Final report

Greenhouse Gas Footprint of the Australian Red Meat Production and Processing Sectors 2020

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Abstract

This report provides an updated account of greenhouse gas (GHG) emissions attributed to the Australian red meat industry based primarily on the 2020 Australian National GHG Inventory. The report presents GHG emissions for beef cattle, sheep meat, and goats in 2020, and recalculates emissions in 2005 and across 2015-2019 using current inventory data. The scope includes livestock production as well as processing that occurred within Australia.

In 2020, total GHG emissions attributed to the red meat industry were 51.25 Mt CO_2-e, representing a 6.4% decrease compared to 2019 and a 64.9% decrease compared to the reference year of 2005. These emissions represented 10.3% of national GHG emissions in 2020.

More than 90% of red meat industry GHG emissions were associated with grazing and land management. Feedlot production contributed 5.8% of total GHG emissions, and processing contributed another 2.1%.

The production and processing of beef cattle contributed most of the red meat industry GHG emissions (88.2%). Sheep and goats contributed 11.6% and 0.15% respectively.

Compared to the previous year, the reduction in total red meat industry GHG emissions in 2020 was largely explained by reductions in livestock numbers.

Executive summary

Background

Since 2015, the Australian red meat industry has been annually reporting GHG emissions, with 2005 as a baseline year, consistent with Australia's Nationally Determined Contribution (NDC) under Article 4 of the Paris Agreement. The main source of data is the Australian National GHG Inventory.

Objectives

Provide an update of the GHG footprint of the Australian red meat production (farm and feedlot) and processing sectors, using data primarily sourced from the Australian National Greenhouse Gas Inventory.

Revise previous assessments for the baseline year 2005 and for the years 2015 to 2019 to reflect changes that have occurred in the underlying national inventory data.

Report the industry's emissions reduction since 2005.

Methodology

This project applied the same methodology that has been used to prepare previous annual updates of red meat industry emissions. The scope of the assessment included the production of beef cattle, sheep for meat, and goats, as well as the domestic processing of these animals. The primary data source was the 2020 Australian National Greenhouse Accounts. Emissions were attributed to the red meat industry based on animal numbers, feed intake, livestock processed, and resource use, as described previously.

Results/key findings

In 2020, total GHG emissions attributed to the red meat industry were 51.25 Mt CO_2-e, representing a 6.4% decrease compared to 2019 and a 64.9% decrease compared to the reference year of 2005. These emissions represented 10.3% of national GHG emissions in 2020. More than 90% of red meat industry GHG emissions were associated with grazing and land management. Feedlot production contributed 5.8% of total GHG emissions, and processing contributed another 2.1%. The production and processing of beef cattle contributed most of the red meat industry GHG emissions (88.2%). Sheep and goats contributed 11.6% and 0.15% respectively. Compared to the previous year, the reduction in total red meat industry GHG emissions in 2020 was largely explained by reductions in livestock numbers.

Benefits to industry

Annual reporting of GHG emissions enables performance tracking with respect to industry targets, such as the target to be carbon neutral by 2030 (CN30). The emissions profile can inform research and development and other strategic actions. Annual reporting of emissions can also play an important role in stakeholder communications, providing evidence that the industry is aware of the GHG footprint and is taking responsible action.

Future research and recommendations

The report suggests opportunities to improve the methodology so that it can more accurately reflect climate actions and production system changes.

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1. Background

The Australian red meat industry is a source of greenhouse gas (GHG) emissions, such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4), that contribute to climate change. As part of its climate action agenda, the industry is striving to become carbon neutral by 2030[1] and has been benchmarking its GHG footprint annually since 2015.

This report continues this series of GHG assessments, providing results for the calendar year 2020, along with updated results for the baseline year 2005 and the years 2015-2019.

2. Objectives

Provide an update of the GHG footprint of the Australian red meat production (farm and feedlot) and processing sectors, using data primarily sourced from the Australian National Greenhouse Accounts.

Revise previous assessments for the baseline year 2005 and for the years 2015 to 2019 to reflect changes that have occurred in the underlying national inventory data.

Report the industry's emissions reduction since 2005.

3. Methodology

3.1 Scope of reporting

This project has applied the same methodology that has been used to prepare previous annual updates of red meat industry emissions (Mayberry 2022).

The scope of the assessment included the production of beef cattle, sheep for meat, and goats, as well as the domestic processing of these animals.

The primary data source was the 2020 Australian National Greenhouse Accounts that represent the Australian Government's submission to the United Nations Framework Convention on Climate Change (DISER 2022a, 2022b).

Emissions from the 2020 National Inventory were allocated to the red meat sector based on animal numbers, feed intake, livestock processed, and resource use, as described previously (Mayberry 2022) and summarised in Appendix 8.3. This was not a product life cycle assessment. Whereas livestock production can take place over several years, the emissions reported here are for individual calendar years

The system boundary included the following emission sources:

- enteric fermentation
- manure management
- agricultural soils, both direct and indirect soil emissions from grasslands and the fraction of croplands used to support the production of feedlot rations
- field burning of agricultural (crop) residues
- liming and urea applications

[1] How red meat is striving to be carbon neutral by 2030; https://www.goodmeat.com.au/environmental-sustainability/cn30/

- electricity and fuel use on farms, in feedlots, and in processing
- land use and land use change relating to cropland, grassland and forest available for grazing

Emissions from dairy cattle and wool production were not included. Emissions attributed to sheep production were allocated to sheep meat production using the protein mass allocation method of Wiedemann et al. (2015).

Emissions from land grazed by livestock were attributed to red meat production based on the relative pasture intake of beef cattle, sheep and dairy cattle.

Emissions from cropland were attributed to red meat production based on the fraction of croplands used to support the production of feedlot rations.

The assessment included the main GHG emission sources but is not comprehensive. Notable exclusions include emissions associated with domestic transport of livestock, the export of live animals and meat products, the production of crops used to feed animals outside feedlots, and the manufacture and transport of fertilizers and other farming inputs.

3.1 Emissions metrics

To aggregate the different GHG emissions and report total CO_2-equivalent emissions, the 100-year global warming potential (GWP100) was used. The GWP values were taken from the IPCC Fifth Assessment Report (AR5, Myhre et al. 2013), consistent with the 2020 National Inventory Report (DISER 2022a). To enable comparison with previous GHG footprint reports for the Australian red meat industry, results were also calculated using GWP values from the IPCC Fourth Assessment Report (AR4, Table 1).

Table 1. 100-year Global Warming Potentials used in this report

	Greenhouse gas	
	CH_4	**N_2O**
GWP_{100} – AR4	25	298
GWP_{100} – AR5	28	265

4. Results

4.1 Greenhouse gas emissions from the Australian red meat industry

In 2020, total GHG emissions attributed to the red meat industry were 51.25 Mt CO_2-e (Table 2), representing a 6.4% decrease compared to 2019 and a 64.9% decrease compared to the reference year of 2005. In 2020, these emissions represented 10.3% of national GHG emissions (Table 2).

More than 90% of red meat industry GHG emissions were associated with grazing and land management (Table 3). Feedlot production contributed 5.8% of total GHG emissions, and processing contributed another 2.1% (Table 3).

The production and processing of beef cattle contributed most of the red meat industry GHG emissions (88.2%, Table 4). Sheep and goats contributed 11.6% and 0.15% respectively.

The reduction in total red meat industry GHG emissions is largely explained by the reductions in beef cattle and sheep numbers in 2020 compared to previous years (Table 5). Enteric fermentation was the single largest source of emissions (40.39 Mt CO_2-e, 78.8% of total emissions, Table 1). Feedlot emissions increased marginally (Table 3), in line with the small increase in this sector measured in head. LULUCF emissions were larger than in 2019, but net negative overall (Table 1).

Table 2. Greenhouse gas emissions (Mt CO_2-e) from the Australian red meat industry by source. Values in italics are sector sub totals.

Source of emissions	2005	2015	2016	2017	2018	2019	2020
Agriculture	***55.97***	***53.14***	***52.38***	***54.14***	***54.50***	***52.11***	***49.86***
Enteric fermentation	46.70	43.72	42.98	44.49	44.86	42.71	40.39
Agricultural soils	4.90	4.92	5.02	5.10	5.07	4.97	5.25
Manure management	3.96	4.02	3.89	4.01	4.05	3.91	3.69
Liming & urea application	0.39	0.47	0.48	0.53	0.51	0.50	0.52
Field burning of agric residues	0.01	0.01	0.01	0.02	0.01	0.01	0.01
LULUFC	***86.96***	***26.74***	***7.60***	***2.89***	***11.29***	***0.06***	***-0.97***
Cropland	0.35	0.06	-0.10	-0.11	-0.06	-0.05	0.09
Forest land	-6.90	-14.31	-26.54	-28.39	-27.33	-21.65	-28.42
Grassland	93.50	40.99	34.24	31.39	38.68	21.76	27.35
Electricity & fuels	*2.90*	2.71	2.49	2.54	2.62	2.59	2.37
Total red meat emissions	***145.82***	***82.60***	***62.47***	***59.57***	***68.41***	***54.76***	***51.25***
Total national emissions	621.13	549.50	525.23	524.16	530.00	516.39	497.70
Proportion of national total (%)	23.5	15.0	11.9	11.4	12.9	10.6	10.3

Table 3. Greenhouse gas emissions (Mt CO_2-e) from farm, feedlot, and processing sectors

Source of emissions	2005	2015	2016	2017	2018	2019	2020
Farm	141.86	78.71	58.92	55.97	64.57	50.71	47.18
Feedlot	2.53	2.55	2.41	2.45	2.63	2.81	2.98
Processing	1.42	1.34	1.15	1.15	1.21	1.23	1.09

Table 4. Contribution of beef cattle, sheep meat, and goats to greenhouse gas emissions (Mt CO_2-e) from the Australian red meat sector

Source of emissions	2005	2015	2016	2017	2018	2019	2020
Cattle	125.83	71.98	56.55	55.81	61.46	48.19	45.21
Sheep meat	19.92	10.53	5.85	3.68	6.87	6.50	5.96
Goats	0.07	0.09	0.07	0.07	0.07	0.07	0.07

Table 5. Livestock numbers and red meat production in 2005, 2015-2018. Data is from the Australian National Greenhouse Gas Inventory activity tables and ABS annual statistics.

	2005	2015	2016	2017	2018	2019	2020
Beef							
Total beef cattle[1] (M head)	25.2	24.6	24.3	24.9	25.1	23.7	22.3
Beef cattle pasture[1] (M head)	24.4	23.7	23.3	24.0	24.1	22.6	21.2
Beef cattle feedlot (M annual equiv[2])	0.82	0.93	0.94	0.94	1.03	1.11	1.11
Beef processed[3] (Mt HSCW)	2.03	2.48	2.08	2.11	2.27	2.38	2.08
Sheep							
Total sheep (M head)	100.7	70.9	70.9	75.7	74.1	69.0	66.7
Lamb & mutton processed (Mt HSCW)	0.62	0.71	0.69	0.70	0.74	0.73	0.66
Wool produced (Mt, greasy)	0.46	0.36	0.36	0.38	0.36	0.31	0.28

[1] excludes dairy cattle
[2] number of animals adjusted for days on feed
[3] excluding veal

4.2 Alternative emission metrics

The results presented in Section 4.1 were calculated using the IPCC AR5 global warming potentials and are therefore not directly comparable to results reported in previous reports for the red meat industry. To facilitate direct comparison, results are also reported using the IPCC AR4 global warming potentials (Table 6). The AR4 GWP of methane is lower (25 compared to 28, Table 1). As such, emissions calculated for the red meat industry were lower (46.6 Mt CO_2-e in 2020, Table 6) compared to results obtained using the AR5 GWPs. In addition, the industry's contribution to national GHG emissions was also lower (9.6% in 2020, Table 6) compared to results obtained using the AR5 GWPs. This is due to methane being a relatively more important GHG gas for the red meat industry than for Australia overall.

Table 6. GHG emissions in 2005 and 2020 calculated using different emissions metrics

	Total national emissions ($Mt CO_2e$)		Emissions from red meat ($Mt CO_2e$)		% national emissions from red meat	
	2005	2020	2005	2020	2005	2020
GWP_{100} – AR4	608.6	487.6	140.2	46.6	23.0	9.6
GWP_{100} – AR5	621.1	497.7	145.8	51.3	23.5	10.3

4.3 Recalculation of inventory time series

Each year, DISER implements various changes to the national inventory. In 2020, this involved various land sector model improvements relating to native forests and savanna fires (DISER 2022a). To enable reliable comparison of red meat industry emissions over time, the entire red meat industry emissions time series from 2005 was recalculated using the latest data reported in the national inventory.

In addition, emission factors for electricity were updated (DISER 2021). For example, the average emissions intensity of electricity used in Australian feedlots has decreased from 0.91 kg CO_2-e/kWh in 2005 to 0.79 kg CO_2-e/kWh in 2020.

5. Conclusion

5.1 Key findings

The Australian red meat industry has reduced GHG emissions by around 65% since 2005 and the rate of GHG emissions reduction has exceeded the overall Australian economy. In 2005 the red meat industry contributed 23.5% of national emissions, whereas in 2020 the contribution had fallen to 10.3%. However, it is important to recognise that reductions in red meat industry GHG emissions have been largely driven by vegetation management. As such, production system GHG emissions, such as those related to enteric fermentation, agricultural soils and manure management, now dominate the GHG emissions profile. In 2019, production system GHG emissions were lower than in 2019; however, this was mainly driven by a reduction in livestock numbers. If livestock numbers increase, GHG emissions could also be expected to increase. This highlights the importance of emissions reductions strategies targeting enteric methane and other agricultural emissions.

5.2 Benefits to industry

Annual reporting of GHG emissions enables performance tracking with respect to industry targets, such as the target to be carbon neutral by 2030 (CN30). The disaggregated emissions profile can be used to inform research and development and other strategic actions. Annual reporting of emissions can also play an important role in stakeholder communications, providing evidence that the industry is aware of the GHG footprint and is taking responsible action.

6. Future research and recommendations

There are three main recommendations to improve the method used to calculate the GHG footprint:

1. Update fixed factors: The method that is presently used to calculate red meat industry GHG emissions uses a variety of fixed factors. For example, the electricity and energy used on farm and in feedlots are based on survey data published several years ago (Wiedemann et al. 2016, 2017). These fixed factors may not reflect current and future red meat industry emissions if farming systems become more or less intensive, or if resource use efficiency changes. The current method, using various fixed factors, may not be able to quantify some GHG emissions reduction interventions. As such, it is recommended to review the use of fixed factors and explore the potential for their periodic recalculation.
2. Explore methods for currently excluded emissions: The current method does not comprehensively cover all GHG emissions related to the red meat industry. For example, the inventory excludes GHG emissions associated with domestic transport of livestock, the export of live animals and meat products, the production of crops used to feed animals outside feedlots, and the manufacture and transport of fertilizers and other farming inputs. To illustrate, if seaweed-based feed supplements were used widely in the industry, the current method would not include the GHG emissions associated with seaweed cultivation and processing into a commercial product for distribution. These emissions may not be insignificant. As such it is recommended to explore methods for quantifying these omitted GHG emission sources.
3. Review of LULUCF emissions: LULUCF emissions and sequestrations are large and have a major bearing on overall results, yet they appear highly uncertain. For example, the current method uses a fixed factor of 0.68 for the proportion of “other native forest” available for livestock. Due to the likely importance of LULUCF emissions to the future attainment of

CN30 targets, it is recommended to explore methods to reduce the uncertainties in LULUCF emission estimates.

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8. Appendix

8.1 List of commonly used terms and acronyms

CO_2-e	Carbon dioxide equivalent. Climate metrics can be used to convert non-CO_2 GHG emissions to carbon dioxide equivalent emissions. There are many different climate metrics and each report different CO_2-e results. There is no universal equivalence between the climate impacts of one GHG compared to another.
DISER	Department of Industry, Science, Energy and Resources. The Federal Department responsible for the Australian National Greenhouse Gas inventory.
Forest land	A vegetation type dominated by trees. An area of at least 0.2 ha with a tree height of at least 2 metres and crown canopy cover of > 20%. The classification also includes lands with a woody biomass vegetation structure that currently falls below but which, *in situ*, could potentially reach the threshold values of the definition of forest land (e.g. young natural stands and plantations, cleared land that is expected to revert to forest). Does not include orchards and other woody horticulture – these are classified as cropland.
Grassland	Rangelands and permanent pastures. Includes areas of sparse woody vegetation that do not meet the definition of forest.
GHG	Greenhouse gas. Includes carbon dioxide, methane, and nitrous oxide, among others. There are also non-GHG climate forcers that impact the climate, such as black carbon.
GWP	Global Warming Potential. These are values that allow for comparison of the global warming impact of the emission to the atmosphere of one GHG compared to another. GWP values depend on the considered time horizon.
IPCC	The Intergovernmental Panel on Climate Change - an intergovernmental body of the United Nations responsible for advancing knowledge on human-induced climate change
LULUCF	Land use, land use change and forestry. A sector of the National Inventory, which includes emissions from cropland, forest land and grassland. Land use change is a permanent change in land use, e.g. from forest land to grassland.
Mt	Mega tonne. Equivalent to 1 million metric tonnes.
UNFCCC	United Nations Framework Convention on Climate Change. The UNFCCC has 197 Parties, including Australia, and is the parent treaty of the 2015 Paris Agreement.

8.2 Previous red meat inventory reports

Project number	Project name	Inventory year
B.CCH.7714	Greenhouse Gas mitigation potential of the Australian red meat production and processing sectors	2015
E.CEM.1909	Greenhouse gas footprint of the Australian red meat and processing sectors	2016
E.CEM.1932	Greenhouse gas footprint of the Australian red meat production and processing sectors 2017 and 2018 updates	2017, 2018
B.CCH.1016	Greenhouse Gas Footprint of the Australian Red Meat Production and Processing Sectors 2019	2019

8.3 Methods used to allocate emissions from the National Greenhouse Gas Inventory to red meat production

Source	Allocation to red meat
Agriculture	
Enteric fermentation	Emissions from beef cattle and goats were reported directly from the national inventory. Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015). Emissions from all other livestock were excluded.
Manure management	Emissions from beef cattle and goats were reported directly from the national inventory. Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015). Emissions from all other livestock were excluded.
Agricultural soils	Direct and indirect emissions associated with animal waste from beef cattle and goats were reported directly from the national inventory. Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015). Emissions from all other livestock were excluded. Direct and indirect emissions from cropland were attributed to beef cattle production based on the proportion of cropland area required to supply feedlots (Wiedemann et al. 2017) Direct and indirect emissions from irrigated pasture were attributed to beef and sheep production based on the proportion of irrigated land used (ABS 4610). Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015). Direct and indirect emissions from non-irrigated pasture were attributed to beef and sheep production based on relative pasture intake. Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015).
Field burning of residues	Emissions were attributed to beef cattle production based on the proportion of cropland area required to supply feedlots (Wiedemann et al. 2017).
Liming	Emissions were attributed to red meat production based on the proportion of lime and dolomite used for beef and sheep farming compared to other agricultural sectors (ABS 2014). Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015).
Urea application	Emissions were attributed to red meat production based on the proportion of urea fertiliser used for beef and sheep farming compared to other agricultural sectors (ABS 2014). Emissions from sheep were allocated between meat and wool production following Wiedemann et al. (2015).
LULUCF	
Forestland	Emissions from forestland remaining forestland were attributed to red meat production based on area of forestland available for grazing (excludes plantations, harvested forests, areas protected for biodiversity and conservation). Emissions were allocated between beef cattle and sheep meat production based on relative pasture intake. Emissions from grassland converted to forestland were attributed to beef cattle and sheep meat production based on relative pasture intake. Emissions from cropland converted to grassland were attributed beef cattle production based on the proportion of cropland area required to supply feedlots (Wiedemann et al. 2017).

Cropland	Emissions from cropland remaining cropland and from land converted to cropland were attributed to beef cattle production based on the proportion of cropland area required to supply feedlots (Wiedemann et al. 2017).
Grassland	Emissions from grassland remaining grassland and from land converted to grassland were attributed to beef cattle and sheep meat production based on relative pasture intake.
Energy	
Energy	Electricity and fuel used for general feedlot operations were calculated based on energy required per 1000-head days (Wiedemann et al. 2017), number of cattle in feedlots and days on feed (DISER 2022a). Electricity and fuel used for feed milling and delivery were calculated based on energy required per tonne of feed (Wiedemann et al. 2017) and feed intake. On-farm electricity and fuel use for beef cattle production were calculated using data reported in Wiedemann et al. (2016) along with total pasture intake. On-farm electricity and fuel use for sheep production were calculated using data reported in Wiedemann et al. (2015) along with number of breeding ewes. Emissions from sheep were allocated between meat and wool production as described above. Greenhouse gas emissions related to electricity and fuel use were calculated using emission factors reported used in the Australian National Greenhouse Accounts (DISER 2021) Greenhouse gas emissions related to processing were obtained from the AMPC Environmental Performance Review series (All Energy 2021) along with quantity of livestock processed (ABS 2022)

Co-production of meat and wool from sheep

Emissions from sheep were allocated between meat and wool production following the protein mass allocation approach of Wiedemann et al. (2015) using production data reported by ABS (2022). In 2020, the allocation was 62.8% to sheep meat, down marginally from 63.7% in 2019.

Attribution of cropland emissions to beef cattle production in feedlots

The area of cropland required to support feedlot cattle production in Australia was obtained from Wiedemann et al. (2017), who reported an average area of cropland per kg liveweight gain. The total area of cropland used was calculated using data describing number of cattle in feedlots, days on feed, and average daily liveweight gain (DISER 2022a). This area was divided by the total cropland area (DISER 2022b) to provide the proportion of cropland that supports feedlot cattle production. This proportion was then applied to all cropland emissions in the inventory to estimate cropland emissions attributable to red meat production.

In 2020, the allocation was 3.7% of cropland emissions to beef cattle production, marginally higher than the 3.5% in 2019.

Proportion of pasture used for beef and sheep-meat production

Emissions from irrigated pasture were allocated to red meat production based on the proportion of area used. The ABS series 4610 reports the area of irrigated land used for various activities including dairy production, production from meat cattle, and production from sheep and other livestock. The area of irrigated pasture used for *sheep and other livestock* is not further disaggregated, and the entire area was allocated to sheep production, then allocated between meat and wool production as described above. While this likely overestimates the area of irrigated pasture used for sheep production, the total area, and therefore emissions included in the red meat inventory are small.

Emissions from non-irrigated pasture were allocated to beef cattle and sheep production based on pasture intake that was calculated using data from the National Inventory. Emissions allocated to sheep production were further allocated between meat and wool production as described above.