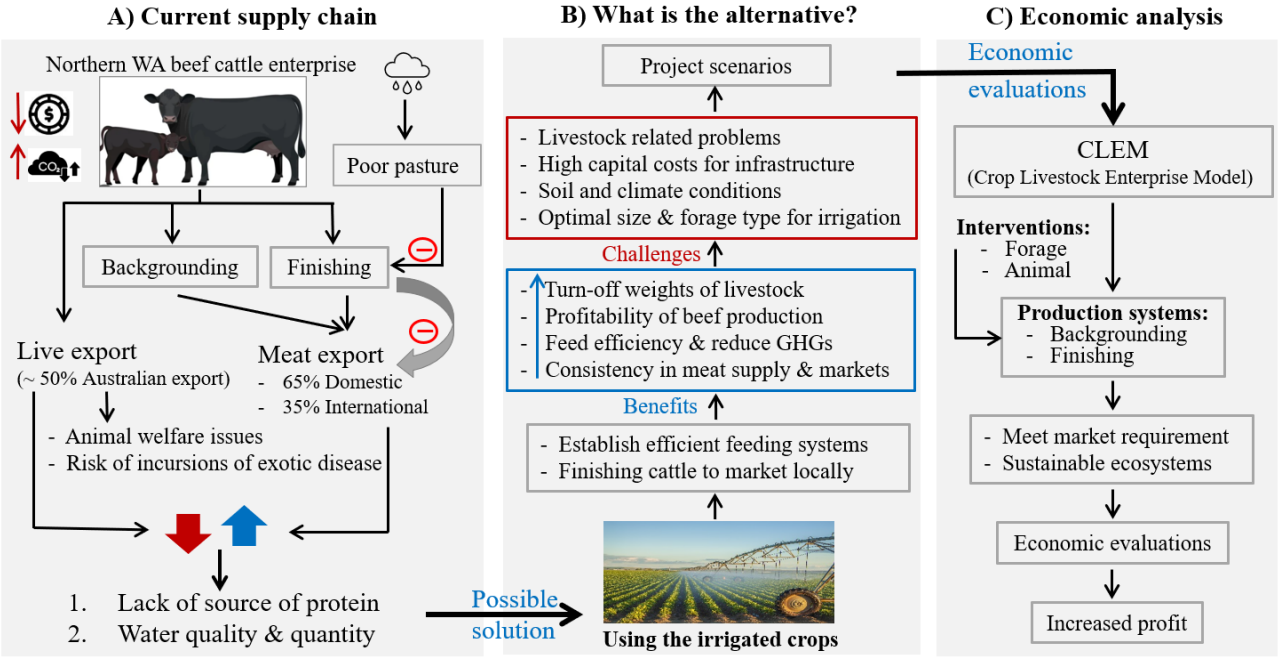

Figure 2. Overview of the current supply chain challenges (A), proposed solutions (B), and economic evaluation of current versus alternative states (C). Note: For blue and red arrows, an upward direction indicates an increase, while a downward direction shows a decrease.

Implementing the strategy of using irrigated crops presents several challenges, with the cost of establishing cropping infrastructure emerging as a particularly significant challenge. Despite the positive effects of using irrigated crops in improving key productivity indicators such as beef turnoff and enterprise profitability, the

capital cost of installing and operating the necessary irrigation infrastructure has a significantly negative effect on returns (MacLeod et al. 2018). Feed options may also be directly sourced from specialist irrigated crop producers such as maize grain or as by-products such as from the processing of cotton seed. There will be competing demands for these products and their use in cattle feeding systems will be determined by the relative cost per unit of energy and protein.

The economic viability of the alternative scenarios is assessed using the CSIRO - Crop Livestock Enterprise Model (CLEM) against the baseline. CLEM integrates functionalities from the Integrated Analysis Tool (McDonald et al. 2019) and the Australian Beef Systems Analyser (Ash et al. 2015), while overcoming limitations such as inflexible data requirements, difficulty in customization, and restricted availability. This is achieved through adopting a modular framework for centralized distribution, maintenance, and development (Meier et al. 2019). The analysis framework will reveal significant supply chain insights by quantifying the economic impact of various animal and forage management interventions within different production systems. The review highlighted how these interventions can be managed to meet market requirements and promote sustainable ecosystems in a way that can increase farm profitability (Figure 2C).

Conclusion

This review assessed the potential of integrating products from irrigated crops (conserved fodder, grain, cotton seed) into feeding systems for the northern WA beef industry. Key findings emphasize the importance of market diversification, consistent meat supply, and infrastructure investment for sustainability. Integrating beef cattle with irrigated cropping offers an opportunity for feedlot finishing, mitigating seasonal supply chain disruptions, and supplying the market during the year when prices are high, thereby improving business profitability. With the capabilities of CLEM, integrating the irrigated crops with beef cattle offers promising scenarios for enhancing the supply chain for local abattoirs and ensuring timely animal sales through strategic animal and pasture management. Future work will involve economic analysis using CLEM outputs to examine the potential benefits of these interventions, demonstrating how they could be managed to meet market requirements and promote sustainable farming practices, recognising alternative feed costs can be highly variable. In conclusion, by acknowledging the challenges and proposing viable solutions, further research with on-farm data can provide insights into how defined scenarios can translate into practical success, ultimately enhancing the beef cattle industry in northern WA.

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