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Article

Equivalence—A Useful Yet Complex Concept in Natural Resource Science

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Abstract: The concept of equivalence is widely employed to aggregate different types of resource depletion or emissions. The practice offers convenience for reporting and can assist policymaking. However, equivalence is typically established using a model based only on selected criteria. If alternative criteria are used, the relative importance of different types of resource depletion or emissions can change. This communication addresses the subject of greenhouse gas (GHG) emissions and carbon dioxide equivalence (CO_2e). Using the Australian beef cattle and sheep meat sectors as a case study, radiative forcing (RF) footprints were quantified, and a method is presented to express these as CO_2e emissions rather than the units W/m^2. RF footprints are an alternative way of aggregating GHG emissions. They incorporate RF from current-year emissions and RF from historical emissions that remain in the atmosphere, avoiding the need to choose an arbitrary time horizon. There is simplicity and familiarity associated with the CO_2e unit. However, it is concluded that whenever GHG emissions are reported as CO_2e emissions, there is a need for transparency about the basis for equivalence, justification of the approach, as well interpretation of the results, and potential implications of selecting other bases of equivalency.

Keywords: Australia; biogenic methane; carbon dioxide equivalence; climate change; emission metric; greenhouse gas; Paris agreement; radiative forcing footprint; ruminant livestock

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1. Introduction

Equivalence is an important, yet complicated, concept in sustainability assessment and policymaking. For example, depletion of critical mineral resources is oftentimes assessed using antimony as a reference substance, with results expressed as Sb-equivalent depletion [1,2]. The method allows for relative comparison of systems requiring different combinations of critical minerals, even though it is well understood that the individual components are not directly interchangeable or substitutable. Other examples include water use and land use. Water scarcity differs across regions, and models have been created to enable water use to be expressed in volumetric units that are equivalent to a region of global average water scarcity [3,4]. However, these models do not capture all the social, economic, and environmental differences pertaining to water consumption. Similarly, for land use, a variety of models have been developed to enable diverse land resource use to be aggregated and compared based on equivalent productive capability [5], equivalent biodiversity value [6], and other criteria. The key point is that these equivalency models can be an aid to decision making and the evaluation of trade-offs. However, the basis of equivalency is also limited, and there is a need to understand the limitations of these models when they are used.

In the same manner, equivalency metrics have been developed for emissions to the environment. To support reduction in environmental harm from the use of industrial chemicals, the USEtox models were developed [7], which assess the fate, exposure, and toxicity of a wide range of substances. Equivalency is expressed in comparative toxicity units for human health impacts (CTUh) and aquatic ecotoxicity (CTUe). A perennial challenge in greenhouse gas (GHG) emissions accounting and the development of strategies to reduce the risks and impacts of climate change is the need to compare the relative impacts of different GHGs and other sources of radiative forcing (RF). There is, of course, no absolute equivalence in climate impact between different GHGs, as they each vary in atmospheric lifetime and radiative efficiency. This is reflected in comments from the IPCC pertaining to the goal of stabilizing the climate, expressed in the Paris Agreement [8]. “Stabilizing the climate will require strong, rapid, and sustained reductions in greenhouse gas emissions, and reaching net zero CO_2 emissions” [9]. This emphasis on reaching net zero CO_2 emissions relates to the very long-term impacts of these emissions, potentially lasting millennia [10,11]. The IPCC further states that, “Limiting other greenhouse gases and air pollutants, especially methane, could have benefits for both health and the climate” [9]. In contrast, methane is known as a short-lived climate forcer [12] with an atmospheric lifetime of around 12 years [13]. In the case of biogenic methane, which is produced and released by living organisms, a steady rate of emission over time can be consistent with climate stabilization [14,15].

Emission metrics are used to compare the climate impacts of diverse GHGs. Typically, the reference substance is CO_2, meaning that results are reported as CO_2 equivalent emissions. The issue is that there are many different metrics that can potentially be chosen for use, each using a different basis for equivalency (Table 1). Some metrics are based on the estimated impact over a certain interval of time, others, at a certain future point in time. What matters is that depending on the chosen metric, the relative importance of different GHGs varies. In the case of methane, metric values are reported to range from 4 to 199 kg CO_2e/kg CH_4 [16]. For organizations, industries, and territories with few non-CO_2 emissions, the choice of metric matters little. However, wherever non-CO_2 emissions are a substantial proportion of overall emissions, the choice of emissions metric can have major implications.

That said, the GWP100 emissions metric (Table 1) has become widely adopted, to the point of being almost ubiquitously applied in corporate GHG emissions accounting and product carbon footprinting programs. Furthermore, the GWP100 has been adopted as the common metric used by Parties to the Paris Agreement to report the CO_2 equivalence of GHG emissions and removals [17]. This metric has been widely critiqued [18–22], highlighting the arbitrary choice of the 100-year time horizon and lack of transparency, as emission profiles of the same CO_2 equivalence may have greatly different climate impacts over time. Even the IPCC describes GWP100 as having no special significance relative to other potential metrics [23]. Accordingly, Parties to the Paris Agreement may additionally apply other emission metrics to report supplemental information on aggregated emissions and removals, with the requirement that this information be presented as CO_2 equivalent emissions and accompanied by details about the metric values used [17]. What this amounts to is a recognition that the most appropriate metric depends on the policy and situational context [15].

In recent years, there has been considerable interest across the ruminant livestock industries in the application of alternative emission metrics [15,24,25], with the GWP* climate metric [26–36] and the radiative forcing footprint [37–40] being the primary two. With GWP*, the main difference compared with GWP100 is that pulses of long-lived GHG emissions are evaluated together with changes in the rate of emission of methane, leading to a result that is more readily interpreted in relation to potential future warming [41,42]. The RF footprint uses the same IPCC-derived equations and parameters used to calculate GWP100 metric values. However, the approach combines radiative forcing from current emissions with radiative forcing from historical emissions that remain in the atmosphere. The results can be likened to a radiative forcing balance sheet and is based on the concept of radiative forcing management. The approach is well suited to performance tracking over time, in much the same way that a corporate balance sheet carries forward from one year to the next. To date, RF footprints have been reported in the units of radiative forcing, i.e., W/m^2. The purpose of this study is to introduce a method of reporting RF footprint results as CO_2 equivalent emissions. The study uses ruminant livestock emissions in Australia for illustrative purposes.

Table 1. Examples of carbon dioxide equivalence (CO_2e).

Emissions Metric	Metric Value for Methane *	Basis of Equivalence
GWP20	84	Integral of radiative forcing over a future 20-year time horizon following a pulse emission
GWP100	28	Integral of radiative forcing over a future 100-year time horizon following a pulse emission
GTP20	67	Change in global mean temperature at a point in time 20 years following a pulse emission
GTP50	14	Change in global mean temperature at a point in time 50 years following a pulse emission
GTP100	4	Change in global mean temperature at a point in time 100 years following a pulse emission

* Metric values taken from IPCC 5th Assessment Report [23].

2. Materials and Methods

2.1. GHG Emissions Data

Greenhouse gas emissions data for the Australian beef cattle and sheep meat sectors were obtained from a recent report [43]. These data included annual emissions for the period 1990 to 2021, with emissions disaggregated by individual GHG (CO_2, N_2O, and CH_4). A lack of consistent timeseries data for other GHG emissions and non-GHG climate forcer emissions precluded their inclusion and were deemed to be of secondary importance. The emissions data used in the report [43] were primarily sourced from Australia's national GHG accounts [44], which are used to support reporting under the UNFCCC and were therefore considered to be of high quality. Detailed descriptions of the methods used to compile these accounts are available [45,46]. Additional methods and data sources are detailed in the main source document [43].

In summary, these timeseries data included emissions related to animal production on farms and on open grazing lands, finishing of cattle in feedlots, as well as domestic red meat processing. Emissions related to the processing of animals from the dairy industry were not included. Emissions related to wool production were also excluded. The types of emission sources included were ruminant enteric methane, manure management, agricultural soils, liming, and urea application. Also included were emissions related to electricity and fuel use, as well as constructed water body methane. Finally, the data included land use, land use change, and forestry (LULUCF) GHG emissions and sequestrations that were related to the activity of beef cattle and sheep production. These included emissions arising from cropland used to grow feedlot rations, as well as emissions and sequestrations related to grasslands and forestland used for livestock production. In Australia, livestock production occurs in a diverse range of agricultural contexts, including managed pastures, native pastures, open woodlands, and rangelands. The emission inventories for the year 2021 are presented in Table 2 for beef cattle and Table 3 for sheep meat.

Table 2. Disaggregated GHG emissions inventory for the Australian beef cattle sector in 2021.

Emission Source	CO_2 kt	CH_4 kt	N_2O kt
Enteric fermentation		1213.5	
Manure management		110.0	1.1
Agricultural soils—fertilizer to pasture			3.1
Agricultural soils—urine and dung			7.1
Agricultural soils—cropping			0.8
Agricultural soils—pasture residue			4.2
Field burning of agricultural residues		0.4	<0.1
Liming	237.3		
Urea applications	158.9		
Electricity, fuel	1748.4		
LULUCF—cropland	181.7	<0.1	<0.1
LULUCF—grassland	8998.1	141.1	5.2
LULUCF—forestland	−34,191.7	84.9	1.9
Constructed water body methane		18.4	
TOTAL	**−22,867.4**	**1568.4**	**23.5**

Table 3. Disaggregated GHG emissions inventory for the Australian sheep meat sector in 2021.

Emission Source	CO_2 kt	CH_4 kt	N_2O kt
Enteric fermentation		277.9	
Manure management		14.1	
Agricultural soils—fertilizer to pasture			0.7
Agricultural soils—urine and dung			2.5
Agricultural soils—pasture residue			1.0
Liming	105.5		
Urea applications	53.0		
Electricity, fuel	685.1		
LULUCF—grassland	2282.9	21.2	0.9
LULUCF—forestland	−10,371.9	21.1	0.5
Constructed water body methane		4.4	
TOTAL	**−7245.5**	**338.7**	**5.6**

2.2. Qunatifying Radiative Forcing (RF) Footprints

Radiative forcing footprints report RF from current-year emissions together with the RF from historical emissions that remain in the atmosphere [37,38,40]. In this study, the analysis timeframe was from 1990, the earliest year for which consistent GHG emissions information was available, as described above [44]. The RF profiles across time associated with pulse emissions of CO_2, N_2O, and CH_4 were calculated using parameters and equations obtained from both the IPCC 5th and IPCC 6th Assessment Reports [47]. These are the same parameters and equations used to calculate the global warming potentials reported in [13,23] and therefore share the same model uncertainty. Emission metrics from the IPCC 5th Assessment Report are currently the more commonly used in national and corporate GHG emissions reporting [17]. Parameters and equations from both the IPCC 5th and 6th Assessment Reports were used in this study for completeness and to enable evaluation of the sensitivity of results to choice of emissions model. Annual RF footprints were expressed in the unit of milliwatts per square meter (mW/m^2). The profile of RF over time provides important information relevant to RF management activities that are aligned to climate stabilization goals. Annual changes in RF footprint (RF in year t—RF in year $t-1$) were expressed in the units mW/m^2 and as CO_2 equivalent emissions by dividing the result obtained in mW/m^2 by the radiative efficiency of CO_2 (Table 4).

Table 4. Radiative efficiency values for carbon dioxide used in this study.

Radiative Efficiency	$W/m^2/ppb$	$W/m^2/kg$
IPCC 5th Assessment Report	1.37×10^{-05} [1]	1.76×10^{-15}
IPCC 6th Assessment Report	1.33×10^{-05} [2]	1.70×10^{-15}

[1] Source [23], [2] source [13].

2.3. Product-Level Analysis

To derive product-level RF footprints, annual changes in sector-level RF footprints were divided by annual production expressed as animal live weight (LW) and as edible bone-free meat. Annual production (LW) was compiled from national statistics [48,49]. To estimate production of edible bone-free meat, a product fraction of 0.35 was used for beef (i.e., edible bone-free meat was 35% of animal LW) and 0.30 for sheep/lamb meat. Economic value was used to allocate the RF footprint between meat production and other nonmeat coproducts, with a value fraction for meat of 0.83, as reported elsewhere [34]. For comparison, product level footprints were also calculated using the GWP100 emissions metric and using the same product and value fractions.

3. Results

For the Australian beef cattle industry, the RF footprint reached a peak in 2018 at 6.02 mW/m^2 when parameters and equations from the IPCC 5th Assessment Report were used (Figure 1A). However, by 2021, the RF footprint decreased to 5.91 mW/m^2, a level similar to that in 2014 (Figure 1A). This indicates that the Australian beef cattle industry has not made an incremental contribution to global radiative forcing since about this time. Historical CH_4 emissions made the single largest contribution to the RF footprint, followed by historical CO_2 emissions (Figure 1A). In 2021, the Australian beef cattle industry actually sequestered more CO_2 than it emitted, largely due to vegetation growth across open forestlands used for grazing, supported by favorable rainfall patterns (Table 2). However, across the years since 1990, emissions of CO_2 have typically exceeded sequestrations. Historical emissions of CO_2 and N_2O are critically important to the RF footprint, since they have a long atmospheric lifetime and they accumulate over time. Over the past 10 years, annual changes in RF footprint of the Australian beef cattle industry have varied from +0.09 to −0.06 mW/m^2 (Figure 1B). Expressed as CO_2 equivalent emissions, these annual changes ranged from +51.8 to −31.7 Mt CO_2e (Figure 1C). A similar pattern of results was obtained when parameters and equations from the IPCC 6th Assessment Report were used to calculate RF footprints (Figure 2A–C). The primary difference was that the results were marginally lower. In 2018, the RF footprint peaked at 5.60 mW/m^2 and declined to 5.49 mW/m^2 in 2021, with an annual change that year of −0.06 mW/m^2 or −33.6 Mt CO_2e.

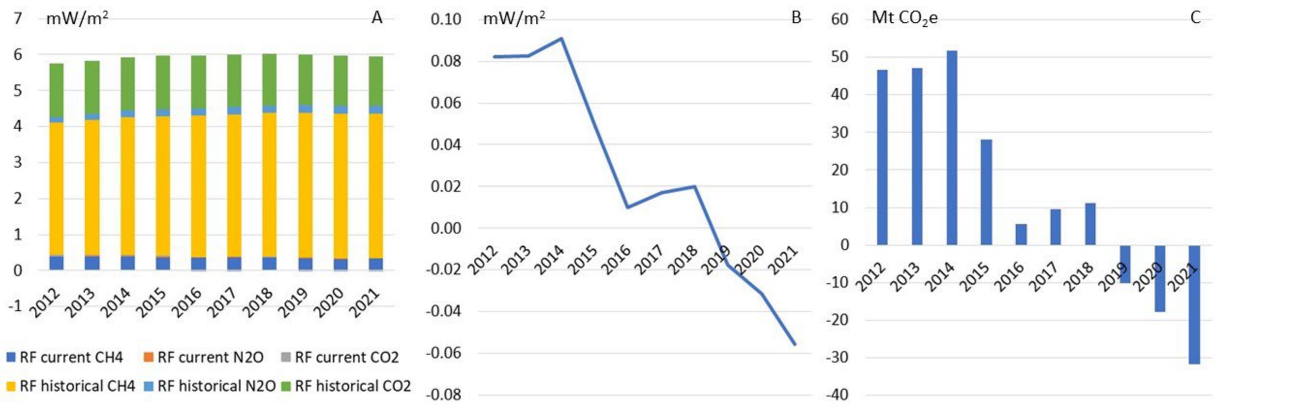

Figure 1. Australian beef cattle industry radiative forcing (RF) footprint (**A**) and annual change in RF footprint expressed in the units mW/m^2 (**B**) and as carbon dioxide equivalent emissions (**C**). Calculations based on models and parameters from the IPCC 5th Assessment Report.

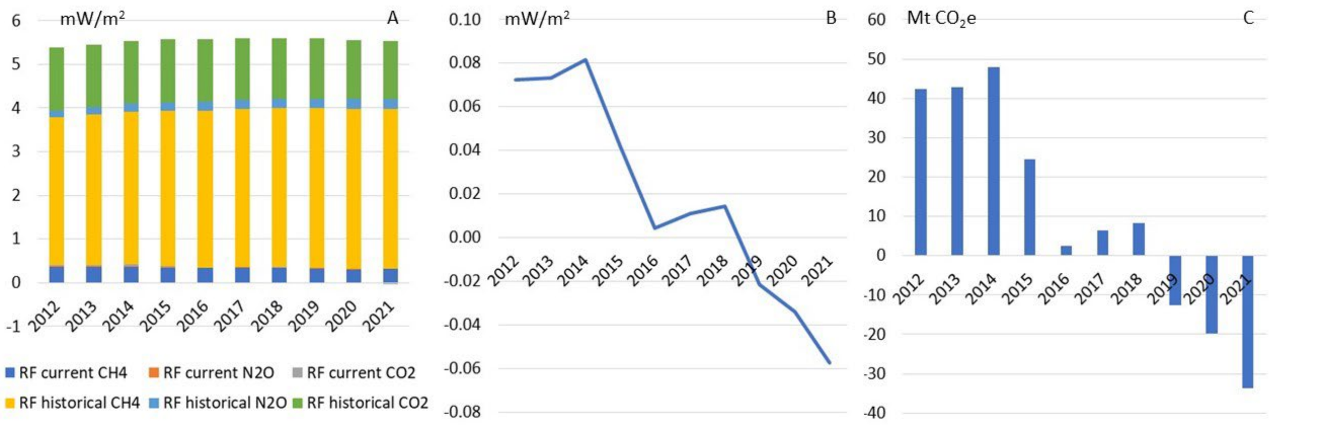

Figure 2. Australian beef cattle industry radiative forcing (RF) footprint (**A**) and annual change in RF footprint expressed in the units mW/m^2 (**B**) and as carbon dioxide equivalent emissions (**C**). Calculations based on models and parameters from the IPCC 6th Assessment Report.

Considering the Australian sheep meat sector, the RF footprint was more or less stable over the period 2012 to 2016 at 1.12 mW/m^2 using parameters and equations from the IPCC 5th Assessment Report (Figure 3A). From this time onward, the RF footprint has been in decline, reaching 1.07 mW/m^2 in 2021. While the Australian sheep meat sector has made an historical contribution to global RF, over the past decade, this contribution has not been added to and has marginally receded. As was the case for the Australian beef cattle industry, historical methane emissions made, by far, the largest contribution to the RF footprint of the Australian sheep meat industry. In 2021, there was also greater sequestration of CO_2 than emission (Table 3). For 7 of the past 10 years, the annual change in RF footprint has been negative, ranging between +0.006 and −0.014 mW/m^2 (Figure 3B). Expressed as CO_2 equivalent emissions, these annual changes ranged from +3.7 to −8.0 Mt CO_2e (Figure 3C). Using parameters and equations from the IPCC 6th Assessment Report to calculate the RF footprint, a similar pattern of results was obtained (Figure 4A–C).

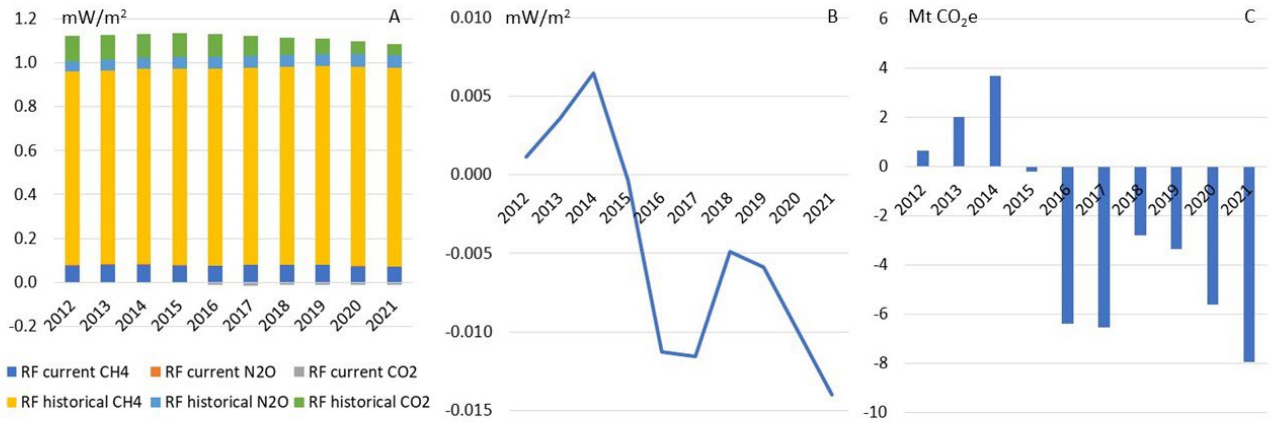

Figure 3. Australian sheep meat industry radiative forcing (RF) footprint (**A**) and annual change in RF footprint expressed in the units mW/m^2 (**B**) and as carbon dioxide equivalent emissions (**C**). Calculations based on models and parameters from the IPCC 5th Assessment Report.

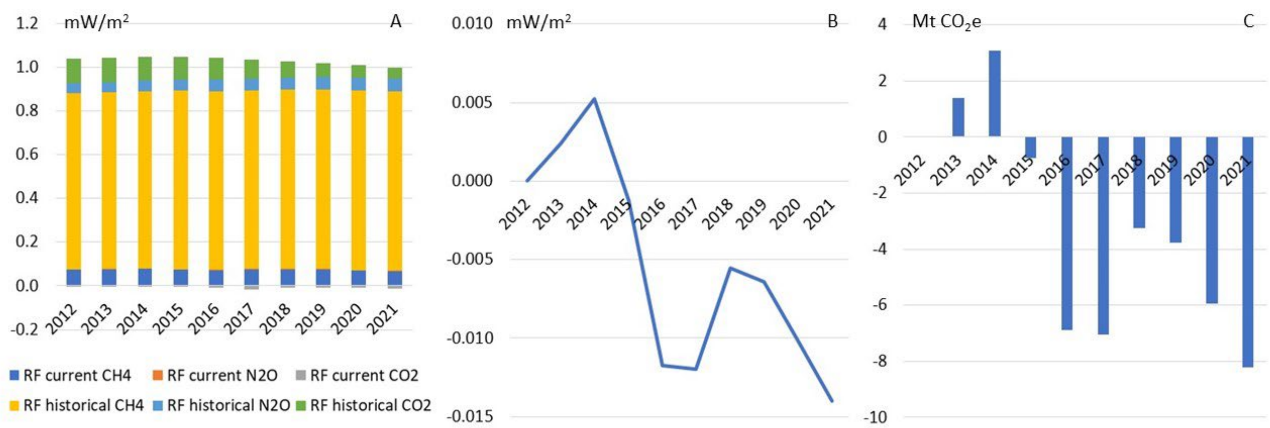

Figure 4. Australian sheep meat industry radiative forcing (RF) footprint (**A**) and annual change in RF footprint expressed in the units mW/m^2 (**B**) and as carbon dioxide equivalent emissions (**C**). Calculations based on models and parameters from the IPCC 6th Assessment Report.

The sector-level RF footprints were also expressed at the product level (Table 5). With the Australian beef cattle sector, the change in RF footprint in 2021 was negative (Figure 1), so negative results also accrued at the product level, i.e., −7.5 kg CO_2e per kg live weight and −17.7 kg CO_2e per kg edible bone-free meat (Table 3). Likewise, in 2021, the change in RF footprint of the Australian sheep meat sector was negative (Figure 3). Therefore, results at the product level were also negative (Table 5). These results reflect that these products come from industries that have reduced their absolute contribution to global RF increase compared with the year before. These results contrast starkly with those obtained with the GWP100 emission metric, which are based exclusively on the current year emissions without considering the historical context. The point that is highlighted is that results are highly dependent on the modelling choices that are made to aggregate GHG emissions and express them as CO_2 equivalent emissions. When parameters and equations from the IPCC 6th Assessment Report were used, results were marginally lower for both the GWP100 emissions metric and the RF footprint.

Table 5. Greenhouse gas emissions for the Australian beef cattle and sheep meat sectors in 2021 assessed using the GWP100 climate metric and radiative forcing (RF) footprint. Results are shown based on models and parameters from the IPCC 5th and 6th Assessment Reports.

		GWP100		RF Footprint	
		AR5	**AR6**	**AR5**	**AR6**
Beef cattle	Sector (Mt CO_2e)	27.3	25.9	−31.7	−33.6
	Product (kg CO_2e/kg LW) [1]	6.4	6.1	−7.5	−7.9
	Product (kg CO_2e/kg edible) [2]	15.2	14.4	−17.7	−18.7
Sheep meat	Sector (Mt CO_2e)	3.73	3.44	−8.0	−8.2
	Product (kg CO_2e/kg LW)	2.5	2.3	−5.2	−5.4
	Product (kg CO_2e/kg edible)	6.8	6.3	−14.5	−15.0

[1] LW: Animal live weight, [2] Bone-free meat.

4. Discussion

The purpose of this communication was to demonstrate the reporting of RF footprint results as CO_2 equivalent emissions. There are several advantages in using CO_2 equivalent units. First, there is familiarity among policymakers and across the broader community, as GHG emissions information is usually communicated in these units. The units of radiative forcing (W/m^2) or of temperature change measured in K are much less familiar. Second, there is an aspect of simplicity. There are numerous GHGs, and it can be an aid to communication when emissions information is presented as a single term. At times, the definition of CO_2 equivalence has been closely associated with the application of global warming potentials, as described by the definition used in the glossary of the IPCC 5th Assessment Report, i.e., "The amount of carbon dioxide (CO_2) that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs" [50]. However, more recently, the IPCC has broadened the definition of CO_2 equivalence, as described in the glossary of the 6th Assessment Report, i.e., "The amount of carbon dioxide (CO_2) emission that would have an equivalent effect on a specified key measure of climate change, over a specified time horizon, as an emitted amount of another greenhouse gas (GHG) or a mixture of other GHGs" [51]. Therefore, extending the concept of CO_2 equivalence to RF footprints is entirely legitimate.

However, there are also potential problems associated with the reporting of GHG emissions information as CO_2 equivalent emissions. As mentioned in the Introduction, there is no absolute equivalence in climate impact between different GHGs, meaning that equivalence can be established only based on selected criteria. As such, the IPCC warns that CO_2 equivalent expressions should not be taken to imply that there is an equivalent effect across all key measures of climate change [51]. Indeed, depending on the chosen metric used to calculate equivalence, the relative importance of different GHGs can vary greatly (Table 1). Accordingly, there is a loss of transparency [19,52–54], biases may not always be evident [55], and there is a need for explanation as to why a particular basis for equivalency has been chosen [18] and how the results should be interpreted [56,57]. These matters are most important because common GWP-based metrics were not developed with any particular policy goal in mind [17], and there is potential for cherry-picking metrics to suit a political perspective or vested interest [18,20].

RF footprints quantify radiative forcing from current-year emissions together with radiative forcing from historical emissions that remain in the atmosphere. They are the radiative forcing equivalent of a financial balance sheet. As such, they support the management of radiative forcing to align with climate stabilization goals. An important benefit of the RF footprint approach is that there is an indefinite time perspective, avoiding the need for an arbitrary choice, which can greatly influence results and conclusions about priorities for climate action. When comparing successive annual RF footprints, the incremental increase or reduction in contribution to global radiative forcing is described. Previously, RF footprint results have been reported in the units of radiative forcing (W/m^2) [37–40]. However, the change in RF can also be expressed as CO_2 equivalent emissions using the radiative efficiency value for CO_2 (Table 4). This can be interpreted as the amount of CO_2 emission (or sequestration) in the current year that would have an equivalent addition to (or reduction in) the entity's RF footprint. In the case of the Australian beef cattle sector, the RF footprint in 2021 was 0.06 mW/m^2 lower than the previous year, equivalent to a net negative CO_2 emission of 31.7 Mt CO_2 (Figure 1). For the Australian sheep meat sector, the RF footprint in 2021 was 0.014 mW/m^2 lower than the previous year, equivalent to a net negative CO_2 emission of 8.0 Mt CO_2 (Figure 3).

RF footprints have previously been quantified for the Australian red meat sector [38,40]. These studies covered earlier time periods, up to 2017 and 2020, respectively. The results of the present study are not directly comparable for two reasons. First, there are differences in system boundary, such as the omission of LULUCF emissions in [38] and the omission of methane emissions from constructed water bodies in [40]. As such, the present study has included a more comprehensive range of emission sources. Second, the underpinning timeseries of GHG emissions obtained from the national accounts [44] is retrospectively revised whenever there are methodological improvements [45,46]. This is to ensure that the timeseries reflects changes in emissions and not changes in accounting methodology. However, that said, the overall conclusions are very consistent, showing a plateauing of RF footprints for both the Australian beef cattle and sheep meat sectors in the recent past, which has the potential to be maintained with ongoing RF management by the industry [38]. The present study confirms that both the Australian beef cattle and sheep meat sectors have for at least the past 3 years been carbon positive (CO_2 sequestrations exceeding CO_2 emissions) and climate neutral (making no incremental contribution to global radiative forcing). Climate neutral is a term that has begun to be used in situations where an industry makes no net contribution to additional temperature increase or no net contribution to increase in radiative forcing [15,58].

It is also possible to express GHG emissions information at the product level to inform sustainable procurement and consumption strategies, as per Sustainable Development Goal 12 [59], and to raise consumer awareness generally [60]. The typical approach involves dividing a system's emissions by the system's output, thereby deriving an average per unit of production. This was the approach that was used in this study (Table 5). This approach does not consider nonlinearity and does not express the marginal change in GHG emissions associated with one additional unit of production [61]. Methods with these attributes are available; however, data availability usually precludes their use, and this is not always relevant information. As shown in Table 5, product-level RF footprint results for Australian beef and lamb differ profoundly from those quantified using the GWP100 emissions metric. These differences highlight the importance of understanding how CO_2 equivalent emissions information has been calculated and how the information can be interpreted. In the case of RF footprints, the product-level results for Australian beef and lamb communicate that these products have been produced by agricultural systems that in the past year have managed their cumulative historical contribution to global RF downward. Regarding results obtained using the GWP100 climate metric, there is a technical definition, i.e., the integral of radiative forcing over a future 100-year horizon and ignoring past contributions. However, it is unclear what is the practical interpretation of this information as it does not differentiate the near- and far-term implications.

It could be argued that RF footprints convey information only about present and temporary stabilization of RF [62]. However, it has never been suggested that ongoing radiative forcing management will not be necessary. The same applies to claims of carbon neutrality, GHG neutrality, or net zero based on the GWP100 climate metric. These apply to an entity's achievement only during the assessment period. Ongoing GHG emissions management will be needed, or ongoing investment in offsets will be necessary to sustain such claims in future. It could also be argued that it is confusing to report CO_2 equivalent emissions using a variety of emission metrics. However, this is already the situation (Table 1), and the definition of CO_2 equivalence in the IPCC 6th Assessment Report makes possible the use of a variety of measures of climate impact [51]. It could equally be argued that it is beneficial to have alternative measures of CO_2 equivalence used more broadly. This would help to ensure that relevant measures are used according to the decision-making context. This might also help to overcome complacency, whereby results obtained with the GWP100 emission metric are used without understanding of meaning and awareness of limitations. As such, it is concluded that a method to report RF footprints using CO_2 equivalent units, as demonstrated in this paper, is timely and valuable.

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Data Availability Statement: All data used in this study are available from the cited sources. Radiative forcing footprints were quantified using parameters and equations publicly available in the IPCC 5th and 6th Assessment Reports.

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Conflicts of Interest: The author has previously undertaken food systems research addressing environmental issues for a variety of private sector organizations and Australian government agencies. This includes Dairy Australia, Meat and Livestock Australia, and the Australian Meat Processor Corporation. The author has never been employed in these organizations. The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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