November 2022

Summary of the study on the carbon footprint of New Zealand sheepmeat and beef

This document summarises the latest study on the carbon footprint of New Zealand sheep and beef (including dairy beef) production. Commissioned by Beef + Lamb New Zealand and the Meat Industry Association and written by world leading experts on Life Cycle Assessment (LCA) at AgResearch, it provides updated figures for consumers and policy makers on the carbon footprint of New Zealand red meat.

What is carbon footprinting?

The carbon footprint of food is a measure of its impact on global warming, expressed as total greenhouse gas emissions throughout the life cycle of the product. While carbon dioxide is the main gas affecting climate change, methane and nitrous oxide also cause atmospheric warming.

To calculate the carbon footprint of a product, a Life Cycle Assessment (or LCA) study is carried out. Most LCA studies estimating the carbon footprints of red meat often only extend to the farm gate and don't take into account transport, retail and waste. Given New Zealand's distance to its main markets, this study takes into account the carbon footprint from cradle-to-grave (i.e. full life cycle of the product) so that consumers can understand the full impact of New Zealand meat.

Why calculate the carbon footprint of food?

New Zealand is the world's second largest exporter of sheepmeat products globally and the sixth-largest beef exporter (as at 2022), with products shipped to over 110 countries. It is important we understand the full carbon footprint of our products, including transportation, so that we can inform our consumers overseas about how our products compare to their locally produced food.

Domestically, it is critical that all New Zealanders understand at both a sectoral and product level the true climate warming impact of sheep and beef farming.

Domestically and internationally, consumers want to understand the climate impact their purchasing decisions are having and the actions they can take to reduce their footprint.

Given this increasing interest it is important to ensure people have the most accurate picture possible.

About this study

Beef + Lamb New Zealand (B+LNZ) and the Meat Industry Association (MIA) commissioned a comprehensive study of the carbon footprint of New Zealand red meat from independent world-leading experts on life cycle assessment (LCA) of livestock systems, Dr Stewart Ledgard, Shelley Falconer, and Dr Andre Mazzetto of AgResearch, using both traditional and emerging improved methodologies.

This study calculates the carbon footprint of beef and sheep meat at each stage of the supply chain from cradle-to-grave using two Global Warming Potential methodologies (GWP100 and GWP*). It also determined the contribution of carbon sequestration from trees within sheep and beef farms and examined the sensitivity of the footprint to two different methods for allocating emissions between meat and its co-products (such as hides, tallow, wool and other components).

A supporting literature study was also undertaken that compared the New Zealand footprint to those of producers in other countries both at the farm level and including processing and transportation. As a short-lived greenhouse gas (GHG) the relative valuation of methane is particularly sensitive to metric-choice and time-horizon.

For carbon sequestration by trees, the study utilised two reports on sequestration, one from the Auckland University of Technology and one from the Ministry for the Environment's 2021 report: *Net emissions and removals from vegetation and soils on sheep and beef farmland*, to calculate the sequestration rates.

Methane metrics

A standard LCA estimates the impact on climate change when a product is produced, compared to the absence of that product. Using GWP100 allows for better comparisons between the different countries and agricultural systems that this report primarily based results on.

GWP100 however has some acknowledged issues with measuring methane impacts, and recent research[1] shows that new sources of methane produce 4.5 times the climate warming impact implied by GWP100, but constant methane emissions (i.e. a steady state of emissions) are 3.5 times smaller than implied by GWP100 and a reduction in methane of 0.3 percent per year is equivalent to no additional warming.

This is relevant in a New Zealand context where methane emissions from sheep have been falling.

To this end, B+LNZ asked for the study to also estimate the carbon footprint of sheep and beef meat using GWP* and it tells a different story.

[1]Oxford Martin School, University of Oxford https://www.oxfordmartin.ox.ac.uk/downloads/reports/ClimateMetricsforRuminentLivestock_Brief_July2022_FINAL.pdf

Using GWP*

Using GWP* in an LCA is not an established practice and, like GWP100, it also has limitations. Applying GWP* answers a different question to that of GWP100: what is the extra warming impact over the last 20 years and what is the direction of change in the warming impact?

One of the main limitations is that GWP* uses data from a point in time, and where a point in time may show that there is no additional warming being created, it cannot speak to the ongoing warming of the emissions.

GWP* is therefore useful for demonstrating the marginal impact of agriculture and the trajectory in which the industry is heading but does not demonstrate the full picture in relation to what else needs to be done. LCAs are generally created to show the emissions of a product rather than its warming effect so consumer understanding may also be limited. The report also presents results using a split gas approach, which shows the amount of long- and short-lived GHG emissions, independent of metrics.

Regardless, LCA is a complex science that requires a thorough knowledge of all aspects of the supply chain.

Read the full reports

The full report and literature review are available our website www.beeflambnz.com or click on the links provided.

This study is about building consumer, industry, and societal understanding of emissions and warming impact per kilogram of meat, so all stakeholders are better able to critically assess information about carbon footprints, particularly the impact of biogenic methane and the specifics of the New Zealand context.

The wider implications of this study

We are increasingly seeing global reports on the carbon footprint of meat compared to other foods using a global average for beef, which does not reflect the huge differences in how red meat is produced.

These global figures are being used in New Zealand, and it is important the New Zealand public understands the significant difference that exists between the global average and highly efficient producers in New Zealand.

Indeed, this report shows that the carbon footprint of New Zealand meat is amongst the lowest in the world and even when exported to international markets can better domestic and imported products carbon footprints.

The report also demonstrates that 'food miles' should not be a determining factor for consumers. The study shows that around 90 percent of emissions are generated on farm and only 2-4 percent generated by transport. The carbon footprint of New Zealand sheepmeat and beef exported to market competes with and is frequently lower than domestic products and other international competitors in China and the USA.

This study also provides context for showing the impact of biological methane on warming and how that impact is different from other greenhouse gases which is useful for consumers to understand, but it does not address what New Zealand's national reduction targets for methane should be.

In recognition of the different warming impact of methane relative to long-lived GHGs, in 2019 the New Zealand Government legislated for split gas emissions targets, one target for long-lived emissions and others for short-lived methane emissions. Under these targets methane must be reduced, but not to net zero. The sheep and beef sector request the Government to draw on GWP* when reviewing what the country's methane targets should be in 2024 and request the Government to start to report annually on warming as well as emissions. The sector believes that the warming goal set for methane targets should be the same as the warming goal set for long lived emissions. It is warming that matters most in climate policy.

This report also opens up the conversation on climate metrics and shows that using different metrics like GWP* and including on-farm sequestration has a significant impact on the carbon footprint of sheep and beef meat. New Zealand sheep and beef producers are stewards of the environment and have worked hard to increase efficiency while protecting native biodiversity. This has resulted in one of the most efficient sectors in the world, with a climate impact that is continuing to reduce.

Post the farm gate, it is also worth noting that the red meat processing sector has an industry-wide goal to phase out coal by 2037, which over time will drive further reductions.

Key findings

Sheep GWP100

1. At the farm gate, New Zealand is **among the most efficient producers of sheepmeat in the world**. The GHG emissions for a kilogram of New Zealand sheepmeat is 6.01 kg CO_2-e per kilogram of liveweight compared to an average of 14.20 kg CO_2-e per kilogram of liveweight for the other countries looked at in the study.
2. When converted from liveweight to meat, sheepmeat equates to 13.32 kg CO_2-e per kilogram sheepmeat.
3. The processing and transport to international markets (in this report China, UK and the USA) adds 1.4 kg CO_2-e per kilogram sheepmeat to the footprint.
4. This makes the average total cradle-to-grave footprint of sheepmeat exported to these markets 14.73 kg CO_2-e per kilogram sheepmeat, which is lower than the sheepmeat produced in most markets that New Zealand exports to and sheepmeat sent to those markets by other exporters.

Beef GWP100

5. At the farm gate, the carbon footprint of a kilogram of New Zealand beef (liveweight) produced is 8.97 kg of CO_2-e, compared to an average of 14.1 kg of CO_2-e per kilogram (liveweight) for the other countries looked at in the study. New Zealand beef producers are also therefore among the most efficient in the world.
6. When converted from liveweight to meat, New Zealand beef equates to 20.90 kg CO_2-e per kilogram meat, while the average footprint was 23.1 kg CO_2-e per kilogram beef.
7. The processing and transport to international markets (in this report Japan and the USA) adds 1.01 kg CO_2-e per kilogram meat to the footprint.
8. This makes the average total cradle-to-grave footprint of beef exported to these markets 21.94 kg CO_2-e per kilogram meat which is at the lower end for beef produced in most markets that New Zealand exports to and beef sent to those markets by other exporters.

Food miles

9. **As described above, transport makes up only a tiny proportion of the total footprint** and, even with these emissions included, New Zealand's climate footprint performance compares favourably with products produced in overseas domestic markets.

Key findings of GWP*, sequestration and mass allocation

This is a novel approach being applied for one of the first times in an LCA. The United Nations Food and Agriculture Organization (FAO) is currently investigating the potential use of GWP in understanding the climate impact of methane. Preliminary advice is that it has some merit in an LCA but also limitations in that account also needs to be taken of ongoing warming. The reason for publishing this report is to build understanding of the difference between metrics and emissions and warming, but it is acknowledged that this is a novel approach.*

Sheep

1. Using the novel GWP* method that focuses on warming and accounting for carbon sequestration by trees on farm, New Zealand sheepmeat has not added any additional warming over the last 20-30 years and has arguably had a climate-neutral impact over this time period.
2. Using GWP* the carbon footprint of a kilogram of sheepmeat (to farm gate) is 2.13 kg CO_2-e per kilogram sheepmeat.
3. When sequestration by trees on-farm is added to the calculation (balancing emissions and net removals) the carbon footprint of NZ sheepmeat is -0.34 kg CO_2-e per kilogram sheepmeat, even when including processing and shipping.
4. This result has come about because the methane produced by sheep in New Zealand has been consistently declining for the last 20-30 years.

Beef

1. Using GWP* the carbon footprint of a kilogram of beef (to farm gate) is 13.11 kg CO_2-e per kilogram beef.
2. When on-farm sequestration is added to the calculation (balancing emissions and net removals) the carbon footprint of NZ beef is 8.64 kg CO_2-e per kilogram beef. When transport and processing are added, the footprint of exported beef is 9.67 kg CO_2-e per kilogram beef. This is significantly lower than the carbon footprint of beef using GWP100, as the methane derived from beef production (including dairy beef) has been stable for the last couple of decades.

Mass allocation

3. The research also highlighted that the traditional methodology of attributing greenhouse gas emissions after meat-processing by economic value currently attributes about 90 percent of the emissions created by sheep and cattle to the meat, and only 10 percent in total to the many other products derived from the animal (such as hides, tallow, collagen and other co-products). If the emissions are attributed by mass instead, that would approximately halve the cradle-to-grave carbon footprint of sheepmeat and beef.

Key findings table

This table shows a summary of results for the carbon footprint of beef and sheepmeat that is exported to overseas markets by stage of production, considering the alternative analyses applied for each stage (using GWP100, GWP* and carbon sequestration for the on-farm stage).

Table 1: NZ carbon footprint in kg CO_2-e per kg meat

	GWP100 (AR5) (economic allocation)	GWP* (economic allocation)	GWP* + carbon sequestration (economic allocation)
Sheepmeat			
On-farm (per kilogram liveweight)	6.01		
On-farm (per kilogram of meat)	13.32	2.13	-1.75*
Processing	0.53	0.53	0.53
Post-processing including transport to market	0.88	0.88	0.88
Sheepmeat total cradle-to-grave	**14.73**	**3.54**	**-0.34 (arguably 'climate neutral')**
Beef			
On-farm (per kilogram liveweight)	8.97		
On-farm (per kilogram of meat)	20.90	13.11	8.64
Processing	0.52	0.52	0.52
Post-processing including transport to market	0.51	0.51	0.51
Beef total cradle-to-grave	**21.94**	**14.15**	**9.67**

Background

Understanding and measuring Global Warming Potential (GWP)

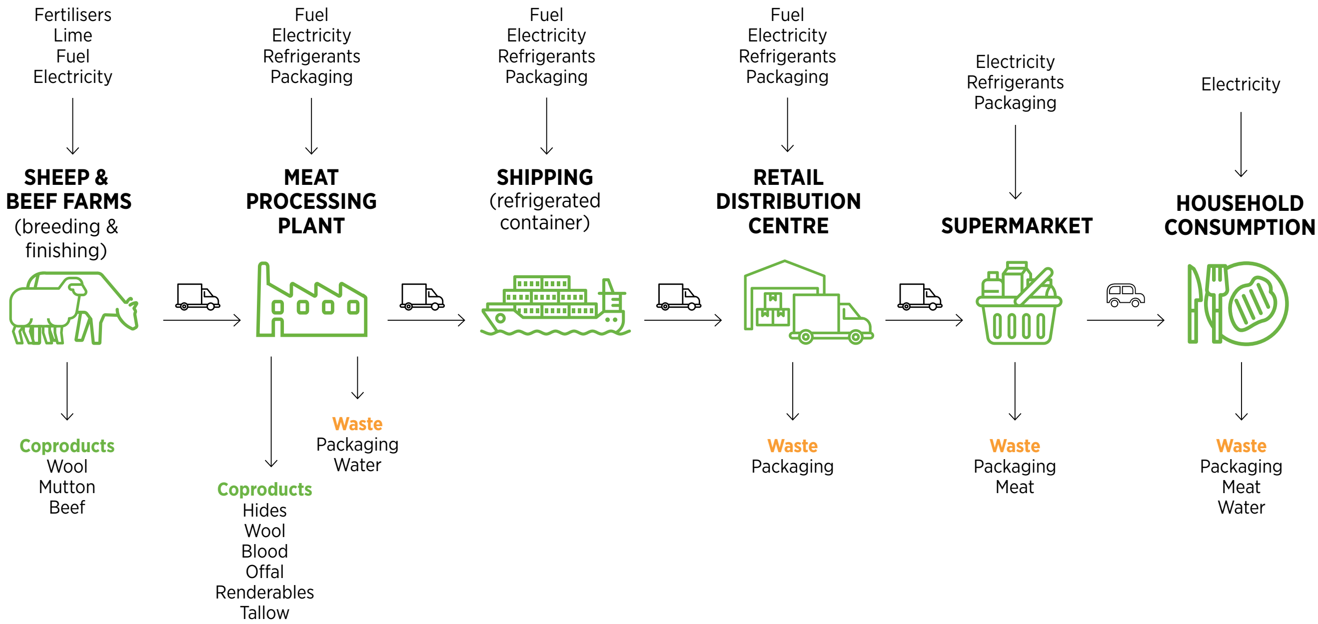
Greenhouse gases (GHGs) warm the earth (i.e. cause global warming) by absorbing heat (or energy) and slowing the rate at which that heat escapes to space; in other words, GHGs act like an insulating blanket for the earth. Common GHGs found in an agricultural setting are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Each of these gases differ in how much heat they absorb and how long they last in the atmosphere (their lifetime).

To compare all the different gases that contribute to global warming, a 'Global Warming Potential' (GWP) metric is used. The GWP100 metric measures how much energy the emissions of one tonne of a particular gas will absorb over a 100 year period, compared to one tonne of carbon dioxide, giving it a CO_2-equivalent conversion factor (CO_2-e). GWP100 is the current globally accepted metric underpinning current Life Cycle Assessment standards.

Emissions across the life cycle

For red meat, a full LCA starts on farm and ends after the product is eaten – also known as 'cradle-to-grave'. This is the truest method to calculate the real footprint of food and should be used for all foods.

Most LCA statistics used globally to compare foods combine the emissions from the first two stages, on-farm production and processing.



Given New Zealand exports a significant proportion of its food (95 percent of sheepmeat and 90 percent of beef) it is important to include shipping and transport.

A full LCA (i.e. cradle-to-grave) takes into account not only the on-farm production, but all the processes involved in processing, packaging, chilling, transporting, distributing, cooking and eating the product and waste disposal.

This study looks at the full life cycle including the following, and also gives an assessment of the on-farm component.

- **On-farm** – the New Zealand average cradle-to-farm-gate carbon footprint for both sheepmeat and beef has decreased since the previous LCA study in 2010.
- **Processing** – meat processing contributes 2-4 percent to the total carbon footprint of red meat.
- **Shipping and transport** – shipping is a minor contributor at only 1-4 percent of the total carbon footprint. Adding all transport stages (including from farm to processing plant and in-market distribution) makes up 2-6 percent of the total carbon footprint.

Summary of New Zealand on-Farm LCA

The weighted average for sheep covering cradle to farm gate was 6.01 kg CO_2-e per kilogram of liveweight and for beef 8.97 kg CO_2-e per kilogram of liveweight.

The figure for on-farm GHG emissions per kg liveweight is converted into a carbon footprint per kilogram of meat, which is the figure usually quoted in global reports.

Allocating emissions to product per kilo

When a production system makes more than one product, emissions are shared, or allocated, among products – such as wool, skins, meat, milk, and other co-products.

On-farm, emissions from sheep production are allocated between liveweight sold for meat and wool, using the recognised 'biophysical' allocation according to the relative protein production in both products.

After meat processing, the traditional method for calculating the carbon footprint of meat products utilised an economic allocation, in which the emissions are allocated according to the economic value of the products.

When this approach is used, just over 90 percent of all the emissions produced by a lamb, sheep or cattle animal is allocated to the meat because this is the most valuable part of the animal.

Using economic allocation and accounting for the edible meat product(s), the carbon footprint for sheepmeat moves from 6.01 kg CO_2-e per kilogram liveweight to 13.32 CO_2-e per kilogram of meat, while the carbon footprint for New Zealand beef moves from 8.97 kg CO_2-e per kilogram liveweight to 20.90 kg CO_2-e per kilogram of meat at the farm gate.

*Table 2: The following table illustrates how the on-farm carbon footprint per kilo **liveweight** is converted into an on-farm footprint **per kilogram of meat***

	Beef	Sheep
Liveweight		
On-farm carbon footprint per kg liveweight	8.97	6.01
Carcass weight		
Proportion of meat from animal liveweight	39%	41%
Proportion of economic allocation that is allocated to meat	91%	92%
On-farm carbon footprint per kg meat	20.90	13.32

Processing and transport to market

The main emission of GHGs for both beef and sheep product systems occurred within the 'cradle-to-farm gate' boundary (90 to 95 percent of total life cycle emissions).

This study took the LCA further than most traditional LCAs however and accounted for meat processing and post processing. Meat processing contributed 2-4 percent of the carbon footprint, while post processing accounted for 2-6 percent.

An important part of the calculations involves accounting for the change from liveweight (leaving the farm gate and transported to abattoirs) to meat that leaves the abattoir gate. The largest emissions from processors is generated through energy usage and there was some variation in the main source of energy amongst processors.

Trucking and shipping were minor contributors to the total cradle-to-grave carbon footprint accounting for 1-4 percent of total emissions, while cooking was also included in the cradle-to-grave analysis.

International comparisons

AgResearch reviewed a range of international studies to compare New Zealand's on-farm emissions and those from the cradle-to-grave.

The international comparisons using GWP100 produces the highest number of comparable studies and is the most consistent with international literature. The researchers only looked at studies that had used similar methodologies, but there are always differences in approach and therefore comparisons are indicative rather than exact.

Comparing the **on-farm carbon footprints** is the best way to compare carbon footprints across countries because:

- this is the most significant contribution to emissions
- most published studies cover this stage only
- there are fewer differences in methodology; and
- this is before additional calculations such as storage conditions, cooking methods and wastage, which vary from country to country.

The following is a summary of the results comparing similar GWP100 methodologies on-farm.

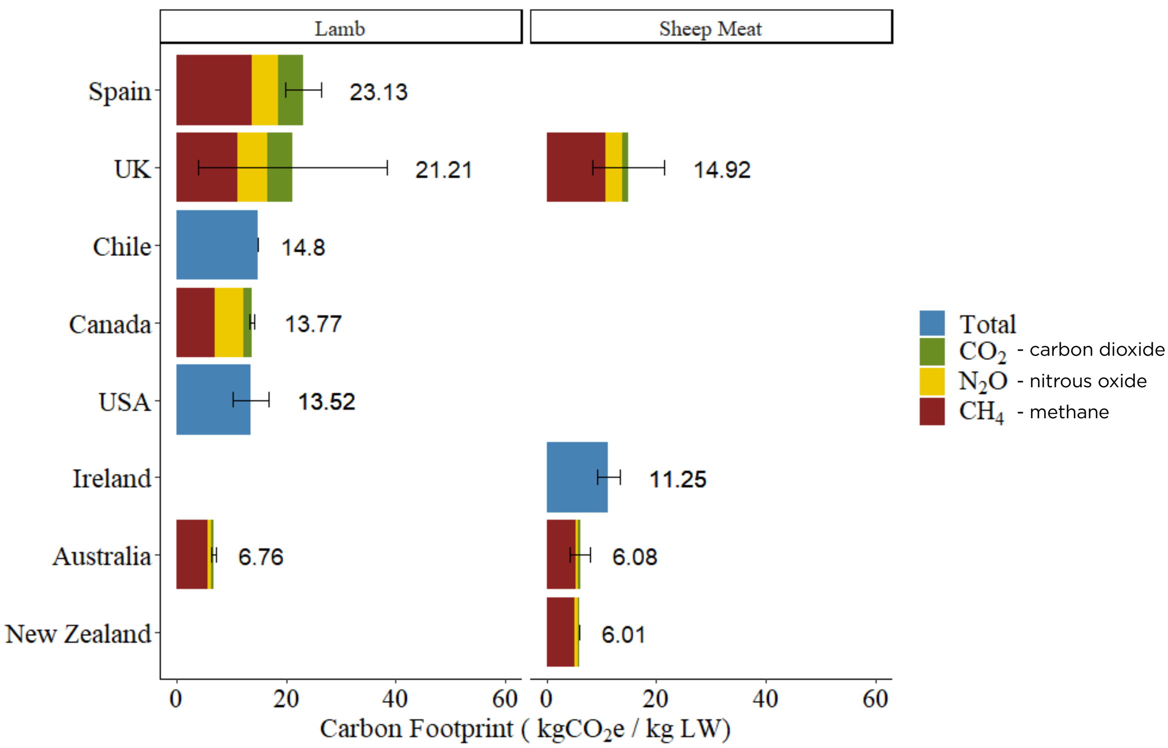
It shows that New Zealand is one of the most efficient producers of beef and sheepmeat.

International comparison of sheepmeat

The range for sheep liveweight in other published studies was 6.8 to 23.1 kg CO_2-e per kilogram liveweight. These studies were generally from more efficient producing countries. The global average is higher than this if developing countries are included.

For New Zealand sheepmeat, the weighted average carbon footprint on-farm is 6.01 kg CO_2e per kilogram liveweight, while the average footprint of sheepmeat for all the countries included in the review was 14.20 kg CO_2e per kilogram liveweight. This is one of the lowest farmgate emissions footprints for sheepmeat in the world.

Figure 1: On-farm carbon footprint of sheep in kg CO_2-e per kg liveweight (GWP100)



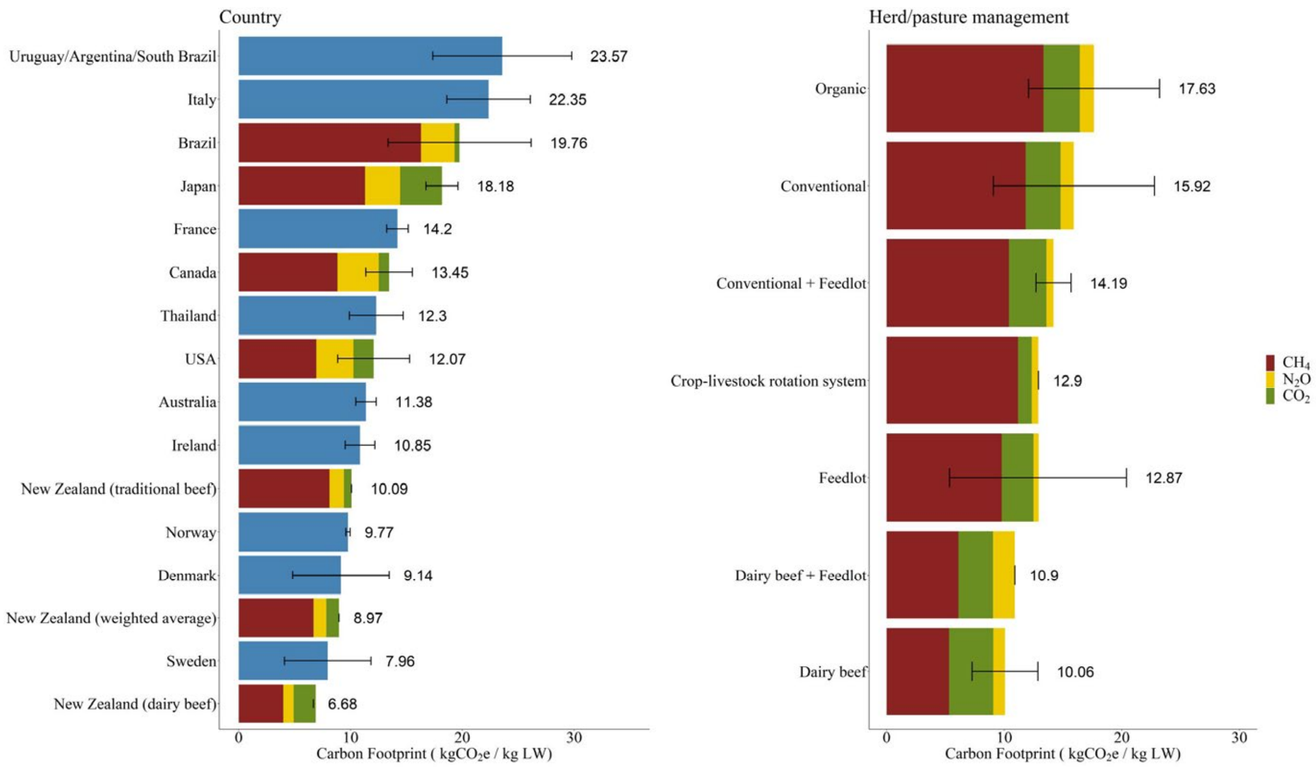
International comparison of beef

The range for beef liveweight in other published studies was 8-23 kg CO_2e per kilogram liveweight. For New Zealand beef, the weighted average carbon footprint (including dairy beef) on-farm is 8.97 kg CO_2e per kilogram liveweight. This is one of the lowest in the world and is only surpassed by a system predominantly made up of dairy beef production such as Sweden.

A contributor to New Zealand's low on-farm average is that a significant proportion of our beef is derived from the dairy industry. This is a very efficient form of beef production as a dairy cow produces milk during its lifetime and then meat, resulting in a low carbon footprint for meat as a proportion of emissions are allocated to milk production. The footprint for dairy beef in New Zealand was 6.68 kg CO_2e per kilogram liveweight. The average on-farm footprint for beef for all the countries reviewed in the study was 14.10 kg CO_2e per kg liveweight (Figure 2). The countries compared in the study are traditionally the more efficient, developed country producers. The global average is likely to be higher as it includes developing countries that are less efficient.

This average New Zealand footprint is therefore much lower than the global average for beef as the countries that were included in the comparison included some of the most efficient in the world.

Figure 2: On-farm carbon footprint of beef kg CO_2-e per kg liveweight (GWP100)



International comparison from cradle-to-grave

The research also compared the carbon footprint of New Zealand sheepmeat and beef exported to key markets with those markets' domestic production.

There are not many international comparisons that use similar methodologies and where they do, there are still many nuances and caveats that need to be applied to ensure that comparisons are 'apples with apples'.

Nevertheless, the research found that emissions from sea freighting to markets makes up a relatively small proportion (e.g. 2.8 percent for sheepmeat to the UK) of the total footprints. The relative efficiency of New Zealand farming systems is such that beef produced compares favourably with overseas domestic product even when transport emissions are included.

For New Zealand sheepmeat, the total emissions (cradle-to-grave) are lower than the world average at the farm gate (from Figure 1) meaning that it is more efficient to produce New Zealand sheepmeat, process it, chill it, ship it to market, and eat it than it is to produce an average kilogram of sheepmeat worldwide.

Table 3: Summary of published beef and sheepmeat carbon footprint studies

Study	Country	Boundary	Farm type	Farm	Processing	Post-processing	Footprint (Total)
				kg CO2e / kg meat			
Beef							
Liefferin et al., 2010	New Zealand	Grave (to mixed markets)	NZ average	20.10	0.50	1.68	22.30
Sanders et al., 2014	USA	up to food consumption		27.00	0.39	3.43	30.82
Wiedemann et al., 2015	Australia	up to USA warehouse	Beef grass	25.49	0.98	0.76	27.22
Wiedemann et al., 2015	Australia	up to USA warehouse	Beef medium-fed grain	21.62	0.98	0.76	23.36
Wiedemann et al., 2015	Australia	up to USA warehouse	Beef long-fed grain	23.82	0.98	0.76	25.56
Huerta et al., 2016	Mexico	up to retail	Extensive system	20.37	1.13	0.24	21.73
Huerta et al., 2016	Mexico	up to retail	Intensive system	19.87	0.25	0.48	20.60
Asem-Hiable et al., 2018	USA	Grave	Pasture + Feedlot	30.67[1]	0.59[1]	3.84[1]	35.10[1]
Vitali et al., 2018	Italy	up to food consumption	Organic beef	20.98	1.27	2.22	24.47
This study (2021)	*New Zealand*	*Grave – exported to the USA*	*NZ average*	*20.90*	*0.52[2]*	*0.66*	*22.08*
This study (2021)	*New Zealand*	*Grave – exported to Japan*	*NZ average*	*20.90*	*0.52[2]*	*0.36*	*21.79*
This study (2021)[3]	*New Zealand*	*Grave*	*NZ average*	*19.70*	*0.52[2]*	*0.36 – 0.66*	*20.59 – 20.88*
Sheep							
McDevitt et al., 2009	New Zealand	Grave (to the UK)	NZ average lamb	14.97	0.57	4.13	19.66
Liefferin et al. (2010)	New Zealand	Grave (to the UK)	NZ average mutton	13.20	0.57	4.13	17.90
Wiedemann et al., 2015	Australia	up to USA warehouse	Conventional	14.40	0.76	0.76	16.07
This study (2021)	*New Zealand*	*Grave – exported to the UK*	*NZ average*	*13.32*	*0.53[2]*	*0.96*	*14.81*
This study (2021)	*New Zealand*	*Grave – exported to China*	*NZ average*	*13.32*	*0.53[2]*	*0.92*	*14.77*
This study (2021)	*New Zealand*	*Grave – exported to the USA*	*NZ average*	*13.32*	*0.53[2]*	*0.77*	*14.62*
This study (2021)[3]	*New Zealand*	*Grave*	*NZ average*	*12.38*	*0.53[2]*	*0.77 – 0.96*	*13.69 – 13.88*

[1] Data was adjusted to a meat component equating to 40% of LW, to align with the current study; [2] Includes transport to abattoir and processing stage; [3] Emissions using AR4 (2007) GWP factors

The research included a literature review to understand the variation in the footprints in various countries. Across all studies, there were large differences in methodology, mainly related to the use of different GWP100 factors, data quality and completeness.

To enable a better comparison within/between countries, a recalculation of the footprints using the same GWP and allocation methods would be necessary. Care needs to be taken when comparing countries therefore.

New ways of looking at Life Cycle Analysis

Accounting for sequestration

Carbon sequestration is the process of permanently capturing and removing carbon-based GHGs from the atmosphere to prevent or slow global warming. Trees and woody vegetation (scrubland and shrubs) capture and remove carbon from the atmosphere.

Many products, such as air travel, use offsetting to reduce their carbon footprint (that is, they pay for activities such as planting trees). This offsetting is reported separately and is currently not part of the traditional LCA footprint methodology.

In the case of sheep and beef farming, however, it is within the farming system itself that carbon is being sequestered. The carbon sequestration lifecycle most naturally mirrors that of the biogenic methane cycle – in that it is on much shorter time frames. This is qualitatively different from offsetting emissions from air travel with a forest. It makes sense, therefore, to account for the woody vegetative sequestration happening within the farm as part of the footprint for New Zealand-produced beef and sheepmeat.

The sequestration of carbon in soil on-farm has not been included in this study. Reports vary as to the amounts and permanence of soil carbon accumulation and there is insufficient evidence from New Zealand for inclusion in this study.

Approximately 20 percent of the sheep and beef farm area in New Zealand is covered with trees and woody vegetation. This study considered the impact of that sequestration, based on a newly released report by the Ministry for the Environment (MfE) (2021).

The estimated net carbon sequestration in woody vegetation (using MfE [2021] data) is equivalent to 29 percent of the total calculated GHG emissions from agricultural production on New Zealand sheep and beef farms.

The MfE report on sequestration was used instead of the one commissioned by Beef + Lamb New Zealand which found that New Zealand farms were sequestering between 63 and 118 percent of on farm emissions. The MfE report was used as it took into account deforestation which is more appropriate for an LCA approach.

Building understanding of the science with GWP*

Background on GWP*

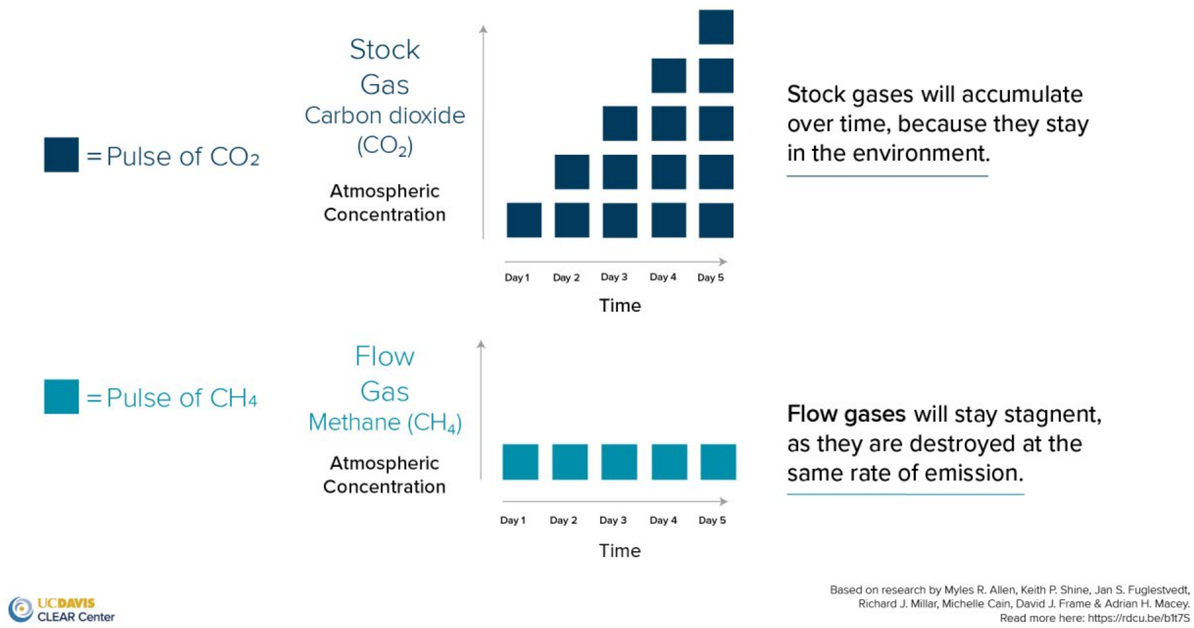
Until now, the most commonly used method for calculating on-farm emissions has been GWP100, which compares the global warming potential of emissions over a 100-year period.

Carbon dioxide resulting from the burning of fossil fuels (CO_2) is the main greenhouse gas contributing to warming, however methane (CH_4) and nitrous oxide (N_2O) also make a significant contribution and it is important to understand their impact.

Carbon dioxide and nitrous oxide are similar, in that they stay in the atmosphere for a long time after they have been emitted with lifetimes of around 1000 and 300 years respectively. Because stocks of these gases build up in the atmosphere over time they are known as 'stock' gases.

Methane is different as it is a short-lived gas and decays significantly within 12 years, by converting into carbon dioxide through natural processes.

The below diagram illustrates the differences between long-lived and short-lived gases and how they contribute to warming.



A recent Intergovernmental Panel on Climate Change (IPCC) report[2] had an important section on methane.

It noted that if total methane emissions are increasing then it has a significant and immediate impact on warming that is more potent than carbon dioxide.

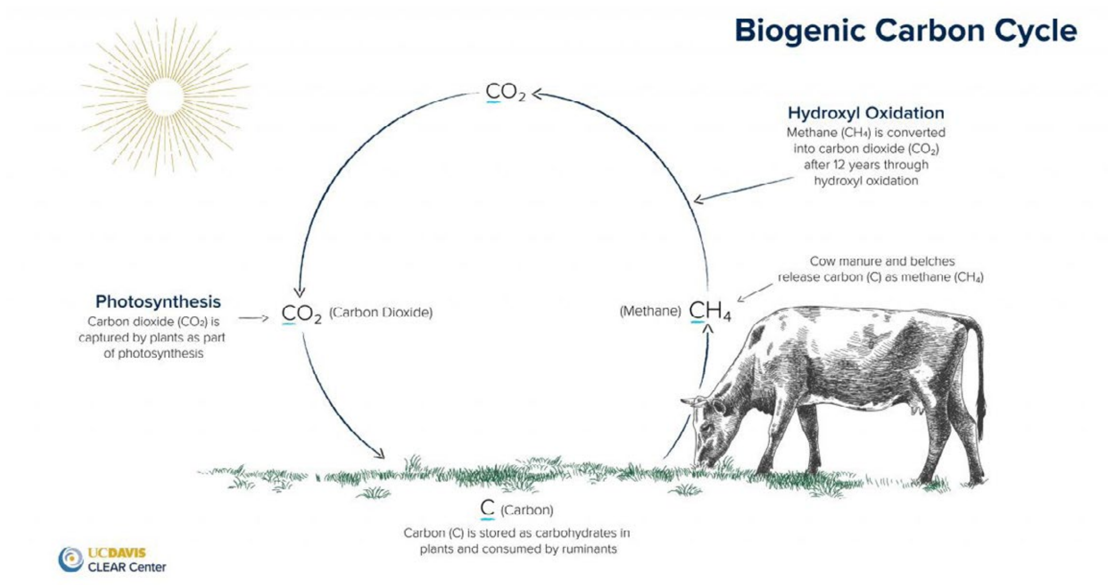
If total methane emissions are stable or decreasing then its effect on warming is very different. In particular if total methane emissions are decreasing by 0.3 percent each year then it is not creating any additional warming, which is similar in effect on the atmosphere to net zero for carbon.

The IPCC report, and a recent Oxford Martin note, also states that GWP100 overstates the impact of methane when emissions are stable or decreasing, as they have been for sheepmeat, and to a lesser extent beef, in New Zealand for the last 30 years.

The IPCC report notes GWP*, in comparison to GWP100, takes into account short-lived climate pollutants (e.g. methane), scales emissions over time and better accounts for the different warming behaviours of short-lived gases.

[2]Forster, P., T. Storelvmo, K. Armour, W. Collins, J. L. Dufresne, D. Frame, D. J. Lunt, T. Mauritsen, M. D. 39 Palmer, M. Watanabe, M. Wild, H. Zhang, 2021, The Earth's Energy Budget, Climate Feedbacks, and 40 Climate Sensitivity. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I 41 to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. 42 Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, 43 K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou 44 (eds.)]. Cambridge University Press. In Press; Chapter 7 (7.1.6.4)

The IPCC report therefore recommended careful choice of metrics when undertaking LCAs, for example comparing the carbon footprint of foods.



Better recognising the impact of methane is important for livestock agriculture, where biogenic methane emissions are a significant proportion of the overall emissions produced.

The FAO is currently holding public consultation as to when and how alternative metrics to GWP100, such as GWP*, could be used for quantifying the climate impact of methane, in recognition that methane is such a significant proportion of the emissions from sheep and cattle. The draft FAO report on *Methane emissions in livestock and rice systems* is currently out for public review.

The FAO report indicates that using GWP* in some circumstances has merit, but also limitations.

Results using GWP*

The GWP* metric calculation requires at least two emission pulses to estimate the different points in time to account for the emission rate change required to estimate CO2-we.

To account for methane's effect over time (e.g. Allen et al. [2018] used a 20 year period); this report extracted data from 20 years prior to the period analysed (current: 2017/2018, before: 1997/1998). Utilising the GWP* methodology, and sequestration, shows that because biogenic methane from sheep in New Zealand has consistently decreased in the last 30 years it has not added any additional warming over this time period, and could arguably be described as being 'climate neutral'.[3]

Methane emissions from beef production in New Zealand have decreased only slightly during the last twenty years. While there has been a decrease in beef cattle numbers, this has been offset by an increase in dairy cows and a portion of dairy cow emissions are counted with beef emissions. Therefore using GWP* for beef still results in a positive number, but it is less than using the traditional GWP100 methodology. (Note: Overall methane emissions from total agricultural production in New Zealand have been stable since the early 2000s)

The IPCC (2018) describe 'climate neutral' as a "concept of a state in which human activities result in no net effect on the climate system. Achieving such a state would require balancing of residual emissions with emission removal…" It does not tell us whether this is cost-effective or equitable.[4]

The FAO's draft report on *Methane emissions in livestock and rice systems* noted that 'climate natural' is a term increasingly being used for non-CO_2 gases and is "a situation where an organisation or industry is making no additional contribution to radiative forcing could be regarded as consistent with climate stabilisation and described as climate neutral. This does not resolve the question of what an acceptable level of radiative forcing from this organisation or industry is."[5]

The use of metrics for understanding methane and livestock's impact on climate change is still evolving. Australia has conducted a study on sheepmeat using radiative forcing that concluded it has been climate neutral, but at this stage the sector is still aiming to be carbon neutral.[6] The US beef and dairy industry has recently released a strategy to become climate neutral.[7]

[3] Using GWP* for methane resulted in a high negative number for sheepmeat as it had significantly reduced over the [20] year period. Based on discussions with GWP* science experts it was advised to put zero for methane's contribution in the LCA.
[4] FAO, p 179, Methane emissions in livestock and rice systems, Sources, quantification, mitigation and metrics, DRAFT for public review, Rome 2022
[5] Ibid,p 181
[6] https://www.mla.com.au/research-and-development/Environment-sustainability/carbon-neutral-2030-rd/
[7] https://clear.ucdavis.edu/sites/g/files/dgvnsk7876/files/inline-files/White-paper-climate-neutrality-beef-dairy.pdf

While the New Zealand red meat sector can celebrate the progress it has made in not adding additional warming on sheepmeat over the last 20-30years, continuous improvement is required. To maintain a climate neutral position using GWP*, reductions need to continue to be made. New Zealand's sheepmeat emissions were also arguably coming off a high level 20 years ago as a result of a significant increase in the flock in the 70s and 80s caused by subsidies.

The science behind GWP* is, however, important. It is important to continue to build understanding of the science to ensure consumers and the public understand the impact livestock is having on the climate in that country and what further contributions that may need to be made.

Mass allocation

The way emissions are allocated has a big impact on the calculated footprint of individual products.

As noted earlier, the traditional approach to calculating the carbon footprint of meat products is to use an economic allocation, in which the emissions are allocated according to the economic value of the products.

When this approach is used, just over 90 percent of all the emissions produced by a sheep or cattle animal is allocated to the meat because this is the most valuable part of the animal.

The study also looked at mass allocation at the processing stage, in which emissions are allocated according to the mass (the total amount) of the products. This approach seeks to account for the many other products produced from the same animal, including skins, meat, milk and co-products.

The economic value changes according to market fluctuations unrelated to actual emissions whereas mass allocation remains constant and more closely approximates biophysical allocation, used at the farm stage.

When applying mass allocation the average GHG results for meat (sheepmeat and beef) were between 49 and 55 percent lower.

Average cradle-to-grave carbon footprint (kg CO_2-e/kg meat)	Beef	Sheepmeat
Economic allocation	21.9	14.7
Mass allocation	10.0	7.5

Summary

As the focus increasingly goes on to the emissions created by products, it's useful to assess whether current methodology accurately represents the impact a product has. This will continue to evolve as the usage of metrics develops.

New Zealand farmers, and consumers domestically and internationally, can have confidence that New Zealand red meat is among the most efficient in the world.

International consumers can also take confidence in the knowledge that even if New Zealand beef or sheepmeat is exported, the total carbon footprint is lower or very similar to domestically produced red meat in those nations.