Project overview

Australian Beef Industry 35-year environmental impact trends analysis

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Brief summary

This project involved an investigation of the environmental performance of the Australian beef herd using life cycle assessment model. In addition to assessing changes over a 35-year timeframe from 1980-2015, results from the whole time series were revised to reflect methodological improvements in impact assessment and herd inventory development.

This report enables communication and progress tracking of key environmental impact parameters for Australian beef production. The study is the most comprehensive of any undertaken in the Australian beef industry at the time of publication.

Objectives

1. Quantify the change in GHG intensity in the Australian beef herd between the years 2010-11 and 2015-16.
2. Quantify the change in water use in the Australian beef herd between the years 2010-11 and 2015-16.
3. Quantify the change in stress weighted water use in the Australian beef herd between the years 2010-11 and 2015-16.
4. Quantify the change over time in energy use for the Australian beef herd between the years 2010-11 and 2015-16.
5. Quantify the change over time in land occupation for the Australian beef herd between the years 2010-11 and 2015-16.
6. Quantify impacts associated with the production of live export cattle, either through to the point of processing in the importing country.

Project outcomes

The analysis showed that total beef production from the Australian beef herd (excl. live export) has increased over the 35-year analysis period by 67%, while estimated beef cows joined to produce slaughter calves increased 9% over the same time period, indicating a substantial improvement in herd productivity. In the period 2010-2015 it was found that:

- carcase weights increased 10% driving an increase in beef production per cow joined.
- Growth rates in young cattle were estimated to have increased 19% in the past 5 years principally in response to higher proportions of cattle fed in feedlots, and a 5% increase in feedlot days on feed since 2010, together with improved performance of the grazing herd.
- GHG emission intensity declined 8.3% (excl. land use and direct land use change), and declined 20% relative to 1980, from 15.8 kg CO_2-e kg LW- 1 in the five years to 1985, to 12.6 kg CO_2-e kg LW-1 in the five years to 2015.
- Emissions from land use and direct land use change declined 93%, and represented a small emission source for the industry when analysed using methods that comply with Australia’s national inventory.
- Energy demand was found to follow a non-uniform trend over the total analysis period, increasing from the five years to 1985 through to the five years to 2005 by 32% to a peak of 13.5 MJ kg LW-1, after which energy demand decreased to 10.8 MJ kg LW-1 in the five years to 2015.
- Total fresh water consumption declined 14% to 486 L kg LW-1. This was 68% lower than the five years to 1985. Water stress decreased 61% over the 35-year analysis period, averaging 283 L H2O-e kg LW-1 in the five years to 2015.

Substantial improvements in productivity via intensification and better management have led to lower environmental impacts and resource use in most instances, with ongoing improvements observed in the 5 years to 2015. This positive trend demonstrates ongoing industry change that has led to substantial declines in resource use and impacts over an extended period of time.

Methods

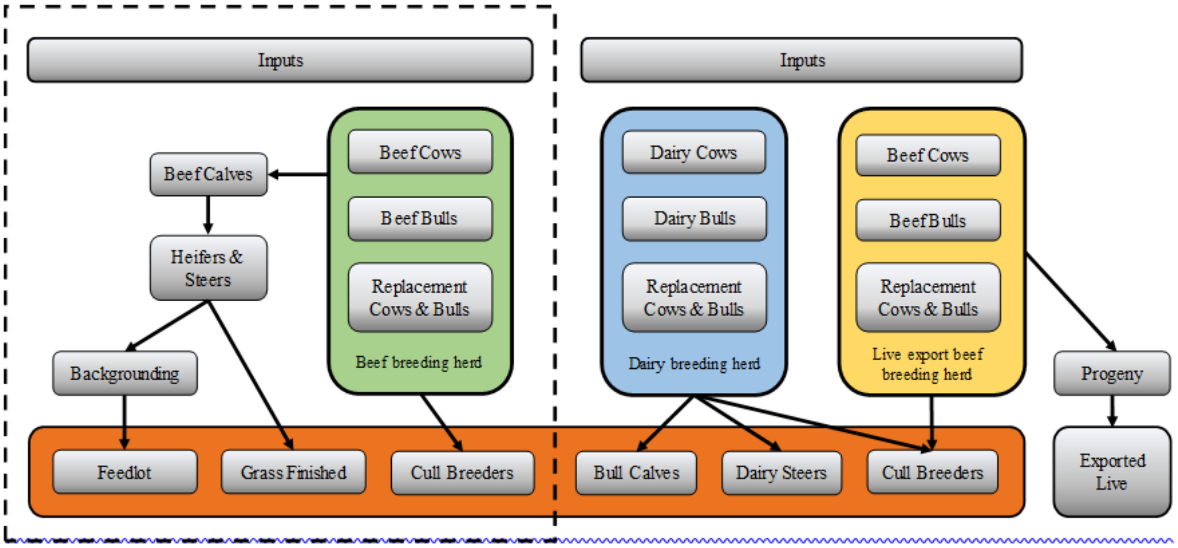
The study investigated GHG emissions using the Intergovernmental Panel on Climate Change (IPCC) AR4 global warming potentials of 25 for CH_4 and 298 for N_2O (Solomon et al., 2007) as applied in the Australian National Inventory Report (Commonwealth of Australia, 2018a). GHG emissions arising from land use (LU) and direct land use change (dLUC) were calculated and reported separately following the guidance of ISO/TS 14067 (ISO, 2013). Energy demand was assessed using the fossil fuel energy demand method (Frischknecht et al., 2007), and fresh water consumption and water stress (Pfister, Koehler and Hellweg, 2009) were also assessed. An inventory of crop land production was developed based on grain and supplementary feed use. Modelling was conducted using SimaPro 8.5 (Pré-Consultants, 2018).

The study examined the primary production system (i.e. cradle to farm gate) using a reference flow of one kilogram of live weight (LW) on-farm, immediately prior to processing. The system included the national beef herd producing cattle processed in Australia, and specifically excluded the dairy herd and beef derived from dairy production, and the live export herd, including beef from this herd (Fig. 1).

The herd was modelled at 5-year intervals, with each period reflecting average production over that five-year period. The Australian beef herd was modelled using a revised inventory developed using three primary datasets: Feedlot livestock numbers (ALFA/MLA, 2018) number, weight and sex of beef cattle processed (ABS, 2019) and herd productivity indicators from the annual ABARES survey (ABARES, 2018a). The slaughter data were adjusted by removing the contribution of cull dairy cows and progeny to meat production, using dairy herd data from ABARES (2018a).

Herd numbers were determined from slaughter data, estimated age and herd productivity indicators (branding/weaning rate and mortality rate). This enabled estimation of the number of joined cows. Replacement heifers were assumed to be held in the herd to replace cows sold for slaughter (estimated to be 13%) and annual mortality. Bull inclusion rates were estimated to be 4% of the cow herd.

Figure 1. System boundary diagram showing coverage of the cradle to farm gate primary production system producing beef cattle processed in Australia (dashed line) and excluded production systems.



Purchased inputs on grazing farms including livestock feed, services, fuel and fertilisers were determined from ABARES (2018a) using the methods of Wiedemann et al. (2015). The inventory values used for energy and services used for the feedlot were from Davis et al. (2009), as applied in Wiedemann et al. (2017).

Background data for upstream processes such as generation and supply of energy and purchased products such as fertiliser were sourced from the Australian LCI database (Life Cycle Strategies, 2015). Feed grain inputs were modelled using inventory data from Wiedemann et al. (2017) and the Australian National Life Cycle Inventory Database (AusLCI) (ALCAS, 2017).

Fresh water consumption is inclusive of cropping irrigation, pasture irrigation, livestock drinking water and the associated supply losses, which were modelled using water use data from ABS for irrigation water use, and drinking water use was predicted from the livestock inventory using the prediction equation derived from CSIRO (2007) by Ridoutt et al. (2012). Drinking water requirements for feedlot cattle were determined from feed intake and ambient temperature using Winchester and Morris (1956). Drinking water supply losses rates were determined for different sources and evaporation losses from farm dams were estimated using methods outlined in Wiedemann et al. (2016).

Livestock GHG emissions were determined using methods reported in the Australian National Inventory Report (Commonwealth of Australia, 2018a) with the exception of feedlot nitrous oxide, where emission factors were revised following more recent Australian research (Sun *et al.*, 2016; Bai *et al.*, 2016; Redding *et al.*, 2015).

Emissions data for land use and land use change from relevant land categories reported in the National Inventory Report (NIR) (Commonwealth of Australia, 2018b) were assessed using spatially disaggregated datasets supplied by the National GHG Inventory Team (S. Reddy, Pers. comm.) and were therefore consistent with the NIR for 1990-2015.

In addition to modelling the results using global warming potential (GWP_{100}) values, a sensitivity analysis was performed using GTP_{100} values of 4 for methane, and 234 for nitrous oxide.

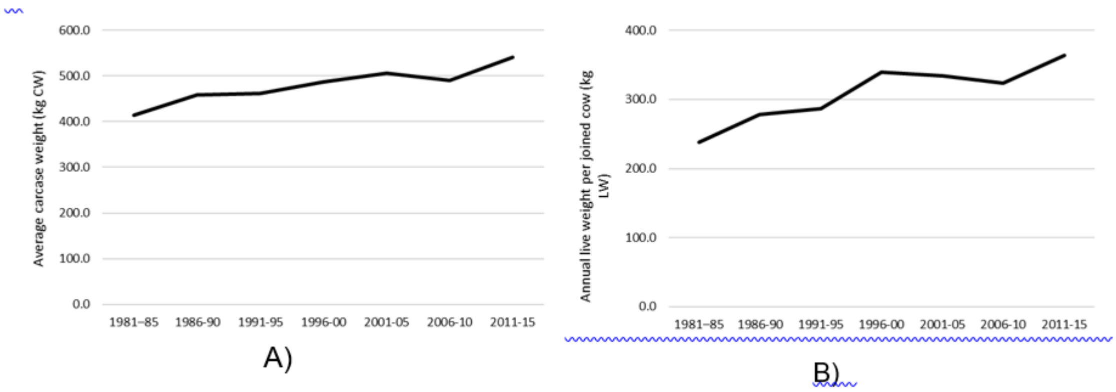
With respect to handling co-products, this was avoided by separating sub-systems at the farm level to divide impacts associated with beef from other agricultural products (i.e. sheep and cereals). The functional unit of the study did not differentiate between beef from different animal classes and no allocation was performed. Manure nutrients from the grazing herd were assumed to return directly to pasture and were considered as a biological feedback loop without the need for allocation. Manure nutrients from feedlot manure were treated as residuals, following guidance from LEAP (FAO, 2016).

Results and Discussion

Total beef production from the Australian beef herd (excl. live export) increased over the 35-year analysis period by 67% to 2.17M tonnes, while estimated beef cows joined to produce slaughter calves increased 9% over the same time period, indicating a substantial improvement in herd productivity. Liveweights and beef production per cow joined increased substantially over the past 35 years (see Fig. 2). Growth rates in young cattle were estimated to have increased 19% in the past 5 years principally in response to higher proportions of cattle fed in feedlots, and a 5% increase in feedlot days on feed since 2010, together with improved performance of the grazing herd in response to higher national average rainfall compared to the immediately preceding periods when rainfall was depressed during the so-called Millennial drought in Australia (BOM, 2015).

In response to herd productivity improvements, the analysis revealed an 8.3% decline in GHG emission intensity (excl. LU and dLUC) in the most recent time period, and a 20% decline in emissions intensity from 15.8 kg CO_2-e kg LW-1 in the five years to 1985, to 12.6 kg CO_2-e kg LW-1 in the five years to 2015 (Fig. 3). The reduction in emissions was primarily associated with decreased enteric methane emissions, which declined in absolute terms from 14.3 kg CO_2-e kg LW-1 to 11.1 kg CO_2-e kg LW-1, and in proportion to the emission profile declined from 91% of total impacts in 1985 and 1990, to 88% in 2015. Emission intensity results in the present analysis were slightly higher than previously estimated by Wiedemann et al. (2015) because of a revision in the herd modelling which resulted in an improved assessment of herd inventories.

Figure 1. Changes in A) average liveweight at slaughter and B) liveweight produced per joined female over the period 1981 to 2015



Compared to international results, Australian beef production in the most recent analysis period was within the range of results for beef LCAs reported by de Vries and de Boer (2015) and was higher than results from the recent study of US beef by Rotz et al. (2019). This result was not unexpected, considering key herd productivity indicators such as weaning rates and average daily gain were lower than reported in comparative literature studies, and considering the present study excluded beef from dairy herds which is typically produced with lower impacts than beef from suckler beef herds (de Vries and de Boer 2015).

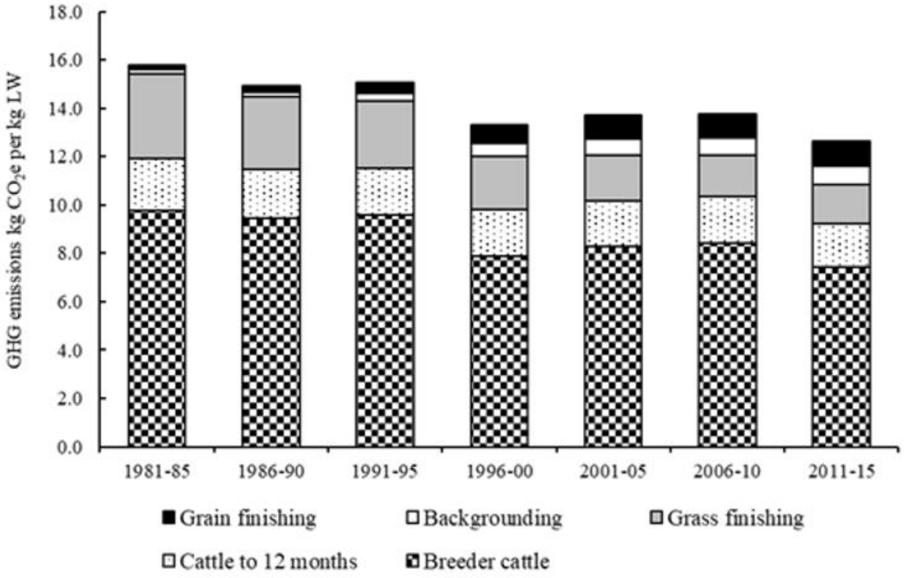
Emissions from LU & dLUC were found to decline 92%, from 46.4 CO_2-e Mt in the five years to 2010 to 3.5 CO_2-e Mt in the five years to 2015, principally because of the substantial reduction in deforestation and the increased rate of sequestration in forests and grassland. Net emissions for the periods 1981-1985 and 1986-1990 were 44.09 and 62.76 CO_2-e Mt respectively, as reported in Wiedemann et al. (2015). Considering these results, the total decline in emissions from the highest point in the five years to 1990 and the present was 94%. These results varied from the previous analysis by the authors because of the revised methods used which align with the NIR.

Table 1. Average annual net emissions in each 5yr period for direct LULUC associated with land used for beef production

Land Classification	**1991-1995**	**1996-2000**	**2001-2005**	**2006-2010**	**2011-2015**
Forest Converted to Grassland	72.3	49.3	56.6	46.9	25.2
Grassland Converted to Forest (excl. Plantation)	-1.89	-4.89	-1.83	0.33	-5.54
Forest Remaining Forest	-14.80	-10.33	-1.60	-2.88	-13.45
Grassland Remaining Grassland	-1.33	0.22	2.43	2.10	-2.75
Net (excl. plantation)	**54.3**	**34.3**	**55.6**	**46.4**	**3.5**

Emissions from LU and dLUC for cropland and other background services ranged from 1.26 kg CO_2-e kg LW-1 in the five years to 1985 to 0.1 kg CO_2-e kg LW-1 in the five years to 2015, largely because of reduced soil carbon losses from cropland over the analysis period.

Figure 2. Changes in greenhouse gases emissions (excluding LU and dLUC) from the production of 1 kg of live weight beef over the period 1981 to 2015



When GHG results were analysed using GTP, reported impacts were substantially lower, ranging from 3.6 kg CO_2-e kg LW-1 in the five years to 1985, to 3.1 kg CO_2-e kg LW-1 in the most recent analysis period. This fundamental difference in reported impacts reflects the different purpose of the GTP metric, which is focused on the impact on temperature at the end of a particular time period (i.e. 100 years) rather than the impact on warming averaged over the 100 year time period. The GTP metric arguably provides more relevant results for comparison with global temperature targets, though it could be argued that a 100 year time period is longer than the temperature targets set in global agreements such as the Paris Accord (United Nations, 2015).

Fossil fuel energy use was revised in the present analysis using improved inventories for feedlots and feed grain production. Energy demand was found to follow a non-uniform trend over the total analysis period (Fig. 4), increasing from the five years to 1985 through to the five years to 2005 by 32% to a peak of 13.5 MJ kg LW-1, after which energy demand decreased to 10.8 MJ kg LW-1 in the most recent time period, which was a 5% overall increase in energy intensity over the 35 year analysis. This overall trend reflected conflicting drivers in energy requirements. Energy demand declined with increasing herd output in response to herd efficiency, but increased in response to intensification and the increase in feedlot beef production.

Total fresh water consumption was found to decline 14% in the most recent five-year period and was 68% lower than the five years to 1985. Over the 35-year period, the dominant trends were the decline in losses associated with drinking water supply and the substantial decline in pasture irrigation, which was partly countered by an increase in irrigation requirements for feedlot ration production (see Fig. 5). In the most recent time period, declines were observed in irrigation water for pasture production, and drinking water, the latter of which declined in response to improved herd efficiency. Losses associated with irrigation water supply were also found to decline compared to the previous analysis period. In contrast, crop irrigation requirements increased, associated with the higher proportion of feedlot finished cattle.

Water stress decreased 61% over the 35-year analysis period, and averaged 283 L H_2O-e kg LW-1 in the five years to 2015. The decline in water stress occurred in the period up to 2010, while in the most recent period, a slight increase (5%) was observed. Over the period to 2010, the decline was largely driven by the decreasing pasture irrigation water consumption, as this affected water demand in the more water stressed regions of southern Australia. A counter trend occurred in more recent years in response to increased demand for grain for lot feeding, which resulted in increased proportions of water stress impacts from grain production.

Figure 3. Changes in fossil energy use from the production of 1 kg of live weight beef over the period 1981 to 2015

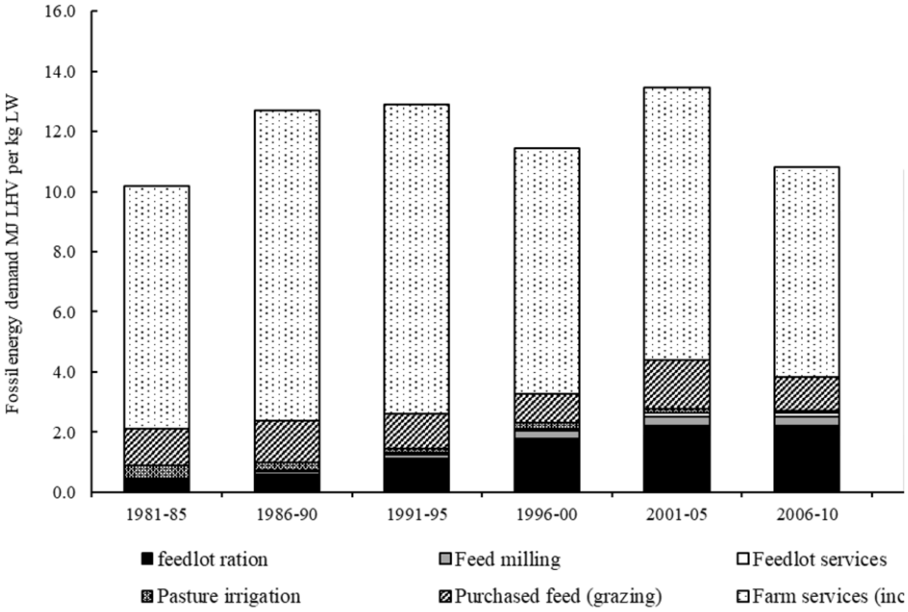
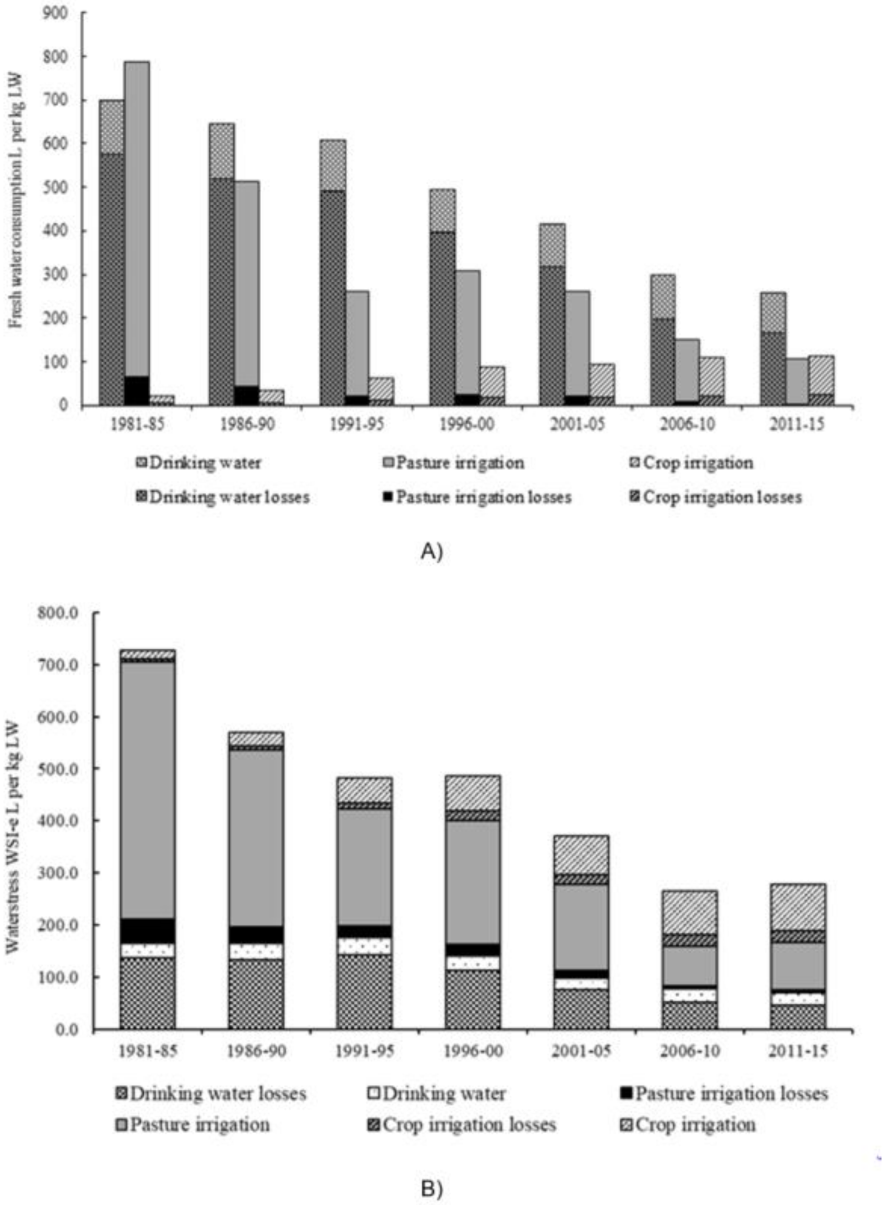


Figure 4. Changes in water consumption and supply losses shown as A) fresh water consumption B) water stress from the production of 1 kg live weight beef over the period 1981 to 2015



A)

B)

Benefits to industry

This report enables industry communication and progress tracking of key environmental impact parameters for Australian beef production. The study is the most comprehensive of any undertaken in the Australian beef industry at the time of publication.

Future research and recommendations

Beef herd productivity has increased substantially over the past 35 years, and this trend continued in the five years to 2015, leading to substantial reductions in environmental impacts from greenhouse gases, water stress and fossil energy use. Water use was found to decrease substantially, largely because of improved water supply systems that reduced losses from artesian bore water sources, and because of reduction in irrigation water use for beef production. In contrast, the proportion of crop land increased as the industry expanded intensive production of beef in feedlots.

This study was developed using available datasets and analysis methods and a series of limitations were observed. A new method was applied in the study to determine the livestock inventory, which has a large bearing on herd productivity and the estimation of GHG emissions and drinking water. Further investigation of herd inventories and performance is required to confirm these estimates, or to develop a more robust and nationally agreed herd inventory and model.

Considering the expected improvements to be gained from better livestock statistics, it is recommended that an update of the study is completed at five yearly intervals, with the next reporting period to include the five years to 2020.

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