SFOC
Solutions for Our Climate

Report

From Farm to Retail:

A Life Cycle Assessment of Meat Consumption in South Korea

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Solutions for Our Climate(SFOC) is an independent policy research and advocacy group that aims to make emissions trajectories across Asia compatible with the Paris Agreement 1.5°C warming target.

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Introduction

Meat consumption has become an inseparable part of the Korean diet, accounting for a significant portion of the daily caloric intake. However, the information available to consumers at the point of purchase is limited to price and origin. This creates an information asymmetry regarding carbon intensity of the meat products. Although the livestock industry accounts for approximately 26% of global agri-food greenhouse gas (GHG) emissions (FAO, 2023), the lack of transparency obscures environmental consequences of individual dietary choices.

This study seeks to address this information gap by providing intuitive, consumer-oriented carbon emissions for meat products. While conventional emission measurements focused primarily on the farming stage, this research calculates the carbon footprint per kilogram of the final meat product to quantify the climate implications of consumer dietary choices.

To ensure the methodological rigor, this study applies a Life Cycle Assessment (LCA) framework with a 'Cradle-to-Retail' system boundary, encompassing farming, slaughtering, processing, and distribution. This provides a systematic analysis across the entire process, from meat production to its arrival at the final consumer. The analysis covers both domestically produced livestock products and imported beef from major exporting countries—United States, Australia, and New Zealand—to quantify the specific emissions profiles of imported meat consumption.

The findings reveal a significant disparity across meat types: the carbon footprint of beef is overwhelmingly higher than that of pork or chicken. 1 kg of beef generates approximately 58.15 kg CO_2-eq, which is approximately 4.4 times higher than pork and 10.8 times higher than chicken.

Furthermore, this study confirms that South Korea's annual per capita meat consumption is among the highest in its East Asian neighbors. It is particularly noteworthy that, among South Korea, China, and Japan, South Korea has the most active beef consumption. As of 2024, imported beef accounts for approximately 60% domestic supply, with annual imports exceeding 420,000 tons. The resulting GHG emissions are estimated to reach approximately 12.5 Mt CO_2-eq per year. The findings suggest that Korea's beef-heavy consumption patterns represent a significant source of national-scale emissions.

It should be noted, however, the Life Cycle Inventory (LCI) database for calculating livestock GHG emissions in Korea remains limited. Standardized national LCI data—such as environmental data based on the feed origin or energy efficiency during domestic processing—remain largely insufficient.

To address these limitations, this study utilized data from international literature and adopted a conservative assumptions to avoid overestimation. Therefore, the emission figures presented in the study should be interpreted as ‘minimum estimates’ representing the lower bound of actual environmental burden.

I. The Gap in Carbon Transparency within Meat Consumption

1.1. The Livestock Sector and Climate Change

According to the Food and Agriculture Organization of the United Nations (FAO), global greenhouse gas (GHG) emissions from agri-food systems reached approximately 16.5 billion tons CO_2-eq as of 2023, with the livestock sector alone accounting for 26%, or 4.3 billion tons CO_2-eq (FAO, 2023) of that total.

In 2023, total GHG emissions from South Korea's agricultural sector reached 22.54 Mt CO_2-eq (Greenhouse Gas Inventory & Research Center of Korea (GGIRCK), 2025). Within the agricultural sector, livestock emissions account for 43%, (12.72 Mt CO_2-eq), with over half attributed to enteric fermentation in cattle. Ruminants, like cattle, possess a unique digestive system with four stomachs, that produce methane (CH_4) during the rumination process. Methane is a potent greenhouse gas with a Global Warming Potential (GWP) more than 28 times higher than that of CO_2 (GGIRCK, 2025). Therefore, the rearing of ruminants entails the release of highly intensive GHGs, making beef consumption more carbon-intensive than other types of meat products.

1.2. Blind Spots in Consumer-Centric Data

Current GHG statistics in South Korea are predominately limited to ‘Cradle-to-Gate’, focusing only on direct emissions from farms. This narrow scope fails to capture the actual carbon emissions of the meat products consumers encounter at the retail level. Actual emissions should be a comprehensive figure that includes GHG emissions from the entire ‘Post-Gate’ process, including farming, slaughtering, processing, and logistics.

However, because post-gate emissions are currently distributed across various sectors such as industry, transportation, and energy, it is nearly impossible to identify the carbon footprint of an individual meat product. This fragmented reporting structure creates an information asymmetry, acting as a barrier for consumers trying to understand their environmental impact of the final purchases.
In particular, given that South Korea relies on imports for about 60% of its beef consumption, it is imperative to quantify emissions across the global supply chain, from overseas production sites to domestic point of sale.

To address these shortcomings, this study utilizes Life Cycle Assessment (LCA) methodology, an international standard for quantifying the environmental impacts of a product throughout its entire life cycle—from raw material extraction to disposal. By establishing a 'Cradle-to-Retail' system boundary, this report eliminates the blind spots inherent in existing emission data that focuses primarily on the farming stage. Moreover, this study expands its scope by including supply chain carbon emissions from major beef-exporting countries with significant market shares in Korea, such as the United States, Australia, and New Zealand.

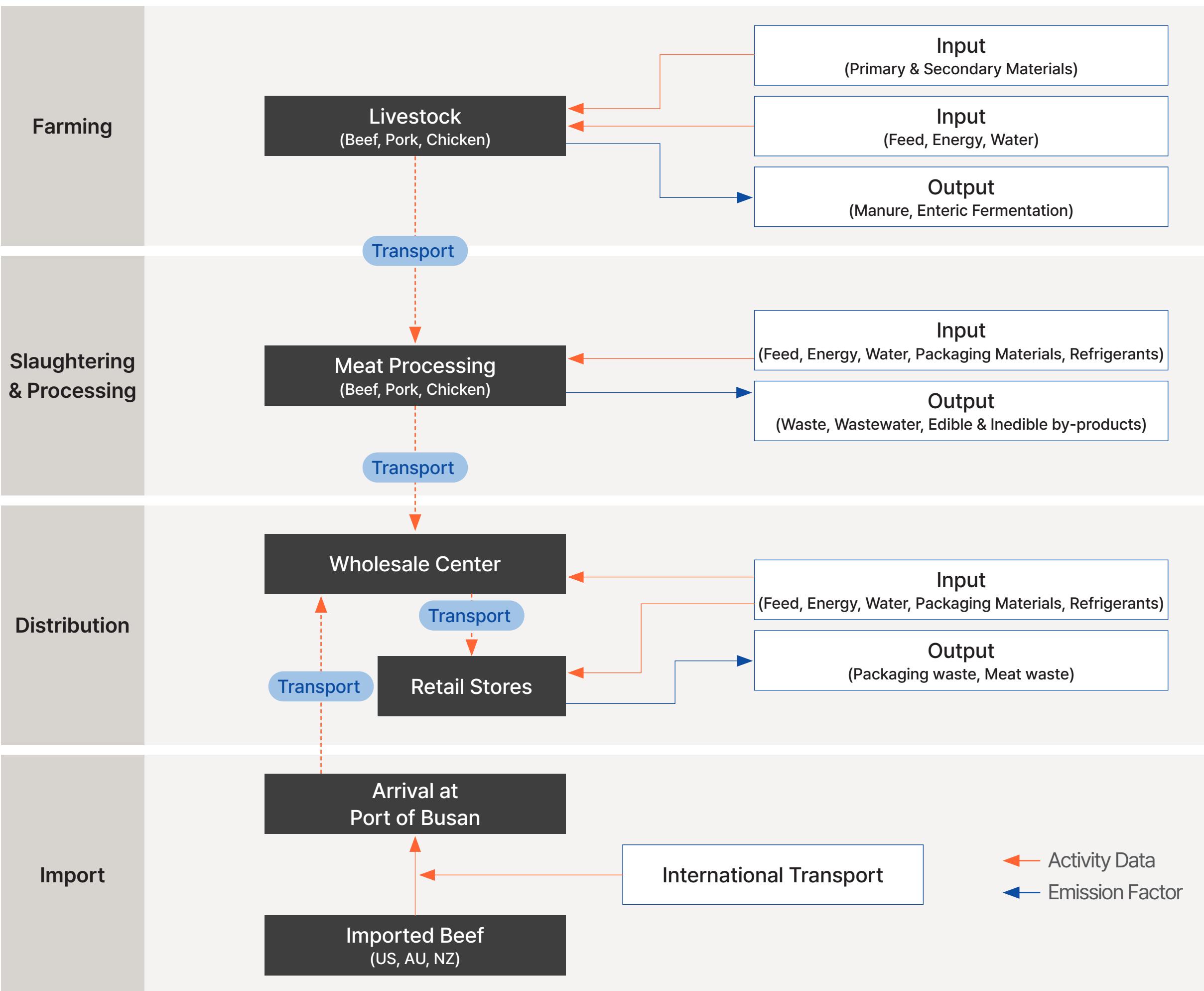
The emission data derived through this LCA study serves as more than just a quantitative figure; it is a tool to visualize climate responsibility for consumers when making dietary choices. Ultimately, the objective of this study is to reveal the 'invisible carbon' of meat products and enable consumers to make sustainable decisions based on environmental impact alongside price and quality.

II. Carbon Footprint Analysis by Meat Product

2.1. Methodology

As outlined in Chapter 1, this study utilizes the Life Cycle Assessment (LCA) methodology to examine the cumulative GHG emissions across the domestic meat supply chain. The scope of the analysis follows the 'Cradle-to-Retail' system boundary (see Diagram 2-1), spanning from the initial farming to the final retail distribution. Detailed methods, including specific calculation formulas and the use of LCI databases, are provided in the Appendix.

[Diagram 2-1] Estimation Scope of GHG Emissions from Domestic Meat Consumption: From Farm Production to Distribution (Cradle-to-Retail)



Source : Complied National Institute of Animal Science (2015)
Development of Carbon-Reduction Livestock Distribution Technology in Response to Global Warming

To provide consumers with intuitive and comparable indicators, the functional unit is defined as **'carbon footprint per kilogram of meat (kg CO_2-eq/kg)'**.

Calculating emissions for livestock is inherently complex due to the 'multiple-output' nature of the production process, in which meat is produced alongside various by-products such as organs and leather, and compost. When multiple types of outputs are produced from a single process, the problem of allocation arises, as the final results vary depending on the criteria used to divide the total GHG emissions among products.

Inputs used during livestock rearing, such as feed and energy, contribute to the growth of the animal as a whole rather than specific meat cuts. In light of this, this study distributed total emissions from resource use proportionally based on the total weight of meat produced. Given the limitations in domestic data infrastructure, it remains difficult to disaggregate the environmental load by individual cut. Consequently, a mass-based allocation method was adopted as an alternative, ensuring methodological consistency under existing data constraints. **Therefore, the results presented in this study represent the average climate impact per kilogarm of meat, regardless of the specific cut, such as sirloin or tenderloin.**

2.2. Comparative Analysis of Emissions by Meat Type

The analysis revealed a very distinct gap in carbon emissions across livestock categories, with beef recording overwhelmingly high figures than pork and chicken.

A. Beef: High Carbon Intensity

Based on the average rearing period for Hanwoo (approximately 30 months), the emissions per kilogram of beef were quantified at 58.15 kg CO_2-eq.

$$CF_{Beef}(kg\ CO_2\text{-}eq/kg) = E_{farm}(57.52) + E_{processing}(0.56) + E_{distribution}(0.08) = 58.15$$

Hanwoo, a native Korean cattle breed, has a longer rearing cycle compared to other livestock and requires an substantially higher amount of cumulative feed inputs. In particular, CH_4 emissions from enteric fermentation, account for the majority of total emissions, reflecting the inherent characteristics of ruminant livestock.

B. Pork: Moderate Emission Profile

With an average rearing period of 180 days, GHG emissions per kilogram of pork were calculated at 13.36 kg CO_2-eq.

$$CF_{Pork}(kg\ CO_2\text{-}eq/kg) = E_{farm}(12.72) + E_{processing}(0.56) + E_{distribution}(0.08) = 13.36$$

While the rearing period for pigs is shorter than that of Hanwoo, GHGs generated during the manure management processes were identified as the primary contributors to carbon emissions.

C. Chicken: Lowest Environmental Load

With an average rearing period of approximately 32 days, GHG emissions per kilogram of chicken were calculated at about 5.36 kg CO_2-eq.

$$CF_{Chicken}(kg\ CO_2\text{-}eq/kg) = E_{farm}(4.66) + E_{processing}(0.66) + E_{distribution}(0.04) = 5.36$$

The species is characterized by superior Feed Conversion Ratio (FCR) and rapid growth cycle, requiring the least resource input per kilogram of meat produced.

2.3. Key Findings and Implications

A. Tenfold Disparity in Emissions

The results indicated that per kilogram of meat, beef emits approximately 4.4 times more GHGs than pork and about 10.8 times more than chicken. Notably, the production stage—farming—was found to account for 85% to 99% of total emissions across all three categories. This suggests that to reduce GHG emissions in the livestock sector, strategies at the production site—improving FCR and adopting low-carbon feed—are key levers to mitigate emissions.

[Table 2-1] GHG Emissions and Contributions by Stage for Major Domestic Livestock Products

(Unit: kg CO_2-eq/kg)

Category	Production (Live weight at the farm)	Slaughtering	Distribution (Processing Plant → Retail Store)	Total
Beef	57.52	0.56	0.08	58.15
	(98.9%)	(1.0%)	(0.1%)	(100%)
Pork	12.72	0.56	0.08	13.36
	(95.2%)	(4.2%)	(0.6%)	(100%)
Chicken	4.66	0.66	0.04	5.36
	(86.9%)	(12.3%)	(0.7%)	(100%)

Source: Compiled by the author based on the analysis results of this study

Note: Calculated based on the Life Cycle Inventory (LCI) data and Life Cycle Impact Assessment (LCIA) methodology for each meat type as described in the Appendix

B. Discrepancy Between Analysis and Actual Emissions

The analysis results presented in Table 2-1 should be viewed as **minimum estimates**. Several emission factors were excluded due to data acquisition challenges, suggesting that the actual GHG emissions generated across the supply chain are likely to be higher. The primary causes of these discrepancies are as follows:

1) Information Asymmetry across Supply Chain

South Korea's livestock GHG management system is heavily concentrated on 'Farm-Gate' stage, leaving the 'Post-Farm' stages—slaughtering, processing, and distribution—in a data blind spot. Not only is there a lack of relevant public data, but existing literature lacks consistent methodologies, creating a fragmented data landscape. This fragmentation of supply chain data results in an underestimation of actual carbon emissions at the point of final consumption, thereby widening information gap between producers and consumers.

2) Major GHG Emission Factors Excluded from the Analysis Scope

Due to limitations in data availability, the several emission factors were excluded from this study. Accordingly, the resulting emission values are should be interpreted as a conservative baseline that excludes unquantified hidden emissions.

- **Feed Supply Chain:** While Hanwoo farms are highly dependent on imported grain feed such as corn and soybean, the GHG emissions associated with overseas cultivation, processing, and long-distance maritime transport were not included.
- **Logistics and Energy:** Emissions from the transportation of live animals, refrigerant leakages throughout the distribution process, and granular energy consumption in storage facilities were excluded.
- **Natural Emission Sources:** Specific indirect factors, such as nitrous oxide (N_2O) emissions from soil due to manure application in pastures, were omitted due to lack of local LCI data.

Despite these structural constraints, this study provides significant value in integrating fragmented domestic meat supply chain data to quantify emissions within a 'consumer-centric system boundary.' The findings establish a rigorous, albeit conservative, reference point for gauging the environmental responsibility inherent in the dietary choices of consumers in South Korea.

III. Overview of Current Meat Consumption

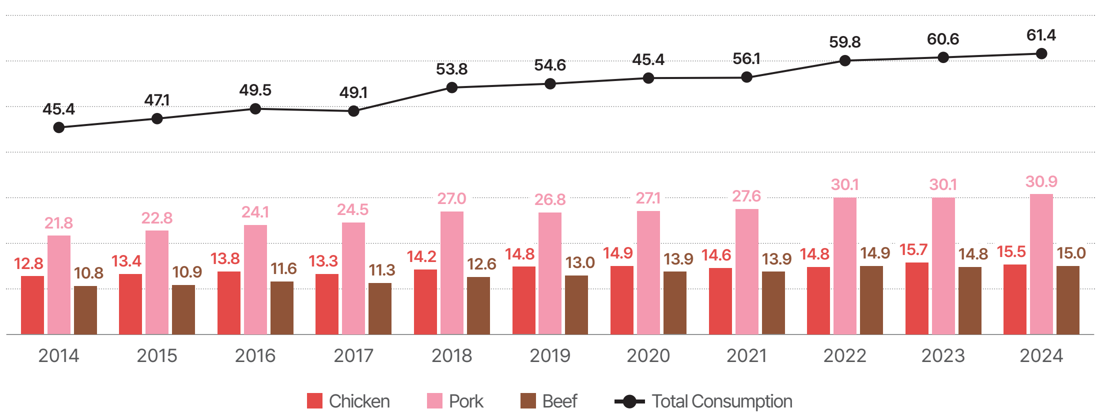
The LCA conducted in Chapter 2 quantitatively identified beef as the primary driver of GHG emissions within the meat products, as it emits an overwhelming amount of GHGs compared to other types of meat. This chapter examines the consumption patterns within the South Korean society to assess the scale of impact caused by these high-carbon sources of meat.

3.1 Comparative Analysis of Meat Consumption: Korea, China, and Japan

A. South Korea: Upward Trend in Beef and Pork Consumption

The total annual meat consumption per capita in South Korea has shown a clear upward trend over the past decade, rising from 45 kg in 2014 to 61 kg in 2024, an increase of 36%. While pork remains the primary meat source (see Figure 3-1), beef consumption has shown significant growth. Per capita beef consumption increased from 10.8 kg in 2014 to 15 kg over the same period, representing a 40% increase in demand.

[Figure 3-1] Annual Per Capita Meat Consumption in South Korea (Unit: kg)

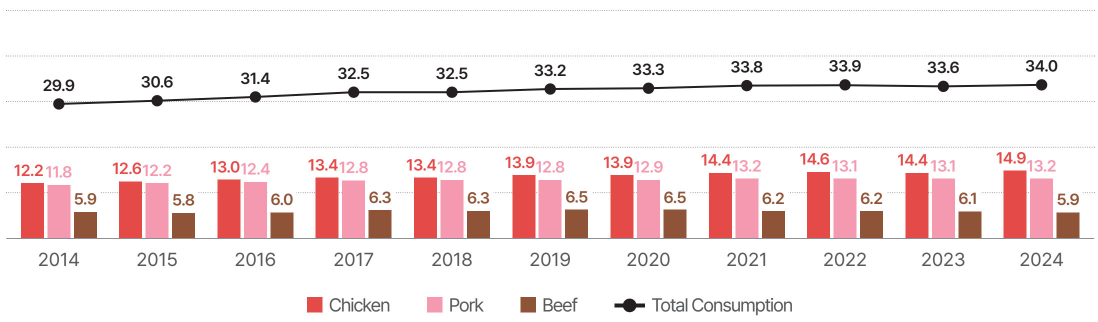


Source: Reconstructed by the author based on data from the Korea Rural Economic Institute (KREI) and the Korea Meat Trade Association (KMTA)

B. Japan: Preference for Pork and Chicken

According to data released by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, total annual meat consumption per capita rose steadily from 29.9 kg in 2014 to 34 kg in 2024. Unlike Korea, Japan's consumption is heavily weighted toward pork and chicken (see Figure 3-2). Meanwhile, annual per capita beef consumption has remained relatively stagnant at around 7 kg between 2014 and 2024.

[Figure 3-2] Annual Per Capita Meat Consumption in Japan (Unit: kg)

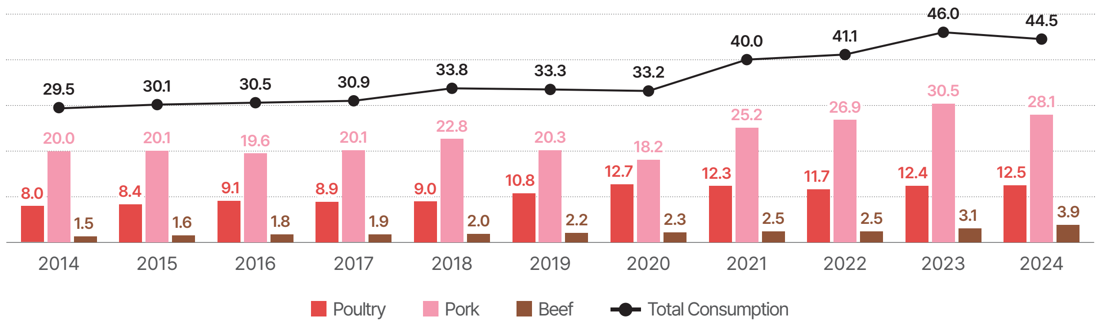


Source: Reconstructed by the author based on data from Ministry of Agriculture, Forestry, and Fisheries (MAFF) (Japan)

C. China: Dominance of Pork Consumption

Data from the National Bureau of Statistics (NBS) of China shows that annual meat consumption per capita skyrocketed from 29.5 kg in 2014 to 44.5 kg in 2024, recording a high growth rate of 50%. Similar to Korea and Japan, pork accounts for the majority of total consumption, and poultry consumption is also showing steady growth. Notably, while beef consumption remains significantly lower than that of Korea and Japan, it has shown an increasing trend, a 2.6-fold increase from 1.5 kg in 2014 to 3.9 kg in 2024. This suggests a gradual but clear shift in consumer preference toward beef.

[Figure 3-3] Annual Per Capita Meat Consumption in China (Unit: kg)



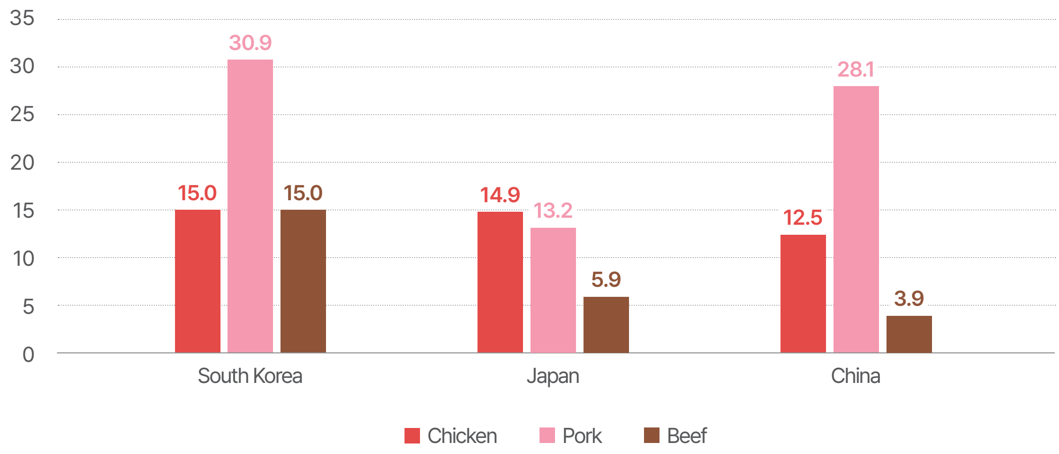
Note: Poultry includes species such as chicken, duck, and goose

Source: Reconstructed by the author based on NBS

3.2. South Korea: Regional Leader in Beef Consumption

A cross-sectional analysis of three East Asian countries in 2024 of Korea highlights distinctive characteristic in the South Korean diet. As illustrated in Figure 3-4, **South Korea's annual per capital beef consumption (15 kg) is significantly higher than its neighbors—approximately 2.5 times higher than Japan (5.9 kg) and 3.8 times higher than China (3.9 kg).**

[Figure 3-4] Comparative Analysis of Per Capita Meat Consumption: Korea, China, and Japan (2024) (Unit: kg)



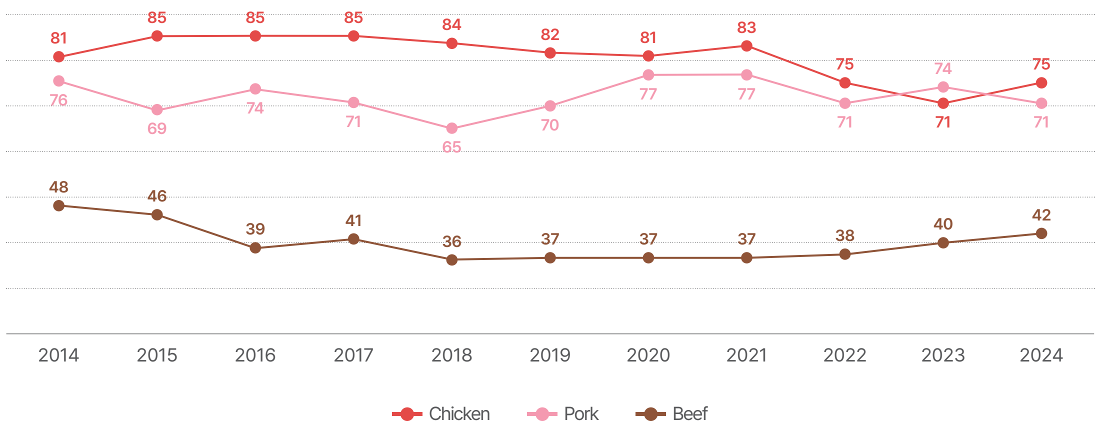
Note: China's 'chicken' category represents total poultry (e.g., chicken, duck, and goose)
Source: Reconstructed by author based on 2024 data from NBS, MAFF (Japan), and KMTA

3.3. Domestic Meat Supply and Demand Structure

A. Intensifying Import Dependency

According to the Korea Meat Trade Association (KMTA), self-sufficiency rates vary sharply by livestock category. While domestic production of chicken and pork remains relatively stable, beef shows an intensifying dependency on imports (see Figure 3-5). **Because domestic production failed to keep pace with the rapid growth in demand over the past decade, the beef self-sufficiency rate has plummeted 42% as of 2024. This has resulted in a structure where 60% of all beef consumed in Korea is imported.**

[Figure 3-5] Comparative Analysis of Meat Self-Sufficiency Rates by Type in South Korea (Unit: %)



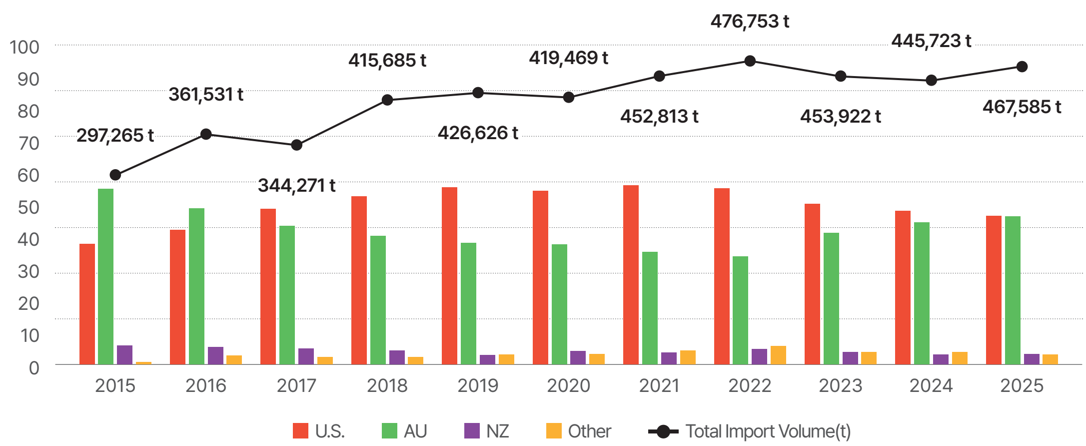
Source: Reconstructed by the author based on data from KMTA

B. Deepening Import Dependency: The U.S.-Australia Duopoly in Korea

South Korea has emerged as the leading beef consumer among East Asian nations, including Chian and Japan. However, as domestic production has failed to keep pace with this accelerating demand, the self-sufficiency rate for beef has fallen to the lowest among major livestock categories. Consequently, a structure heavily reliant on imported beef has been established to satisfy domestic demand.

This persistent imbalance between domestic supply and demand has driven import volumes to record highs. Since 2015, the scale of import volumes has steadily increased, recently exceeding 460,000 tons per year (see Figure 3-6). While the market was historically dominated by U.S. beef, the landscape is undergoing a significant supply chain reorganization due to the rapid market penetration of Australian products. As of 2025, the U.S. and Australia each account for approximately 47% of the market, effectively establishing a duopoly between these two exporters.

[Figure 3-6] Beef Import and Market Share by Country in Korea (Unit: %)



Source: Reconstructed by the author based on data from KMTA

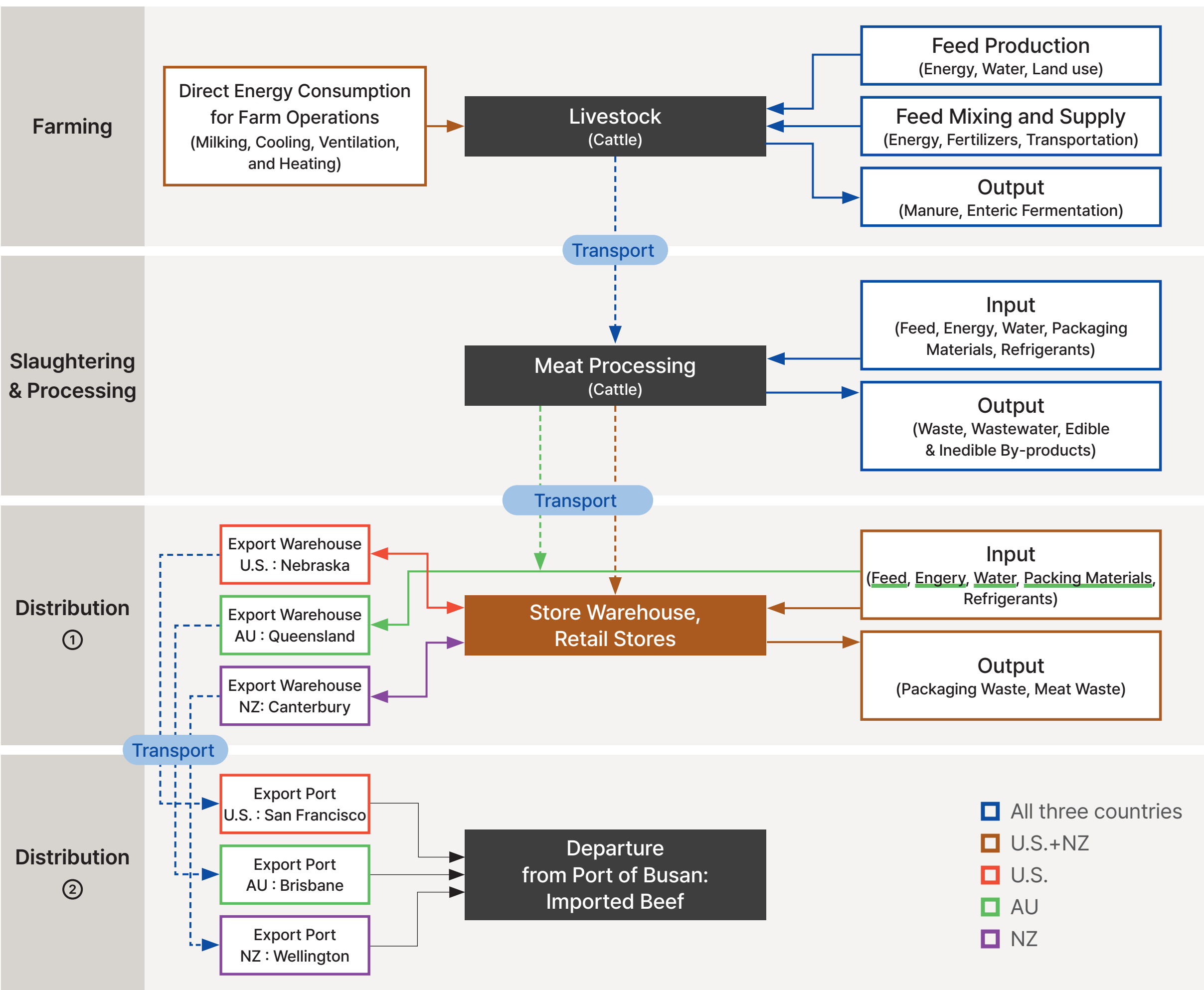
IV. Analysis of GHG Emissions from Imported Beef by Origin

4.1. Analysis Overview

Chapter 3 identified that imported beef accounts for 60% of South Korea's total consumption. Thus, an LCA limited to domestic production provides an incomplete picture of the total GHG emissions driven by domestic meat consumption.

To address this, this chapter conducts an LCA for the three major exporters—the United States, Australia, and New Zealand—which collectively hold over 90% of the Korean import market. This analysis utilizes existing international literature, and the system boundary follows a 'Cradle-to-Retail' framework (see Diagram 4-1), encompassing the rearing, international maritime logistics (e.g. Export Port → Busan Port) and domestic distribution. The calculation metric is set as the carbon footprint per kilogram of meat at the retail level. Detailed LCI data and the step-by-step methodologies used in the analysis are documented in the Appendix.

[Diagram 4-1] System Boundary for Imported Beef: Cradle-to-Retail GHG Emission Accounting Scope



Source : Complied from Asem-Hiablieet al., 2018; Wiedemann et al., 2015,; Mazzettoet al., 2023

4.2. Comparative Carbon Footprint Results of Imported Beef by Country

The findings reveal that GHG emissions for imported beef are the highest for the United States, followed by Australia and New Zealand. These disparities are primarily driven by nation-specific rearing methodologies and feeding systems.

A. U.S. Beef: High Carbon Intensity

The U.S. utilizes a system that enables shipment within a short rearing period of approximately 16 months. This system consists of initial pasture grazing, followed by hay and by-product feeding, and intensive grain feeding in the finishing stage. Based on data from Nebraska-based production cycles, the total lifecycle emissions per kilogram of beef were quantified at 32.05 kg CO_2-eq.

$$CF_{US\ Beef}(kg\ CO_2\text{-}eq/kg) = E_{farm}(30.67) + E_{processing}(0.59) + E_{distribution}(0.79) = 32.05$$

B. Australian Beef: Moderate Emissions

Australian production typically involves initial pasture grazing followed by varying durations of grain fattening: categorized as mid-term (approximately 115 days) or long-term (approximately 330 days). Based on this production system, the GHG emissions across the supply chain—from farms in Queensland, a major beef-exporting, through the Port of Brisbane and the to Busan—were estimated at 26.82 kg CO_2-eq per kilogram of beef.

$$CF_{AU\ Beef}(kg\ CO_2\text{-}eq/kg)= E_{farm}(25.49) + E_{processing}(0.98) + E_{distribution}(0.35) = 26.82$$

C. New Zealand Beef: Low-Carbon Emissions

New Zealand employs a mixed cattle-sheep farming system that relies on pasture grazing for over 95% of its feed. While the rearing period of 28.5 month is longer than those of the U.S. and Australia, the minimal use of processed concentrates effectively lowers the production-stage emissions. The total GHG emissions across the supply chain from Canterbury to South Korea were found to be 20.51 kg CO_2-eq for kilogram of beef.

$$CF_{NZ\ Beef}(kg\ CO_2\text{-}eq/kg)= E_{farm}(19.71) + E_{processimg}(0.52) + E_{distribution}(0.\ 28) = 20.51$$

D. Production-Dominant Emission Structure

The analysis of life cycle emissions for imported beef revealed that, across all countries, the farm-level stage accounts for over 95% of total emissions. In contrast, the contributions from the slaughtering, processing, and international transportation stages were found to be relatively negligible. This result is very similar to the emission structure observed in domestic meat (see Table 2-1), suggesting that the most effective strategy for reducing GHG emissions in the livestock sector lies in farm-level livestock management.

[Table 4-1] GHG Emissions of Imported Beef by Country of Origin and Contribution by Supply Chain Stage (Domestic Distribution Basis) (Unit: kg CO_2-eq/kg)

Category	Production	Slaughtering & Processing	Distribution (Export Plant → Korea Retail Store)	Total
US	30.67	0.59	0.79	32.05
	(95.7%)	(1.8%)	(2.5%)	(100%)
AU	25.49	0.98	0.35	26.82
	(95.0%)	(3.7%)	(1.3%)	(100%)
NZ	19.71	0.52	0.28	20.51
	(96.1%)	(2.5%)	(1.4%)	(100%)

Note: Calculated based on the LCI data and LCIA for each livestock type as described in the Appendix

Source: Compiled by the author based on the analysis results of this study

[Table 4-2] Key Features of Literature Used for Estimating GHG Emissions of Imported Beef

Category	U.S.	AU	NZ
References	Asem-Hiablie et al., 2018	Wiedemann et al., 2015	Mazzetto et al., 2023
Scope	Cradle-to-Grave	Cradle-to-Warehouse	Cradle-to-Grave
Allocation Methods	Step-wise Hybrid Allocation: Biophysical and Economic	Step-wise Hybrid Allocation: Biophysical and Economic	Step-wise Hybrid Allocation: Biophysical and Economic
Rearing Methods/ Feed	Feeding System: Pasture Grazing → Growing Phase (Hay & By-products) → Finishing Phase (Grain-fed)	Pasture-based Rearing with Grain-finishing	Mixed Grazing (Cattle & Sheep) on Pasture-based Systems (Over 95% Forage-fed)

Category	U.S.	AU	NZ
Rearing Period	16 months	Mid-term grain-finishing: ~115 days Long-term grain-finishing: ~330 days	28.5 months
Export Region	Nebraska (NE)	Queensland (QLD)	Canterbury (CAN)
Export Port	San Francisco	Brisbane	Tauranga

Source: Compiled by the author based on the analysis results of this study

4.3. GHG Emissions from Imported Beef Consumption

Since approximately 60% of domestic beef consumption depends on imports, the GHG emissions resulting from imported meat cannot be overlooked. This section calculates the total annual GHG emissions from imported beef consumption by combining the carbon footprint estimates for each country with the 2024 domestic import statistics.

The analysis results in Table 4-3 reveal that the estimated total GHG emissions from consuming imported beef in South Korea in 2024 reached 12.52 Mt CO_2-eq. The figure represents a holistic carbon footprint previously obscured from the domestic consumer's perspective.

[Table 4-3] GHG Emission Contributions by Major Beef Importing Nations in 2024

Country of Origin	Carbon Footprint per Unit (A)	Annual Import Volume (B)	Total GHG Emissions (A×B)	Emission Share
	(kg CO_2-eq/kg)	(t)	(Mt CO_2-eq)	(%)
U.S.	32.05	215,161	6.89	55%
AU	26.82	199,223	5.34	43%
NZ	20.51	14,034	0.288	2%
Total		428,418	12.52	100%

Note: Calculated based on Figure 3-6 in Chapter 3 and Table 4-1

Source: Compiled by the author based on the analysis results of this study

While monitoring emissions from domestic farms is relatively accessible, quantifying the footprint of beef produced across international borders remains a complex challenge. Importing more than 420,000 tons of beef annually implies that, as a major consuming nation, South Korea must also acknowledge the indirect responsibility for emissions generated during both the production and long-distance maritime transport. **Ultimately, the 12.52 Mt CO_2-eq of annual GHG emissions from imported beef serve as a critical baseline for identifying the 'hidden emissions' that have long remained unaccounted in the global food supply chain.**

V. GHG Emissions from Domestic Meat Consumption

5.1. Climate Report Card: The Impact of National Per Capita Meat Consumption

The previous chapters examined the supply chain carbon emissions of imported beef produced in major countries. However, these emissions are ultimately driven by consumer demand. In other words, every meat product selected by a consumer directly influence carbon emissions embedded in the food supply chain.

This chapter shifts the focus from analysis from the '**supplier**' to the '**consumer**' to quantify how individual dietary choices contribute to South Korea's overall GHG emission profile.

Estimated emissions were calculating by combining per capita meat consumption with the life cycle assessment results derived from this study, as summarized in Table 5-1. **The analysis reveals that the annual meat consumption per capita in South Korea in 2024 reached 61.4 kg. When converted using the carbon footprint coefficients for each type of meat derived in this study, the annual GHG emissions per capita amount to approximately 1,115 kg CO_2-eq.**

[Table 5-1] Comparative Analysis of Per Capita Meat Consumption and GHG Emissions in South Korea (2024)

Category	Per Capita Consumption (kg/year)	Consumption Share (%)	GHG Emissions (kg CO_2-eq) (capita/year)	Emission Share (%)
Beef	15	24.40	619	55.50
Pork	30.9	50.30	413	37.00
Chicken	15.5	25.30	83	7.50
Total	61.4	100.00	1,115	100.00

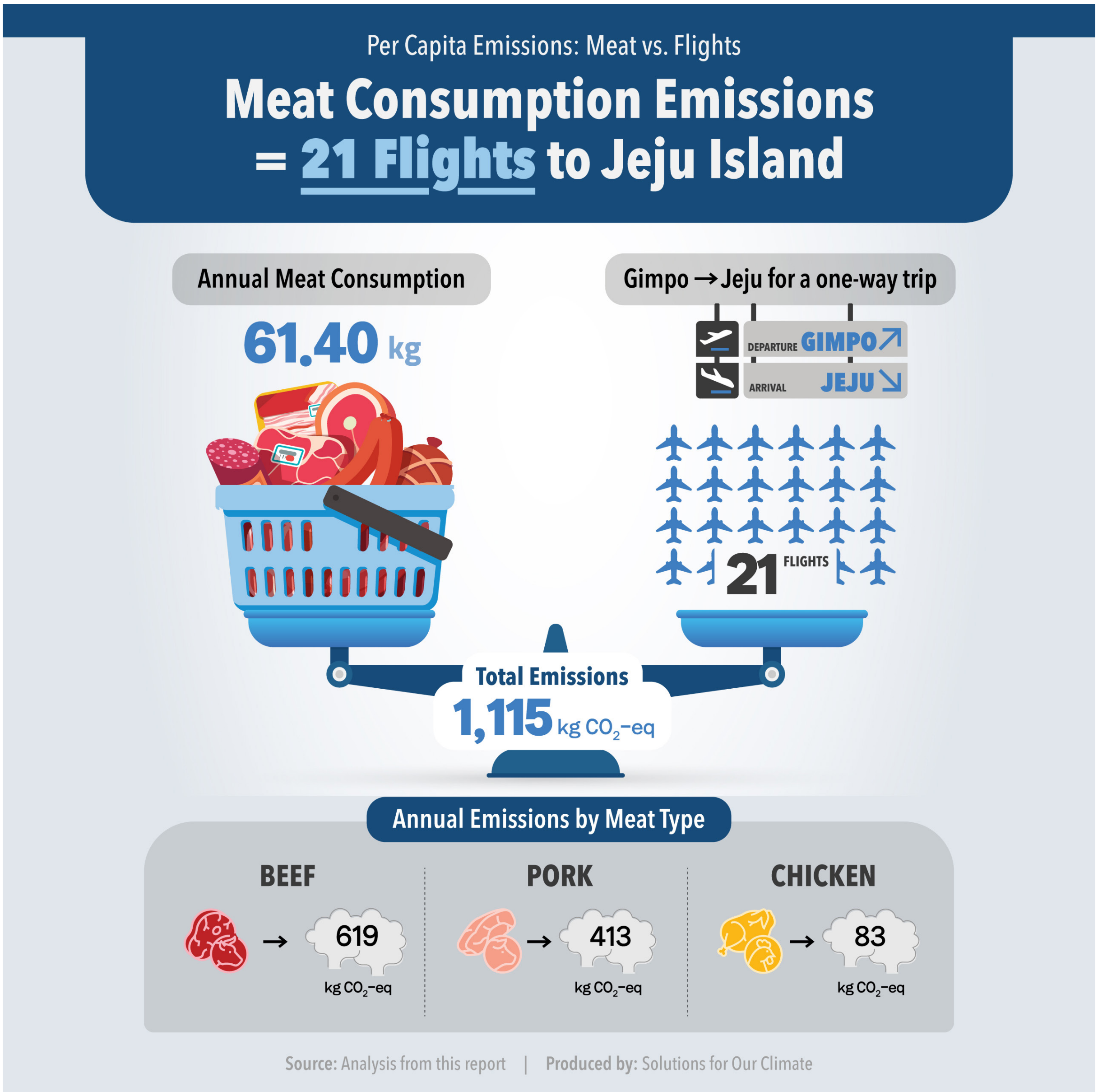
Source: Compiled by the author based on data from the Korea Meat Trade Association (KMTA) and the analysis results of this study

Notes: (1) Meat consumption figures represent the sum of both domestic and imported products, based on the data in Figure 3-4 of Chapter 3
(2) GHG emissions are based on the results from Table 2-1 in Chapter 2 and Table 4-1 in Chapter 4, and were calculated by applying the specific reference data for each meat type used in this study

To illustrate the scale of the estimated 1,115 kg CO_2-eq generated by annual per capita meat consumption, this study compared these emissions with those from domestic aviation. **The analysis shows that the annual carbon footprint associated with per capita meat consumption in South**

Korea is equivalent to 21 one-way flights between Gimpo and Jeju. Based on estimated emissions of 53 kg CO_2[1] per one-way flight, 21 flights would generate approximately 1,113 kg CO_2.

[Figure 5-1] Climate Report Card: The Impact of National Per Capita Meat Consumption



Note: (1) Based on the figures presented in Table 5-1

(2) GHG emissions from aircraft use are calculated based on CO_2 emissions

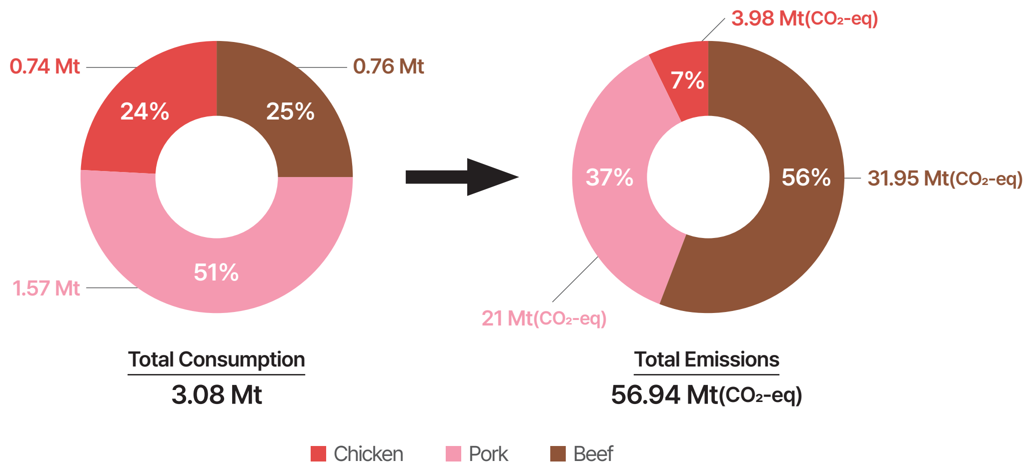
1 'Carbon Reduction Initiatives of Jeju Air Pilots,', *Gyeongbuk Domin Ilbo*, September 19, 2017

5.2. National-Scale Comparison: Meat Consumption vs. The Energy Sector

While the previous chapter examined the carbon emissions associated with individual meat consumption, this chapter expands the analysis to the national level by comparing the environmental impact of meat consumption with that of major industrial sectors. As shown in Figure 5-2, total meat consumption in 2024 was recorded at approximately 3.081 Mt.

By applying the LCA coefficients, the total GHG volume is estimated at 56.94 Mt CO_2-eq. Notably, beef accounts for approximately 56% of this total (31.95 Mt CO_2-eq), representing the largest share of emissions among all meat categories.

[Figure 5-2] Comparative Analysis of Total Meat Consumption and GHG Emissions by Meat Type (2024)



Source: Compiled by the author based on KMTA data and the analysis results of this study

To contextualize this volume, a sectoral comparison was conducted against coal-fired power plants (see Table 5-2). **The results show that emissions from meat consumption are equivalent to 34% of the total emissions from all coal-fired power plants in South Korea.** Furthermore, this annual volume substantially exceeds the annual emissions of the Taean Power Station, one of the largest coal-fired facilities in South Korea—by more than 2.6 times.

[Table 5-2] Comparative Analysis of GHG Emissions from Meat Consumption and Major Coal-Fired Power Plants (2024) (Unit: Mt CO_2-eq)

	Category	GHG Emissions	Comparison
①	Total Emissions (Meat Consumption)	56.94	Findings of This Study
②	Taean Power Station (Units 1–10)	22.10[2]	**① is more than 2.6 times the size of ②**
③	Aggregate Emissions: All Domestic Coal Power Plants (2024)	167.20[3]	**① is approximately 34.1% of ③**

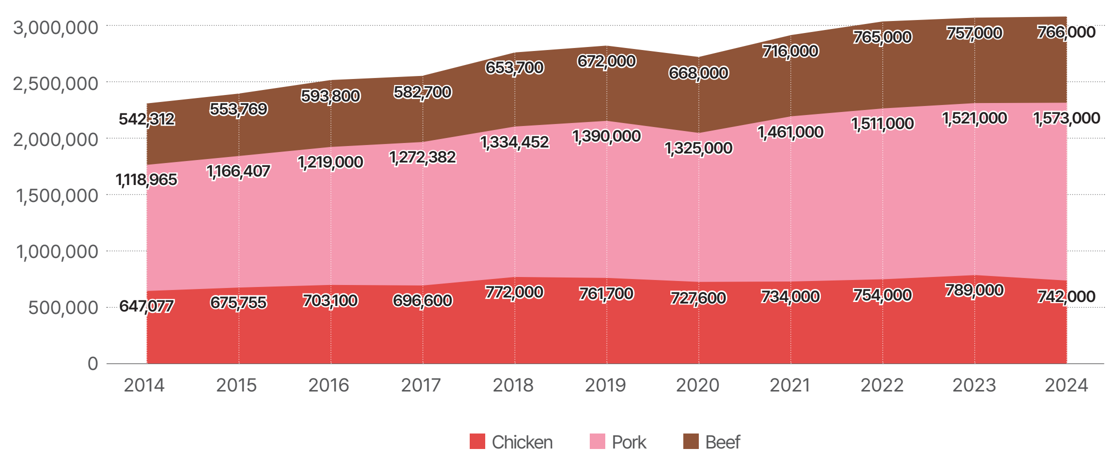
Source: Compiled by the author based on the analysis results of this study

5.3. Meat Emissions Driven by Beef Consumption

A. Steadily Increasing Meat Consumption

Total meat consumption in South Korea was recorded at 2.31 Mt in 2014 and rose to 3.08 Mt in 2024, marking a 33.5% increase over the decade. Although consumption rose across all meat categories, the growth in beef consumption was particularly pronounced. **South Korea's beef consumption grew from about 0.54 Mt in 2014 to 0.766 Mt in 2024, growing by 41.2%, higher than the growth rates observed for pork (40.5%) and chicken (14.6%).**

[Figure 5-3] Historical Trends in Domestic Meat Consumption by Type (2014–2024) (Unit: t)



Source: Compiled by the author based on KMTA data

2 Chungnam Province. (May 2, 2025). *Chungnam accounts for 57.8% (68.22 Mt) of national coal-fired power GHG emissions.* http://www.chungnam.go.kr (Accessed: April 14, 2026)

3 KRICT Carbon Neutrality Center. (August 20, 2025) *Trends in power generation and emissions by energy source.* Carbon Neutrality Web Platform (Accessed April 14, 2026).

B. Beef Emissions: Accounting for More Than Half of Total Emissions

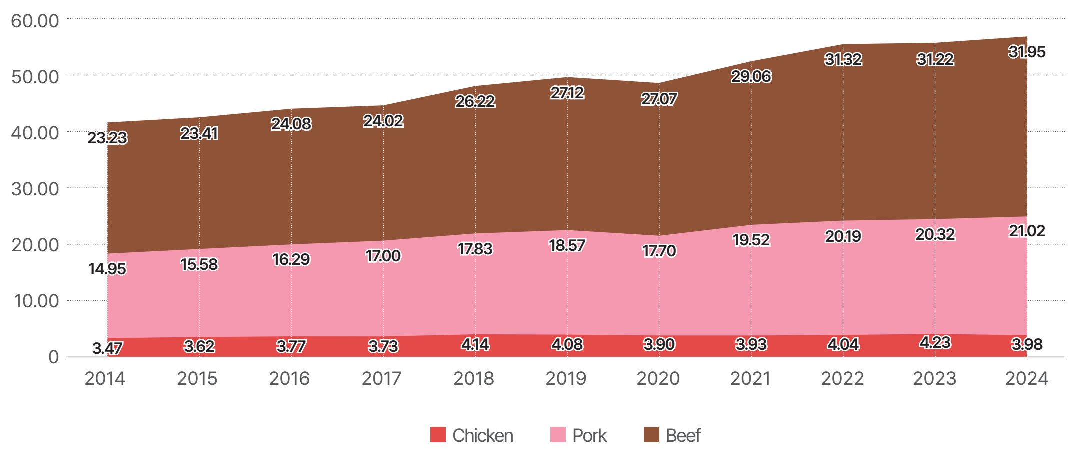
As illustrated in Figure 5-3, South Korea's total meat consumption has shown a steady upward trend. To assess the climate impact of this domestic meat consumption, Figure 5-4 presents the total GHG emissions calculated based on the carbon footprint coefficients derived in this study.

Estimated emissions from meat consumption rose from 41.65 Mt CO_2-eq in 2014 to 56.94 Mt CO_2-eq in 2024. This marks a sharp growth rate of 36.7% over the past decade, underscoring the growing contribution of dietary consumption patterns to national GHG emissions.

Furthermore, beef had a disproportionately large impact on emissions in 2024. Although beef sector accounted for only 25% of total meat consumption, it was responsible for approximately 56% of total sectoral emissions, equivalent to 31.95 Mt CO_2-eq. The growing share of carbon-intensive beef consumption has therefore become a major driver of rising emissions from the meat sector.

[Figure 5-4] Historical Trends in GHG Emissions from Meat Consumption in South Korea (2014–2024)

(Unit: Mt(CO_2-eq))



Source: Compiled by the author based on the analysis results of this study

Note: the meat-specific carbon footprint coefficients established in this study (Table 2-1 in Chapter 2 and Table 4-1 in Chapter 4) were utilized for the total consumption figures in Figure 5-3

VI. Conclusion

6.1. The Carbon Scorecard of Meat Consumption

Current GHG emission accounting systems for livestock are confined to direct farm-level emissions, creating a structural gap in providing product-level carbon data to end consumers. To address this information blind spot, this study conducted a 'Cradle-to-Retail' LCA, that incorporates emissions from processing to distribution. By converting GHG data into product-based units (per kilogram of meat), this study sought to make more intuitive for consumers. In addition, by accounting for emissions generated throughout the global production and distribution chains of imported beef, this study examined the climate implications of domestic meat consumption in South Korea.

The analysis confirms that beef is the primary driver of livestock sector's climate impact, generating disproportionately higher emissions than other types of meat. **Specifically, the GHG emissions of beef were approximately 4.4 times higher than pork and 10.8 times higher than chicken, representing the heaviest environmental burden within the meat category.**

A notable finding of this report is that South Korea has emerged as a highly meat-intensive society, outpacing both China and Japan in per capita consumption. In particular, the preference for beef—the most carbon-intensive option—is especially pronounced. **As of 2024, South Korea's annual per capita beef consumption stands at 15kg, which is 2.5 times higher than Japan (5.9kg) and 3.8 times higher than China (3.9kg). Aggregate emissions from domestic beef consumption were estimated at 31.95 Mt CO_2-eq, while total emissions from overall meat consumption in South Korea reached at 56.94 CO_2-eq. This volume is equivalent to nearly 34% of the annual emissions from nation's entire coal-fired power sector.**

Ultimately, this study provides a foundation for improving public awareness of the environmental implications of meat consumption by visualizing the carbon footprint of meat products, which has long remained obscured within producer-centered emissions accounting systems.

6.2. The Hidden Reality Underestimated Emissions

The emission levels presented in this study are likely to underestimate the full environmental impact of meat consumption due to data and methodological constraints. In the absence of a comprehensive

LCI database for livestock meat products, this study relied heavily on international proxy coefficients. The estimates thus may not fully reflect a wide range of farming practices or the characteristics of local processing industries.

Moreover, livestock production is a multi-output system where meat, by-products, and manure are generated simultaneously. While this study aimed to calculate the environmental burden by specific cuts (e.g., pork belly and tenderloin), the limited availability of data required a simplified allocation method based on the whole animal. Additionally, despite livesector's heavy reliance on imported feed grain, particularly for cattle, emissions associated with upstream feed production and supply chains were excluded from the system boudary due to insufficient statistical data.

As a result, the carbon emission figures presented in this study should be interpreted as conservative, baseline values that likely underestimate the overall environmental impact of meat consumption.

6.3. Next Steps

Despite South Korea's high per capita meat consumption compared to its East Asian neighbors, consumers still have limited access to carbon information related to meat products. The current domestic GHG accounting system is restricted to aggregating direct farm-level emissions, rather than building a ‘National Standard LCI Database’ for individual product units. In contrast, Australia’s 'AusLCI[4]' maintains a detailed unit process data covering entire supply chain—from feed cultivation to retail distribution—setting a global benchmark for livestock LCA. The Australian case provides a clear roadmap for the data infrastructure South Korea should pursue.

However, as the domestic livestock LCA system is still in an early stage of development, publicly available databases remain limited, making it difficult to conduct detailed LCAs for specific meat products and their environmental impacts. To address this information gap, the government must strengthen the carbon data infrastructure by expanding the LCI databases across all stages of the livestock value chain.

In conclusion, a foundation must be established to transform producer-oriented GHG data into consumer-accessible information. This includes developing public data systems that provide environmental indicators alongside price and orogin at the point of purchase, empowering consumers to make climate-informed purchasing decisions.

4 https://www.auslci.com.au/index.php/Home

Appendix

This appendix describes the LCA methodology, detailed analysis procedures, and foundational data utilized in this study. Its purpose is to provide the evidential basis that supports the objectivity and reliability of the analysis.

1. Framework of Life Cycle Assessment (LCA)

A. Definition of LCA

The journey of a kilogram of meat from farm to consumer's table involves a multi-stage process: birth and rearing of livestock, slaughtering, processing, and long-distance distribution. Life Cycle Assessment (LCA) is an international standard methodology, codified under ISO 14044[1] designed to quantitatively analyze and evaluate the environmental impacts of resource and energy consumption, as well as the resulting pollutant emissions, throughout a product's entire life cycle—from raw material extraction ('Cradle') to final disposal ('Grave').

The Food and Agriculture Organization (FAO) of the United Nations adopted the LCA approach as the standard methodology for measuring the climate impacts of livestock supply chains in its 2013 report, *GHG emissions from Pig and Chicken Supply Chains* (FAO, 2013). The FAO mandates a systemic accounting of all inputs and outputs within a clearly defined system boundary (see Appendix Table 1).

B. Four-Step Analysis

In accordance with the FAO guidelines and the precedents set by the by the National Institute of Animal Science (NIAS), this study follows a rigorous four-stage procedure:

1. **Scope Definition:** Selection of target products and definition of the system boundary.
2. **Life Cycle Inventory (LCI) Analysis:** Collection of data regarding resource consumption (e.g., feed, and energy) and emissions at each stage of the supply chain.
3. **Life Cycle Impact Assessment (LCIA):** Conversion of raw inventory data into GHG emissions using the Global Warming Potential (GWP).
4. **Carbon Footprint Derivation:** Final aggregation of data to determine the total climate impact per kilogram of the finished meat.

1 ISO 14044:2006(en) Environmental management — Life cycle assessment — Requirements and guidelines

[Appendix Table 1] GHG Emission Sources Included and Excluded in Ruminant Environmental Assessments

Supply chain	Activity	GHG	Included	Excluded
Upstream	Feed production	N_2O	Direct and indirect N_2O from: • Application of synthetic N • Application of manure • Direct deposition of manure by scavenging animals • Crop residue management	• N_2O losses related to changes in C stocks • Biomass burning • Biological fixation • Emissions from non N fertilizers and lime
		CO_2 N_2O CH_4	• Energy use in field operations • Energy use in feed transport and processing • Fertilizer manufacture • Feed blending • Production of non-crop feeds (fishmeal, lime and synthetic amino acids) • CH_4 from flooded rice cultivation • Land-use change related to soybean cultivation	• Changes in carbon stocks from land use under constant management practices
	Non-feed production	CO_2	• Embedded energy related to the manufacture of on-farm buildings and equipment	• Production of cleaning agents, antibiotics and pharmaceuticals
Animal production unit	Livestock production	CH_4	• Enteric fermentation • Manure management	
		N_2O	• Direct and indirect N_2O from manure management	
		CO_2	• Direct on-farm energy use for livestock, e.g. cooling, ventilation and heating	
Downstream	Post farmgate	CO_2; CH_4; HFCs	• Transport of live animals and products to slaughter and processing plant • Transport of processed products to retail point • Refrigeration during transport and processing • Primary processing of meat into carcasses or meat cuts and eggs • Manufacture of packaging	• On-site waste water treatment • Emissions from animal waste or avoided emissions from on-site energy generation from waste • Emissions related to slaughter by-products e.g. rendering material, offal, hides and skin • Retail and post-retail energy use • Waste disposal at retail and post-retail stages

Source : FAO(2013)

2. Scope of Study: System Boundary Definition

To accurately measure the GHG emissions of livestock products, establishing the scope of analysis—the ‘system boundary'—is paramount. This is critical because the results for the same meat product can vary significantly depending on the research boundaries. According to the National Institute of Animal Science (NIAS, 2015), the domestic meat supply chain is an integrated network consisting of the on-farm farm stage, slaughter and processing, import, and distribution (NIAS, 2015).

Reflecting this supply chain structure, this study adopts a 'Cradle-to-Retail' boundary. This boundary encompasses the entire lifecycle from the initial production stage (livestock rearing), through slaughtering, processing, and distribution, up to the point at which the consumer purchases the product at a retail store (see to Figure 2-1).

Particularly for imported beef, the analysis incorporates GHG emissions from overseas rearing and slaughter, as well as emission generation during international maritime transport to South Korea, to the fullest extent permitted by the available data (see Figures 2-1 and 4-1).

3. Life Cycle Inventory (LCI) Analysis

A. The Concept of Life Cycle Inventory (LCI)

The meat products found in retail markets are the result of highly complex supply chains involving feed production, livestock rearing, slaughtering, processing, and distribution. Each of these stages requires specific resource inputs and generates environmental burdens. LCI is the systematic process of collecting and organizing these inputs and emissions.

Therefore, the LCI serves as a form of 'environmental accounting ledger', recording the total energy and resources used alongside the GHG and pollutants generated throughout a product's lifecycle. LCI can map the emission structure across the supply chain and identify 'hotspots', where environmental burdens are most concentrated.

B. Data Collection and Methodological Constraints

LCA in south Korea was first introduced in the late 1990s, with initial databases primarily established around manufacturing sectors such as steel, electronics, and chemicals. The adoption in the agricultural and livestock sectors was relatively delayed; data accumulation began in earnest after

2009, following the establishment of agri-food carbon emission calculation and monitoring systems (Park et al., 2024).

Despite these efforts, LCI data for the livestock sectors remains insufficient, both in terms of recency and representativeness. In light of these data constraints, this study utilized proxy data—average values from prior research and literature—for certain items.

Furthermore, variations in data availability exist across different stages of the supply chain. For instance, while activity data is relatively accessible for the rearing stage, the processing and distribution stages often lack consistent, publicly available process-specific data. Therefore, the LCI items for this study were constructed based on available data.

C. Detailed LCI Data Configuration by Meat Type

In the following LCI data tables, activity data refers to the actual input used to calculate GHG emissions. For example, in feed analysis, it represents the total feed required to raise a single head of livestock. Specifically, rearing one pig requires approximately 331.81 kg of feed, while rearing one broiler chicken requires 2.29 kg.

The emission factor indicates the amount of GHG emissions generated per unit of activity data, typically expressed in kg CO_2-eq/kg. For example, producing a kilogram of mixed feed for pigs generates approximately 1.97 kg CO_2-eq, while a kilogram of feed for broilers results in 1.60 kg CO_2-eq.

By integrating these activity metrics with corresponding emission factors, the total resources consumed and GHGs emitted per individual can be quantified for each for each livestock category.

[Appendix Table 2] Key Features of Literature Used for Estimating GHG Emissions of Imported Beef

Category	U.S.	Australia	New Zealand
Reference	Asem-Hiablie et al., 2018	Wiedemann et al., 2015	Mazzetto et al., 2023
Scope	Cradle-to-Grave (Feed production to disposal)	Cradle-to-Warehouse (includes cold storage in exprorting country)	Cradle-to-Grave (For export beef products in New Zealand)
Allocation Method	Multi-Step Hybrid Allocation (Biophysical & Economic)	Multi-Step Hybrid Allocation (Biophysical & Economic)	Multi-Step Hybrid Allocation (Biophysical & Economic)
Rearing and Feed Characteristics	Pasture Grazing → Growing Phase (Hay & By-products) → Grain-Finished Phase	Pasture-based and Grain-Finished	Mixed Grazing (Cattle & Sheep) on Pasture-based (> 95% grass-fed)
Rearing Period	Approx. 16 months	Medium-fed: ~115 days Long-fed: ~330 days	Approx. 28.5 months
Export Region	Nebraska (NE)	Queensland (QLD)	Canterbury (CAN)
Export Port	San Francisco	Brisbane	Tauranga

Source: Compiled by the author based on the analysis results of this study

[Appendix Table 3] LCI Data Structure by Process Stage for Imported Beef Emissions

Country of Origin	Stage	Item	Input			Output		
			Value	Unit	Source	Value	Unit	Source
U.S.	Production					30.67	kg CO_2-eq/kg meat	Asem-Hiablie et al.(2018)
	Slaughtering & Processing					0.59	kg CO_2-eq/kg meat	Asem-Hiablie et al.(2018)
	Distribution	[Inland Transport in Exporting Country] Road Freight (Trucking) (Nebraska → San Francisco)	2.73	ton·km	FAF5 (tool)	0.195	kg CO_2-eq/ton·km	U.SLCI (Transport,combinationtruck,long-haul,dieselpowered)
		[International Transport] Ocean Freight (Maritime Shipping) (Port of San Francisco → Port of Busan)	9.116	ton·km	sea-distance.org (tool)	0.02	kg CO_2-eq/ton·km	Wernet et al.(2016)
		[Inland Transport in Importing Country ①] Road Freight (Trucking) _Average	0.153	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors
		[Inland Transport in Importing Country ②] Road Freight (Trucking) _Shortest Distance	0.005	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors
		[Inland Transport in Importing Country ③] Road Freight (Trucking) _Longest Distance	0.4	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors

Source: Compiled by the author based on the analysis results of this study

[Appendix Table 3] (cont.) LCI Data Structure by Process Stage for Imported Beef Emissions

Country of Origin	Stage	Item	Input			Output		
			Value	Unit	Source	Value	Unit	Source
Australia	Production					25.49	kg CO_2-eq /kg meat	Wiedemann et al.(2015)
	Slaughtering & Processing					0.98	kg CO_2-eq /kg meat	Wiedemann et al.(2015)
	Distribution	[Inland Transport in Exporting Country] Road Freight (Trucking) (Port of Queensland → Port of Brisbane)	1.299	ton·km	NHVRGO,Routeplanner (calculation tool)	0.089	kg CO_2-eq/ton·km	Ledgard et al.(2021)
		[International Transport] Ocean Freight (Maritime Shipping) (Port of Brisbane → Port of Busan)	7.745	ton·km	sea-distance.org (calculation tool)	0.02	kg CO_2-eq/ton·km	Wernet et al.(2016)
		[Inland Transport in Importing Country ①] Road Freight (Trucking) _Average	0.153	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors
		[Inland Transport in Importing Country ②] Road Freight (Trucking) _Shortest Distance	0.005	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors
		[Inland Transport in Importing Country ③] Road Freight (Trucking) _Longest Distance	0.4	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors

Source: Compiled by the author based on the analysis results of this study

[Appendix Table 3] (cont.) LCI Data Structure by Process Stage for Imported Beef Emissions

Country of Origin	Stage	Item	Input			Output		
			Value	Unit	Source	Value	Unit	Source
New Zealand	Production					19.71	kg CO_2-eq /kg meat	Mazzetto et al. (2023)
	Slaughtering & Processing					0.52	kg CO_2-eq /kg meat	Mazzetto et al. (2023)
	Distribution	[Inland Transport in Exporting Country] Road Freight (Trucking) (Canterbury → Wellington)	0.165	ton·km	NHVRGO,Routeplanner (calculation tool)	0.089	kg CO_2-eq/ton·km	Ledgard et al.(2021)
		[International Transport] Ocean Freight (Maritime Shipping) > (Wellington → Port of Busan)	9.817	ton·km	sea-distance.org (calculation tool)	0.02	kg CO_2-eq/ton·km	Wernet et al.(2016)
		[Inland Transport in Importing Country ①] Road Freight (Trucking) _Average	0.153	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors
		[Inland Transport in Importing Country ②] Road Freight (Trucking) _Shortest Distance	0.005	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors
		[Inland Transport in Importing Country ③] Road Freight (Trucking) _Longest Distance	0.4	ton·km	NIAS (2015)	0.192	kg CO_2-eq/ton·km	Kang et al. (2025); Ministry of Environment, Environmental Product Declaration Assessment Factors

Source: Compiled by the author based on the analysis results of this study

[Appendix Table 4] LCI Data Composition for Beef Production in Korea by Life Cycle Stage

Functional Unit: One head of Hanwoo (approx. 180-day rearing period)

Stage	Item	Input			Output		
		Value	Unit	Source	Value	Unit	Source
Production	Concentrate Feed	10775.38	kg/head	Proxy Data	0.614	kg CO_2-eq /kg	Proxy Data
	TMR Feed	4578.95	kg/head	Proxy Data	0.614	kg CO_2-eq /kg	Proxy Data
	Rice Straw	3848.45	kg/head	Proxy Data	0.091	kg CO_2-eq /kg	Proxy Data
	Hay	1136.98	kg/head	Proxy Data	0.223	kg CO_2-eq /kg	Proxy Data
	Silage	464.93	kg/head	Proxy Data	0.053	kg CO_2-eq /kg	Proxy Data
	Drinking Water (Groundwater)	1254.47	kg/head	Proxy Data			
	Electricity	1777.8	kwh/head	Proxy Data	0.683	kg CO_2-eq /kg	Proxy Data
	Diesel Production (Upstream)	136.46	kg/head	Proxy Data	0.447	kg CO_2-eq /kg	Proxy Data
	Diesel Combustion (Direct)	136.46	kg/head	Proxy Data	3.21	kg CO_2-eq /kg	Proxy Data
	Enteric Fermentation (CH_4) Male, <1 year				39	kg CH_4/ head /yr	Official Data
	Enteric Fermentation (CH_4) Male, ≥1 year				61	kg CH_4/ head /yr	Official Data
	Enteric Fermentation (CH_4) Female, <1 year				33	kg CH_4/ head /yr	Official Data
	Enteric Fermentation (CH_4) Female, ≥1 year				53	kg CH_4/ head /yr	Official Data
	Manure Management (CH_4)				1	kg CH_4/ head /yr	Official Data
	Annual Nitrogen Excretion (Nex)				49.68	kg CH_4/ head /yr	Official Data
	Manure N_2O Slurry Storage/Liquid Fertilizer				0.01	kg N_2O-N/kgN	Official Data
	Manure N_2O Composting				0.005	kg N_2O-N/kgN	Official Data
	Manure N_2O Combined Composting & Liquid				0.01	kg N_2O-N/kgN	Official Data
	Manure N_2O Aerobic Treatment (Purification)				0.005	kg N_2O-N/kgN	Official Data
	Manure N_2O Others				0.1	kg N_2O-N/kgN	Official Data
	Manure N_2O Contracted Treatment				0.006	kg N_2O-N/kgN	Official Data
	Manure Treatment Facility - Composting				80.12	%	Official Data
	Manure Treatment Facility - Liquid Fertilization				1.14	%	Official Data
	Manure Treatment Facility - Combined (Solid/Liquid)				3.81	%	Official Data
	Manure Treatment Facility - Purification/Treatment				0.15	%	Official Data
	Manure Treatment Facility - Others				0.77	%	Official Data
	Manure Treatment Facility - Outsourced Service				14.67	%	Official Data

Stage	Item	Input			Output		
		Value	Unit	Source	Value	Unit	Source
Slaughtering & Processing	Slaughtering Process				0.107	kg CO_2-eq /kg	Proxy Data
	Packing				0.45	kg CO_2-eq /kg	Proxy Data
Distribution	Road Freight (Trucking)_Average Distance	152	km	Official Data	0.192	kg CO_2-eq/ton·km	Official Data
	Road Freight (Trucking)_Shortest Distance	5	km	Official Data	0.192	kg CO_2-eq/ton·km	Official Data
	Road Freight (Trucking)_Longest Distance	400	km	Official Data	0.192	kg CO_2-eq/ton·km	Official Data

Official Data: Derived from official databases provided by governments, public institutions, and the IPCC

Proxy Data: Adopted from research data found in reputable domestic and international literature to complement missing local inventory

Source: Compiled by the author based on the analysis results of this study

[Appendix Table 5] LCI Data Composition for Pork Production in Korea by Life Cycle Stage

Functional Unit: One head of pig (approx. 180-day rearing period)

Stage	Item	Input			Output		
		Value	Unit	Source	Value	Unit	Source
Production	Concentrate Feed	331.81	kg/head	Proxy Data	1.97E+00	kg CO_2-eq/kg	Proxy Data
	Drinking Water (Groundwater)	1254.47	kg/ head	Proxy Data	0.00E+00	kg CO_2-eq/kg	Proxy Data
	Electricity	6.37	kwh/ head	Proxy Data	6.83E-01	kg CO_2-eq/kg	Proxy Data
	Diesel Production (Upstream)	1.6364	kg/ head	Proxy Data	4.47E-01	kg CO_2-eq/kg	Proxy Data
	Diesel Combustion (Direct)	1.6364	kg/ head	Proxy Data	3.21E+00	kg CO_2-eq/kg	Proxy Data
	Enteric Fermentation (CH_4) (<2 months)				0.16	kg CH_4/head/yr	Official Data
	Enteric Fermentation (CH_4) (2-4 months)				0.3	kg CH_4/ head/yr	Official Data
	Enteric Fermentation (CH_4) (4-6 months)				1.45	kg CH_4/ head/yr	Official Data
	Manure Management (CH_4)				8	kg CH_4/ head/yr	Official Data
	Annual Nitrogen Excretion (Nex)				10.97	kg N/ head/yr	Official Data
	Manure N_2O Composting				0.01	kg N_2O-N/kgN	Official Data
	Manure N_2O Slurry/Liquid Fertilizer				0.005	kg N_2O-N/kgN	Official Data
	Manure N_2O Combined (Solid/ Liquid)				0.005	kg N_2O-N/kgN	Official Data
	Manure N_2O Purification (Treatment)				0.005	kg N_2O-N/kgN	Official Data
	Manure N_2O Others				0.001	kg N_2O-N/kgN	Official Data
	Manure N_2O Outsourced Treatment				0.005	kg N_2O-N/kgN	Official Data
	Facility Operation - Composting				18.9	%	Official Data
	Facility Operation - Liquid Fertilization				5.8	%	Official Data
	Facility Operation - Combined Treatment				6.39	%	Official Data
	Facility Operation - Purification				13.72	%	Official Data
	Facility Operation - Others				0.76	%	Official Data
	Facility Operation - Outsourced Service				54.42	%	Official Data
Slaughtering & Processing	Slaughtering Process				0.107	kg CO_2-eq /kg	Proxy Data
	Packing				0.45	kg CO_2-eq /kg	Proxy Data

Stage	Item	Input			Output		
		Value	Unit	Source	Value	Unit	Source
Distribution	Road Freight (Trucking)_Average Distance	152	km	Official Data	0.192	kg CO_2-eq/ton·km	Official Data
	Road Freight (Trucking)_Shortest Distance	5	km	Official Data	0.192	kg CO_2-eq/ton·km	Official Data
	Road Freight (Trucking)_Longest Distance	400	km	Official Data	0.192	kg CO_2-eq/ton·km	Official Data

Official Data: Derived from official databases provided by governments, public institutions, and the IPCC

Proxy Data: Adopted from research data found in reputable domestic and international literature to complement missing local inventory

Source: Compiled by the author based on the analysis results of this study

[Appendix Table 6] LCI Data Composition for Chicken Production in Korea by Life Cycle Stage

Functional Unit: One head of broiler (approx. 32-day rearing period)

Stage	Item	Input			Output		
		Value	Unit	Source	Value	Unit	Source
Production	Concentrate Feed	2.29	kg/head	Proxy Data	1.60E+00	kg CO_2-eq/kg	Proxy Data
	Drinking Water (Groundwater)	4.57	kg/head	Proxy Data	0.00E+00	kg CO_2-eq/kg	Proxy Data
	Electricity	0.16	kwh/head	Proxy Data	6.83E-01	kg CO_2-eq/kg	Proxy Data
	Diesel Production (Upstream)	0.0815	kg/head	Proxy Data	4.47E-01	kg CO_2-eq/kg	Proxy Data
	Diesel Combustion (Direct)	0.0815	kg/head	Proxy Data	3.21E+00	kg CO_2-eq/kg	Proxy Data
	Manure Management (CH_4)				0.02	kgCH_4/두/연	Official Data
	Annual Nitrogen Excretion (Nex)				0.31	kgN/두/연	Official Data
	Manure N_2O Composting				0.001	kgN_2O-N/kgN	Official Data
	Manure N_2O Slurry/Liquid Fertilizer				0.005	kgN_2O-N/kgN	Official Data
	Manure N_2O Combined (Solid/Liquid)				0.001	kgN_2O-N/kgN	Official Data
	Manure N_2O Purification (Treatment)				0.005	kgN_2O-N/kgN	Official Data
	Other Manure N_2O				0.001	kgN_2O-N/kgN	Official Data
	Manure N_2O Outsourced Treatment				0	kgN_2O-N/kgN	Official Data
	Facility Operation - Composting				62.04	%	Official Data
	Facility Operation - Combined Treatment				1.87	%	Official Data
	Facility Operation - Purification				0.18	%	Official Data
	Facility Operation - Others				0.77	%	Official Data
	Facility Operation - Outsourced Service				33.14	%	Official Data
Slaughtering & Processing	Slaughtering (Electricity, Water, Waste Treatment)				0.18	kg CO_2-eq /kg	Proxy Data
	Processing				0.45	kg CO_2-eq /kg	Proxy Data
Distribution		0.19	ton·km	Proxy Data	0.192	kg CO_2-eq/ton·km	Official Data

Official Data: Derived from official databases provided by governments, public institutions, and the IPCC

Proxy Data: Adopted from research data found in reputable domestic and international literature to complement missing local inventory

Source: Compiled by the author based on the analysis results of this study

4. Life Cycle Impact Assessment (LCIA) and Emission Calculation

A. Life Cycle Impact Assessment (LCIA) Framework

Simply listing emission volumes is insufficient to comprehensively evaluate the actual environmental impact of GHGs generated during livestock production. Different types of GHGs have varying degrees of impact on global warming. LCIA is the process of quantitatively evaluating environmental impacts by reflecting these differences.

In the LCIA stage, the magnitude of the actual environmental impact is calculated based on the activity data and emission profiles collected during the LCI phase. In other words, LCIA is a conversion mechanism that puts various pollutants emitted during production and distribution into a single, comparable standard.

B. Application of Global Warming Potential (GWP)

During the livestock rearing process, various GHGs—CO_2, CH_4, and N_2O—are emitted. Methane is a byproduct of enteric fermentation in ruminants, while nitrous oxide is a key GHG produced during manure management and nitrogen cycling in soil. Given that these gases has a different impact on global warming even at the same masses, they must be unified under a single metric.

In this study, GHG emissions across the entire supply chain for beef, pork, and poultry were calculated in terms of Carbon Dioxide Equivalent (CO_2-eq). The metric applied for this conversion is the Global Warming Potential (GWP). GWP quantifies the impact of a specific greenhouse gas on global warming over a defined time horizon relative to CO_2. This study applied GWP values for each GHG in accordance with the standards of the Greenhouse Gas Inventory and Research Center (2025). Under the GWP100 horizon, CH_4 has 28 times the global warming impact of CO_2 and N_2O has approximately 265 times the potential.

[Appendix Table 7] Global Warming Potential (GWP) by GHG

Greenhouse Gas	Chemical Compound	GWP-100
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrogen oxide	N_2O	265

GHG emissions (CO_2-eq) = Activity Data × Emissions Factor × GWP: GWP per GHG

Source: Greenhouse Gas Inventory and Research Center (2025)

The final carbon dioxide equivalent (CO_2-eq) values were calculated from the standards in Appendix Table 7. The activity data, such as feed, energy, and fuel consumption from each stage was multiplied by its respective emission factors and then adjusted by the corresponding GWP value for each GHG.

C. Calculation of Carbon Footprint

Utilizing the data from the LCI phase, GHG emissions were converted into CO_2-eq/kg during the LCIA stage. This allowed for the quantitative assessment of GHG emissions generated at each stage of the supply chain, including production, slaughtering, processing, and distribution. To ensure the results are easily understood by consumers, the emissions from each stage were consolidated into a Carbon Footprint metric. This shows the total GHG generated per unit product—a kilogram of meat—reaching the retail shelf (CO_2-eq/kg).

Finally, the total carbon footprint is defined as the sum of emissions across all lifecycle stages, expressed by the following equation:

$$CF_{product}(kg\ CO_2\text{-}eq/kg) = E_{farm} + E_{processing} + E_{distribution}$$

E_{farm} : Emissions generated during the rearing stage at the farm
$E_{processing}$: Emissions generated during the slaughtering and primary processing of meat products
$E_{distribution}$: Emissions from the distribution stage (e.g. transport, storage)

References

- National Bureau of Statistics of China. China Statistical Yearbook: Time-Series Statistics, 2014–2024. https://www.stats. gov.cn/english/Statisticaldata/yearbook.
- Ministry of Agriculture, Forestry and Fisheries (MAFF). Food Balance Sheet: Time-Series Statistics, 2014–2024. https://www.maff.go.jp.
- Korea Rural Economic Institute. (2026). 2026 Livestock Supply and Demand Outlook and Key Issues [2026 Agricultural Outlook Conference Presentation Materials].
- Korea Meat Trade Association (KMTA). (2014–2024). Meat Consumption Trends: Total and Per Capita Consumption by Livestock Species. https://www.kmta.or.kr/kr/data/stats_ spend.php.
- Greenhouse Gas Inventory and Research Center. (2025). National Greenhouse Gas Inventory (1990–2023) ('06 Guidelines). Ministry of Climate, Energy and Environment.
- Rural Development Administration. (2024). Smart Livestock Statistics 30: Issue No. 3, 2024.
- Kang, J., Kim, C., Kim, T., & Jeong, J. (2024). Chapter 4. Supply and Demand Trends and Outlook for Korean Native Cattle, Swine, and Dairy Cattle. In Korea Rural Economic Institute, Agricultural Outlook 2024.
- Lee, H., Shim, M., Jeong, S., & Seo, G. (2020). Chapter 21. Supply and Demand Trends and Outlook for Poultry. In Korea Rural Economic Institute, Agricultural Outlook 2020.
- Kang, H., Lee, J., Kim, G., Hwang, Y., Park, G., & Lee, D. (2024). Environmental Impact Analysis of Livestock Manure Recycling Processes Using Life Cycle Assessment (LCA). Journal of Korean Society of Environmental Engineers, 46(10), 582–591.
- Ko, K., Hwang, Y., Park, G., Cho, H., & Je, M. (2005). Environmental Assessment of Power Generation Systems Using the LCA Method. Journal of Korean Society of Environmental Engineers, 27(7), 704–711.
- Kim, K., Jeong, Y., & Kim, P. (2017). Development of Emission Factors and Verification Guidelines for Estimating Greenhouse Gas Reduction Effects in Crop and Livestock Sectors. Ministry of Agriculture, Food and Rural Affairs.
- Kim, K., Bharanidharan, R., Kim, J., Woo, Y., Lee, G., Lee, M., Kim, Y., Lee, J., Lee, J., Lee, S., Jeong, J., Song, J., & Baek, Y. (2018). Development of Nationally Applicable Emission Factors and Advancement of Estimation Methods for Major Greenhouse Gas Sources in the Livestock Sector. Rural Development Administration.
- Kim, C., Jang, J., Kwon, H., & Nam, J. (2009). Application of Carbon Labeling Systems in the Agricultural Sector and Its Implications (Basic Research Report). Korea Rural Economic Institute.
- Nam, J., Ok, Y., Choi, B., Lim, S., Jeong, Y., Jang, Y., & Yang, J. (2008). Life Cycle Assessment Methodology for Environmental Evaluation of Winter Rapeseed. Korean Journal of Environmental Agriculture, 27(2).
- Rural Development Administration. (2023, January 31). More Accurate Estimation of Greenhouse Gas Emissions in the Livestock Sector [Press Release]. https://www.rda.go.kr/board/board.do?mode=view&prgId=day_farmprmninfoEntry&dataNo=100000784864.
- Rural Development Administration. (2025, February 10). Improving the Accuracy of Greenhouse Gas Emission Estimation from Broiler Manure Treatment [Press Release]. https://www.korea.kr/briefing/ pressReleaseView.do?newsId=156673719.
- Rural Development Administration. (2025, September 17). Completion of Korea-Specific Livestock Greenhouse Gas Emission Factors for Carbon Neutrality by 2050 [Press Release]. https://www.rda.go.kr/board/ board.do?mode=view&prgId=day_farmprmninfoEntry&dataNo=100000805279.
- Park, G., Yeon, S., Park, Y., Lee, G., Kim, Y., & Jeong, Y. (2022). Study on the Environmental and Industrial Characteristics of Hanwoo from a Life Cycle Perspective. Hanwoo Board.

- Park, G., Choi, E., Jang, H., Yeon, S., & Jeong, S. (2024). Registration of Technical Elements for the Low-Carbon Agricultural and Livestock Product Certification System and Establishment of a Life Cycle Inventory Database. Rural Development Administration.
- Park, Y., Lee, G., & Yang, S. (2015). Life Cycle Assessment of Milk Production from Dairy Cattle in Korea. Journal of Korean Society of Environmental Engineers, 37(1), 52–59.
- Shim, G., Jeong, J., So, K., Lim, S., Noh, G., Kim, G., Jeong, C., & Lee, D. (2010). Agricultural Environmental Impact Assessment through the Introduction of Life Cycle Assessment. Korean Journal of Soil Science and Fertilizer, 43(2), 237–241.
- Yang, S., Kim, K., Ra, C., Lee, G., Kim, J., Lee, S., & Lee, G. (2014). Development of Greenhouse Gas Emission Factors and Emission Assessment in the Livestock Sector. Rural Development Administration.
- Greenhouse Gas Inventory and Research Center. (2025). 2024 National Greenhouse Gas Inventory Report. Ministry of Climate, Energy and Environment.
- Yoon, S., & Son, B. (2012). Life Cycle Assessment for Estimating Carbon Emissions of Organic Farming Materials: Focusing on Charcoal, Wood Vinegar, and Microbial Agents. Korean Journal of Organic Agriculture, 20(3), 297–311.
- Yoon, S., & Yoo, D. (1998). Quantitative Assessment of Greenhouse Effect Gases in the Agricultural and Livestock S
- Asem-Hiablie, S., Battagliese, T., Stackhouse-Lawson, K. R., & Rotz, C. A. (2019). A life cycle assessment of the environmental impacts of a beef system in the USA. The International Journal of Life Cycle Assessment, 24(3), 441–455.
- Basset-Mens, C., Ledgard, S., & Boyes, M. (2009). Eco-efficiency of intensification scenarios for milk production in New Zealand. Ecological Economics, 68(6), 1615–1625.
- Basset-Mens, C., Ledgard, S., & Carran, A. (2005). First life cycle assessment of milk production from New Zealand dairy farm systems. In Proceedings of the Australian and New Zealand Ecological Economics in Action Conference (pp. 258–265).
- Beukes, P. C., Gregorini, P., & Romera, A. J. (2011). Estimating greenhouse gas emissions from New Zealand dairy systems. Animal Feed Science and Technology, 166, 708–720.
- Bengtsson, J., & Seddon, J. (2013). Cradle to retailer life cycle assessment of chicken products in Australia. Journal of Cleaner Production, 41, 291–300.
- Biswas, W. K., & Naude, G. (2016). A life cycle assessment of processed meat products supplied to Barrow Island. Journal of Food Engineering, 180, 48–59.
- Department of Agriculture, Fisheries and Forestry. (2025). Red meat export statistics 2025.
- Dorca-Preda, T., Mogensen, L., Kristensen, T., & Knudsen, M. T. (2021). Environmental impact of Danish pork at slaughterhouse gate. Livestock Science, 251, 104622.
- Dourmad, J. Y., Ryschawy, J., Trousson, T., Bonneau, M., Gonzalez, J., Houwers, H. W. J., ... & Morgensen, L. (2014). Evaluating environmental impacts of contrasting pig farming systems with life cycle assessment. Animal, 8(12), 2027–2037.
- FAO. (2016a). Environmental performance of large ruminant supply chains: Guidelines for assessment.
- FAO. (2016b). Greenhouse gas emissions and fossil energy use from poultry supply chains: Guidelines for assessment.
- FAO. (2018). Environmental performance of pig supply chains: Guidelines for assessment (Version 1).
- FAO. (2025). GHG emissions from agrifood systems: Global, regional and country trends, 2001-2023.
- FAO. (2013). Greenhouse gas emissions from pig and chicken supply chains : A global life cycle assessment.
- Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., ... & Tempio, G. (2013). Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
- Hamerschlag, K., & Venkat, K. (2011). Meat Eater's Guide to Climate Change+ Health: Lifecycle Assessments: Methodology and Results 2011. Environmental Working Group.
- Hur, S. J., Kim, J. M., Yim, D. G., Yoon, Y., Lee, S. S., & Jo, C. (2023). Impact of livestock industry on climate change: Case study in South Korea—A review. Animal Bioscience, 37(3), 405.

- Jeong, D., Kim, Y. S., Cho, S., & Hwang, I. (2023). A case study of CO_2 emissions from beef and pork production in South Korea. Journal of Animal Science and Technology, 65(2), 427.
- Kang, H. Y., Hwang, Y. W., Lee, J. H., Cho, S. J., Jeon, Y. S., Kim, N. S., & Kim, J. (2025). Evaluating the greenhouse gas emissions footprint of chicken meat production in South Korea. Food and Bioproducts Processing, 150, 230–239.
- National Heavy Vehicle Regulator (NHVR). (2025). NHVR GO, Route planner tool.
- Ledgard, S., Falconer, S., & Mazzetto, A. (2021). Carbon footprint of New Zealand beef and sheep exported to different markets. Report for the Meat Industry Association and Beef+ Lamb New Zealand.
- Ledgard, S. F., Falconer, S. J., Abercrombie, R., Philip, G., & Hill, J. P. (2020). Temporal, spatial, and management variability in the carbon footprint of New Zealand milk. Journal of Dairy Science, 103(1), 1031–1046.
- Leinonen, I., Williams, A. G., Wiseman, J., Guy, J., & Kyriazakis, I. (2012). Predicting the environmental impacts of chicken systems in the United Kingdom through a life cycle assessment. Poultry Science, 91(1), 8–25.
- Lupo, C. D., Clay, D. E., Benning, J. L., & Stone, J. J. (2013). Life-cycle assessment of the beef cattle production system. Journal of Environmental Quality, 42(5), 1386–1394.
- MacLeod, M., Gerber, P., Mottet, A., Tempio, G., Falcucci, A., Opio, C., Vellinga, T., Henderson, B. & Steinfeld, H. (2013). Greenhouse gas emissions from pig and chicken supply chains: A global life cycle assessment. Food and Agriculture Organization of the United Nations (FAO), Rome.
- Meat & Livestock Australia Limited. (2023). Red Meat Greenhouse Gas Emissions Update 2023.
- Mazzetto, A. M., Falconer, S., & Ledgard, S. (2023). Carbon footprint of New Zealand beef and sheep meat exported to different markets. Environmental Impact Assessment Review, 98, 106946.
- Oak Ridge National Laboratory, National Transportation Research Center. (2025). Freight Analysis Framewrok Version 5 (FAF5).
- Opio, C., Gerber, P., Mottet, A., Falcucci, A., Tempio, G., MacLeod, M., Vellinga, T., Henderson, B. & Steinfeld, H. (2013). Greenhouse gas emissions from ruminant supply chains: A global life cycle assessment. Food and Agriculture Organization of the United Nations (FAO), Rome.
- Pelletier, N., Pirog, R., & Rasmussen, R. (2010). Comparative life cycle environmental impacts of three beef production strategies. Agricultural Systems, 103(6), 380–389.
- Peters, G. M., Rowley, H. V., Wiedemann, S., Tucker, R., Short, M. D., & Schulz, M. (2010). Red meat production in Australia. Environmental Science & Technology, 44(4), 1327–1332.
- Poore, J. & Nemecek, T., (2018). Reducing food's environmental impacts through producers and consumers. Science, Volume 360, pp. 987-992.
- Putman, B., Rotz, C. A., & Thoma, G. (2023). A comprehensive environmental assessment of beef production and consumption in the United States. Journal of Cleaner Production, 402, 136766.
- Roman-White, S., Rai, S., Littlefield, J., Cooney, G., & Skone, T. J. (2019). Life cycle greenhouse gas perspective on exporting liquefied natural gas from the Unites States: 2019 update (No. DOE/NETL--2019/2041). National Energy Technology Laboratory (NETL).
- Robertson, M. R., & Klimas, C. (2019). A playful life cycle assessment of the environmental impact of children's toys. DePaul Discoveries, 8(1), 7.
- Sea-Distances.org. 검색일: 2026년 3월 17일. https://sea-distances.org/
- Stats NZ Tatauranga Aotearoa, Infoshare. (2024). Agriculture, Variable by Regional Council.
- Stats NZ Tatauranga Aotearoa, Infoshare. (2025). Overseas merchandise trade datasets..
- U.S. Department of Agriculture, Foreign Agricultural Service. (2025). Global Agricultural Trade System (GATS).
- Thoma, G. J., Baker, B., & Knap, P. W. (2024). A life cycle assessment study of the impacts of pig breeding. Animals, 14(16), 2435.
- Thoma, G., Putman, B., Matlock, M., Popp, J., & English, L. (2017). Sustainability assessment of U.S. beef production systems.

- van der Werf, H. M., Kanyarushoki, C., & Corson, M. S. (2009). An operational method for evaluation of dairy farms by life cycle assessment. Journal of Environmental Management, 90(11), 3643–3652.
- van Selm, B., de Boer, I. J., Ledgard, S. F., & van Middelaar, C. E. (2021). Reducing greenhouse gas emissions of New Zealand beef. Agricultural Systems, 186, 102936.
- Webb, J., Williams, A. G., Hope, E., Evans, D., & Moorhouse, E. (2013). Do foods imported into the UK have a greater environmental impact than the same foods produced within the UK?. The International Journal of Life Cycle Assessment, 18(7), 1325-1343.
- Wiedemann, S., Biggs, L., Watson, K., Gould, N., & McGahan, E. (2019). Australian Beef Industry 35-year environmental impact trends analysis.
- Wiedemann, S., McGahan, E., Murphy, C., Yan, M. J., Henry, B., Thoma, G., & Ledgard, S. (2015). Environmental impacts and resource use of Australian beef and lamb exported to the USA. Journal of Cleaner Production, 94, 67–75.
- Zhang, N., Ledgard, S., Falconer, S., Luo, J., Ma, L., & Bai, Z. (2025). Implications of environmental constraints and opportunities on livestock production. Cleaner Environmental Systems, 16, 100266.

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