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Additional data collection for Tier 2 greenhouse gas inventory in cattle production in Vietnam

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ABSTRACT

This study generated country-specific data to support Tier 2 greenhouse gas (GHG) emission estimation in Vietnam's cattle sector, aiming to enhance the accuracy of national GHG inventories. Key parameters collected include breed composition, herd structure, live weight, milk yield and composition, growth and reproductive performance, feeding practices, and manure management. Data were compiled from on-farm surveys (222 farms in six provinces), provincial-level expert group discussions, and expert consultations, covering the period 1994–2023. On-farm surveys provided the most reliable quantitative information (e.g., weights, feed intake, milk yield), while group discussions contributed regional insights on herd structure and management practices. Expert judgment was used to reconstruct historical data. Results highlight clear regional differences in dairy and beef systems and demonstrate the value of combining data sources to fill gaps required by the Intergovernmental Panel on Climate Change (IPCC) Tier 2 methodology. The study recommends periodic data collection cycles: every 2–3 years for dairy productivity, every 3–5 years for herd structure and manure management, and immediate updates when production systems change. Implementing these recommendations will significantly improve the precision of GHG inventories in Vietnam's livestock sector, providing a stronger evidence base for emission reporting and sustainable mitigation policies.

Keywords: *Greenhouse gas; Beef cattle; Dairy cattle*

Introduction

The livestock sector is a major contributor to global greenhouse gas (GHG) emissions, with ruminants accounting for the largest share due to enteric methane and manure management. Globally, ruminant species contribute about 65% of livestock waste and nearly one-third of total sectoral GHG emissions (O'Mara, 2011). In Vietnam, methane emissions from enteric fermentation were estimated at 10.8 million tonnes CO_2-eq in 2019 (FAOSTAT, 2019), reflecting the rapid expansion of both beef and dairy cattle populations over the past three decades.

Dairy cattle numbers increased from about 15,400 in 1994 to more than 325,000 in 2022, concentrated mainly in medium- and large-scale farms in favorable regions. Beef cattle populations also grew, from 3.29 million in 1994 to 6.01 million in 2022, with production largely dominated by smallholder systems using semi-grazing or confined feeding. While cattle production supports national food security and rural livelihoods, it is also a growing source of GHG emissions.

The Intergovernmental Panel on Climate Change (IPCC) recommends the Tier 2 methodology for countries with significant ruminant emissions, as it relies on country-specific parameters such as breed composition, productivity, feed

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intake, and manure management. Unlike Tier 1, which applies default emission factors and provides only rough estimates, Tier 2 enables more accurate inventories that are essential for designing and evaluating mitigation strategies. Vietnam has so far relied mainly on Tier 1, which limits the precision of its national GHG reporting and hinders assessment of progress toward the country's net-zero emission target by 2050.

A critical barrier to Tier 2 adoption is the lack of consistent, reliable, and updated data on cattle production systems. Existing datasets are fragmented, outdated, or limited in scope, especially regarding feed intake, manure management, and performance parameters. To address this gap, the present study was conducted to collect additional data from multiple sources, including on-farm surveys, provincial-level expert group discussions, and expert consultations. The objective is to provide a comprehensive, validated dataset for use in Tier 2 GHG inventories, thereby improving the accuracy of national emission estimates and supporting evidence-based livestock and climate policies in Vietnam.

Materials and methods

Material, Locations, and Time

The study was conducted in six provinces (Hanoi, Bac Giang, Thanh Hoa, Binh Dinh, Dong Nai, and Ben Tre) representing the northern, central, and southern regions of Vietnam in terms of dairy and beef cattle production. Data collection and fieldwork were carried out from March 2024 to October 2024. Collected data were used to estimate values for the period from 1994 to 2023.

Methods

Data Collection Strategy

A comprehensive review of available datasets and literature was first undertaken to identify critical gaps relevant to Tier 2 greenhouse gas (GHG) inventory development. Based on these gaps, appropriate methodologies were designed to capture missing information.

Manure management practices: Focus group discussions (FGDs) with provincial livestock officials and national experts.

Herd composition, animal weights, and growth performance: FGDs with experts, farmer interviews, and on-farm surveys.

Feeding systems and rations: FGDs with experts and provincial officials, farmer interviews, and extrapolation following IPCC guidelines.

Reproductive and production performance (e.g., calving rates, lactation, milk yield, milk composition): Expert group discussions and farmer interviews.

Workload and management practices: Expert FGDs and farmer interviews.

Field sampling survey

Focus group discussions (FGDs) with experts: A total of 10 experts specializing in cattle production systems, animal nutrition and feed, and manure management were invited from research institutes, universities, and the Department of Livestock Production across the northern, central, and southern regions of Vietnam. The consultations focused on defining cattle age groups (e.g., calves, growing, reproductive age), production systems, and fattening regimes.

FGDs with provincial livestock officials (PLO): In each of the six provinces, 5–6 livestock and animal health officials participated in FGDs. Discussions focused on: (i) The distribution of cattle sub-categories (growing, breeding, fattening, feedlot); (ii) Feeding systems (stall-fed, confined grazing, extensive grazing) and their relative proportions; (iii) Manure management practices by species and production system over different time periods (1994–2023).

Interviews with dairy and other cattle farmers: Interviews were conducted with 222 cattle farms across the six provinces (Bac Giang, Hanoi, Thanh Hoa, Binh Dinh, Dong Nai, and Ben Tre). In each province, for dairy and other cattle, two to three large farms (>300 cows); 15-20 medium farms (>20 and <300 cows); and 15-20 small farms (< 20 cows) were invited for interviews randomly under the introduction of the local authorities.

Data Processing and Statistical Analysis

All collected data were compiled in Microsoft Excel. Statistical checks were applied to assess representativeness and minimize bias across regions and farm types. When direct measurements were unavailable, extrapolation and interpolation methods consistent with IPCC (2006; 2019) guidelines were used to estimate values.

Results and discussion

Data Gap Filling for Tier 2 GHG Inventory in Dairy Cattle

Breed Structure of Dairy Cattle

Dairy cattle are classified into three breed groups: HF cattle, HF crossbred cattle, and other dairy cattle. These breed groups exhibit different milk production capacities, which in turn influences methane (CH_4) emission factors. The breed structure of dairy farming is presented in Table 1. The data in this table was collected from two main sources: provincial-level expert group discussions and survey data.

Table 1. Breed structure in periods from 1994-present

Period	Breed	Unit	North		Central		South	
			Household	Farm	Household	Farm	Household	Farm
1994–2017	HF crossbred*	%	50.2	50.2	0.0	0.0	0.0	0.0
	HF*	%	49.8	49.8	100.0	0.0	0.0	0.0
	Other dairy cattle*	%	0	0	0	0	0	0
2018–Present	HF crossbred	%	85.0	83.07	51.08	29.65	92.50	89.72
	HF	%	10.0	14.86	48.92	70.35	7.50	10.28
	Other dairy cattle	%	5.0	2.07	0.00	0.00	0.00	0.00

Note: The percentage values in table 1 represent the average of data collected from two sources: provincial expert group discussions and survey data.

The breed composition within each breed group was further divided into two categories: lactating cows and other cows. The percentage data for each category was obtained from two sources: provincial expert group discussions and on-farm survey data. The proportion of each category within the breed groups was consistent across the three regions: North, Central, and South.

The current structure of dairy cattle herds is presented in table 2. The data in this table represents the average values derived from both sources. The variation between the two sources is minimal, and the differences in the average values are insignificant. Thus, data from both sources are considered reliable. However, organizing expert group discussions is faster and requires less time and effort than conducting farm surveys. Therefore, for this indicator, data collection through provincial-level expert discussions is a feasible approach.

Table 2. Current breed structure of of dairy cattle farming

Breed	Growth Stage	Unit	North	Central	South
HF crossbred	Total herd	%	100.00	100.00	100.00
	Lactating cows	%	58.18	54.04	53.34
	Other cows	%	41.82	45.96	46.66
HF	Total herd	%	100.00	100.00	100.00
	Lactating cows	%	46.15	43.08	58.73
	Other cows	%	53.85	56.92	41.27
Other dairy cattle	Total herd	%	0	0	0
	Lactating cows	%	0	0	0
	Other cows	%	0	0	0

Live Weight Estimation in Dairy Cattle

The weight of dairy cattle was categorized into two groups: lactating cows and other cows. The weight data used for these groups represents the average values collected from two sources: provincial-level expert group discussions and on-farm survey data. Table 3 presents the weight distribution of different dairy cattle breeds across regions, farm types, and growth stages.

Table 3. Current weight of dairy cattle

Breed	Growth Stage	North		Central		South	
		Farm	Household	Farm	Household	Farm	Household
HF Crossbred	Lactating cows	442.1		419.4	500.0	409.1	380.8
	Other cows	235.1		201.5	227.0	212.1	209.5
HF	Lactating cows	525.0		571.7		482.5	
	Other cows	215.0		333.0		222.8	

Among the different data sources, on-farm survey data is considered the most accurate for assessing cattle weight. In dairy farms, cattle are weighed regularly, making it easy to obtain precise measurements. Although household farmers do not weigh their cattle as frequently as commercial farms, they can estimate weights fairly accurately based on their experience.

For provincial experts and policymakers, weight data is typically derived from reports submitted by farms or results from development projects and research programs. Given the higher accuracy of direct on-farm measurements, it is recommended to prioritize survey data collected from dairy farms for weight-related indicators.

Milk Production Performance of Dairy Cattle

Indicators related to milk production, such as lactation length per cycle, milk yield, milk fat content, and protein percentage, are currently lacking and need further investigation. Typically, dairy farms maintain detailed records of milk production, making data collected from these farms highly reliable.

The average lactation period of dairy cows is over 300 days, so milk production data is generally surveyed once per year. Table 4 summarizes the milk production performance of different dairy cattle breeds.

Table 4. Dairy production performance by breed

Breed	Indicator	Unit	North		Central		South	
			Farm	Household	Farm	Household	Farm	Household
HF crossbred	Calving interval	months	13.81		14.29	15.00	13.74	14.35
	Lactation length per cycle	days	306.25		325.00	385.00	327.53	314.00
	Milk yield per cycle	kg	5199.0		4600.0	5345.0	4136.7	4141.7
	Milk fat content	%	3.93		3.78	4.10	4.59	4.41
	Milk protein content	%	6.83		8.58	8.50	8.89	8.83
HF	Calving interval	months	18.00		14.50		15.50	
	Lactation length per cycle	days	360.00		316.67		380.00	
	Milk yield per cycle	kg	7200.0		6008.1		5335.0	
	Milk fat content	%	4.00		3.57		4.25	
	Milk protein content	%	8.50		8.60		9.00	

Source: On-farm survey data

Proportion of Dairy Cattle in Different Farming Systems

By analyzing the proportion of dairy cattle raised under different farming systems and the total number of cattle, it is possible to estimate the number of cows in farms and households. There has been a significant shift in dairy farming from household-based operations to farm-based systems, particularly in recent years. The proportion of dairy cattle raised in households and farms was collected through provincial expert group discussions (table 5).

This indicator varies depending on the livestock development strategy of each province or national livestock development plans. Therefore, collecting this data every five years is considered appropriate.

Table 5. Proportion of dairy cattle in different farming systems

Period	Farming system	Unit	North	Central	South
1994-2017	Household	%	0	32.15	100
	Farm	%	0	67.85	0
2018-nay	Household	%	68	2.15	40
	Farm	%	32	97.85	60

Source: Provincial expert group discussions

Feeding Practices of Dairy Cattle

Dairy cattle feed is categorized into different types: Total mixed ration (TMR), concentrate feed, fresh forage, dry roughage, and supplements. The quantity and type of feed have a direct impact on milk productivity. For dairy cows, feed availability remains stable in both the rainy and dry seasons. Sufficient preparation of fresh forage ensures that milk productivity is not affected by seasonal changes.

Feed data is collected from on-farm surveys, and this data collection is typically conducted once per year. Table 6 summarizes feeding practices for dairy cattle in different farming systems, across different breeds and seasons.

Table 6. Dairy cattle feeding by farm type and season

Period	Unit	HF cattle				HF crossbred cattle			
		Rainy season		Dry season		Rainy season		Dry season	
		Farm	Household	Farm	Household	Farm	Household	Farm	Household
Lactating cows									
TMR	kg	27.50		27.50					
Concentrate feed	kg	5.00		5.00		8.50	6.50	8.50	6.57
Fresh forage	kg						15.00		15.00
-Cultivated grass	kg	34.33		29.33		31.30	33.67	26.94	30.00
-Corn stalks/leaves	kg					11.00	14.00	10.00	10.00
Dry roughage	kg	1.50		1.50		4.62	3.79	4.48	3.57
Silage	kg	5.00		7.50		13.18	7.00	13.00	8.50
Mineral premix, salt lick	% *	0.00		0.00		68.29	85.71	65.85	85.71
Other	kg	7.63		4.50		8.14	7.00	11.49	
Non-lactating cows									
TMR	kg	18.00		18.00					
Concentrate feed	kg	1.30		1.30		2.08	2.28	2.05	2.25
Fresh forage	kg								4.00
-Cultivated grass	kg	22.67		19.89		21.40	18.44	17.67	16.00
-Corn stalks/leaves	kg								
Dry roughage	kg	1.53		1.53		3.32	3.47	3.23	3.70
Silage	kg					25.60		21.76	
Mineral premix, salt lick	% *	0.00	0.00	0.00	0.00	43.09	52.38	42.28	52.38
Other	kg	1.83		1.83		5.37		8.93	

**: % of farms reporting using this supplement*
Source: On-farm survey data

Manure Management Systems in Dairy Farms

Data on manure management methods was collected from two sources: provincial expert group discussions and on-farm surveys. A comparison of data from both sources showed only minor discrepancies, indicating that both sources are reliable for use. However, organizing expert group discussions is quicker and requires less time and effort than conducting on-site farm surveys. Therefore, data on this indicator can be collected primarily through provincial-level expert group discussions (table 7).

Table 7. Manure management systems in dairy cattle production

Period	Manure Management Method	Unit	North		Central		South	
			Household	Farm	Household	Farm	Household	Farm
1994-2017	Storage in piles/bags (no additives)	%	0.0		13.6	25.0	6.2	0.0
	Storage in piles/bags with additives (straw, microbial inoculants, lime, etc.)	%	5.5		25.0	0.0	0.0	0.0
	Use of biological bedding	%	0.0		0.0	0.0	0.0	0.0
	Use of stall bedding (no microbial additives)	%	0.0		0.0	0.0	0.0	0.0
	Biogas system	%	85.0		10.4	0.0	0.8	3.0
	Drying manure	%	0.0		40.2	75.0	79.8	97.0
	Lagoon (large covered ponds/tanks)	%	0.0		0.0	0.0	1.0	0.0
	Wastewater ponds/ channels for slurry	%	5.5		0.0	0.0	0.0	0.0
	Fresh manure collection and daily application to fields	%	4.0		4.1	0.0	9.8	0.0
	Direct discharge into public drainage systems (canals, ditches, rivers)	%	0.0		0.0	0.0	1.5	0.0
	Other	%	0.0		6.8	0.0	0.9	0.0
	Total	%	100.0		100.0	100.0	100.0	100.0
2018-present	Storage in piles/bags (no additives)	%	0.0		14.3	25.0	12.2	11.5
	Storage in piles/bags with additives (straw, microbial inoculants, lime, etc.)	%	2.4		2.1	0.0	0.0	0.0
	Use of biological bedding	%	0.0		0.0	0.0	0.0	0.0
	Use of stall bedding (no microbial additives)	%	0.0		0.0	0.0	0.0	0.0
	Biogas system	%	85.7		10.4	0.0	3.6	4.6
	Drying manure	%	0.0		61.1	75.0	80.3	81.7
	Lagoon (large covered ponds/tanks)	%	0.0		0.0	0.0	0.3	0.0
	Wastewater ponds/ channels for slurry	%	2.4		0.0	0.0	0.0	0.0
	Fresh manure collection and daily application to fields	%	9.6		5.4	0.0	2.7	0.0
	Direct discharge into public drainage systems (canals, ditches, rivers)	%	0.0		0.0	0.0	0.4	0.0
	Other	%	0.0		6.8	0.0	0.5	2.3
	Total	%	100.0		100.0	100.0	100.0	100.0

Source: On-farm survey data

Data Gap Filling for Tier 2 GHG Inventory in Other Cattle Other cattle (excluding feedlots)

Breed Structure of Other Cattle (Excluding Feedlots)

Beef cattle breeds are classified into four breed groups and one group of intensively fattened cattle. The four breed groups include: local cattle (Yellow cattle), Lai Sind cattle (Yellow × Sind), other Zebu crossbreeds (Brahman, Droughtmaster, Sahiwal, etc.), and other specialized beef cattle (BBB, Limousin, Angus, Charolais, etc.). The classification of beef cattle into these groups is based on body size and stature, which directly relate to productivity. Since productivity affects methane (CH_4) emissions, this classification is relevant for emissions assessments.

Table 8. Structure of beef cattle breeds at household and farm scale in three regions (1994–present) (%)

Period	Breed	North		Central		South	
		Household	Farm	Household	Farm	Household	Farm
1994-2000	Local breed	94	30	63.5	43.5	65	20
	Lai Sind	6	60	24	36.5	20	10
	Other Zebu crossbred	0	8	11	19	14	50
	Other specialized beef breed	0	1	1.5	1	1	20
	Beef cattle at feedlot	0	2	0	0	0	0
2001-2015	Local breed	50	20	23.1	11.6	40	17.5
	Lai Sind	30	50	50.9	55.9	35	32.5
	Other Zebu crossbred	18.5	27.5	22	27	15	35
	Other specialized beef breed	1.5	2.5	4	5.5	10	15
	Beef cattle at feedlot	0	0	0	0	0	0
2016-present	Local breed	11.3	9.3	14.9	7	15	8.5
	Lai Sind	25.3	35.9	21.4	18.5	30.2	24.6
	Other Zebu crossbred	31.2	28.5	43.7	46.6	26	34.2
	Other specialized beef breed	31	25.1	19.3	27.2	22.1	22.7
	Beef cattle at feedlot	1.2	1.2	0.7	0.7	6.7	10

The proportions of beef cattle breeds raised at household and farm levels were gathered from three sources: (1) expert consultations, (2) provincial-level focus group discussions, and (3) surveys conducted at livestock farms. The percentage figures in table 8 represent the average values obtained from these sources. For the periods 1994–2000 and 2001–2015, the data represent the average values from sources (1) and (2). For the period from 2016 to the present, the data represent the average values from all three sources.

The discrepancies between data from sources (2) and (3) compared to the average values were smaller than those between source (1) and the average. Therefore, breed structure data can be obtained from source (2), which is the provincial-level expert focus group discussions.

Moreover, current livestock data is managed through digital software, updated regularly (twice a year), allowing provincial livestock management officials to track the number and breed composition of cattle in their respective provinces.

The proportions of different breed groups remain relatively stable over a certain period. Changes occur when there are shifts in government policies, provincial strategies, or international project support. Currently, provincial livestock development strategies are typically planned in five-year cycles. Therefore, five years is a suitable timeframe for reassessing the breed composition.

Table 9. Current cattle population structure by growth stage for each breed (in percentage)

Breed	Growing stage	North	Central	South
Local breed	Total herd	100	100	100
	Growing cattle (0–17 months)	21	36	50
	Fattening cattle (18–30 months)	49	17	18
	Breeding cattle (>30 months)	30	47	32
Lai Sind	Total herd	100	100	100
	Growing cattle (0–17 months)	17	43	32
	Fattening cattle (18–30 months)	47	29	16
	Breeding cattle (>30 months)	37	28	51
Other Zebu crossbreeds	Total herd	100	100	100
	Growing cattle (0–17 months)	34	44	38
	Fattening cattle (18–30 months)	48	24	27
	Breeding cattle (>30 months)	18	31	35
Other specialized beef breeds	Total herd	100	100	100
	Growing cattle (0–17 months)	37	43	47
	Fattening cattle (18–30 months)	48	43	42
	Breeding cattle (>30 months)	15	14	11
Beef cattle in feedlots	Total herd	100.0	0.0	100.0
	Imported	0.0	0.0	80.0
	Domestic	100.0	0.0	20.0

The breed structure includes three categories based on growth stages: Growing cattle (0–17 months), fattening cattle (18–30 months), breeding cattle (>30 months). Different breeds and growth stages require distinct feeding regimes, which impact feed intake and methane emission factors. Therefore, determining the composition of each breed group within these growth stages is an important indicator.

The percentage distribution of cattle by growth stage within each breed was collected from two sources: provincial-level expert focus group discussions and on-site livestock farm surveys. The figures in Table 9 represent the average values from these two sources. The discrepancies between these sources were minimal, with only slight deviations from the average values. As a result, data from both sources are considered reliable. However, conducting expert discussions is a faster and less resource-intensive method compared to direct farm surveys. Therefore, for this indicator, data can be collected through provincial-level focus group discussions.

Weight Categories of Other Cattle (Excluding Feedlots)

Cattle weight is categorized into three growth stages: Growing stage (0–17 months), fattening stage (18–30 months), breeding stage (>30 months). The weight data for each cattle group represents the average values obtained from two sources: (1) Provincial-level expert focus group discussions and (2) Surveys conducted at livestock farms.

Among these sources, the most accurate data on the weight of male and female cattle at different growth stages for each breed comes from farm surveys. On farms, cattle are weighed regularly, making data collection straightforward. Although household farmers do not weigh their cattle as frequently as farms do, they can estimate weights with reasonable accuracy based on experience.

For provincial experts and livestock management officials, weight data is typically obtained through reports submitted by farms or results from various projects and programs. Therefore, to ensure the highest accuracy for weight indicators, data should primarily be collected through on-site farm surveys (Table 10).

Table 10. Cattle weight by growth stage

Period	Growth stage	Sex	North				Central				South			
			Local cattle (kg)	Lai Sind (kg)	Ot her Zebu cross (kg)	Other specialized beef breed (kg)	Local cattle (kg)	Lai Sind (kg)	Other Zebu cross (kg)	Other specialized beef breed (kg)	Local cattle (kg)	Lai Sind (kg)	Other Zebu cross (kg)	Other specialized beef breed (kg)
1994-2000	Growing stage (0–17 months)	Male	91.3	130.0	148.0		80.0	106.8			81.3	108.8		
		Female	75.5	114.5	130.0		74.9	93.3			78.8	98.3		
	Fattening stage (18–30 months)	Male	189.0	252.7	260.0		185.7	237.8			181.3	239.0		
		Female	159.7	225.7	226.7		164.8	203.0			163.0	202.7		
	Breeding stage (>30 months)	Male	240.0	299.3	306.7		239.8	299.2			223.0	321.7		
		Female	199.3	245.0	253.3		199.2	244.7			185.0	256.0		
2001-2015	Growing stage (0–17 months)	Male	96.3	120.0	150.5		84.9	119.6	162.5		82.5	111.8	177.3	
		Female	85.5	104.5	130.0		78.6	102.3	140.8		80.0	101.0	160.3	
	Fattening stage (18–30 months)	Male	216.7	246.7	358.7		192.7	248.0	366.5		183.7	244.3	389.7	
		Female	196.7	223.3	286.7		169.5	210.3	309.7		165.0	210.0	336.0	
	Breeding stage (>30 months)	Male	230.0	298.3	446.3		243.5	302.8	447.7		226.3	325.7	458.7	
		Female	210.0	246.7	323.3		202.5	244.8	379.7		187.7	255.7	419.3	
2016-present	Growing stage (0–17 months)	Male	118.3	141.6	168.6	237.9	93.4	133.9	164.3	218.5	86.7	118.4	184.4	201.9
		Female	96.3	116.9	144.8	188.5	91.8	113.7	143.5	191.8	82.5	106.1	154.8	177.0
	Fattening stage (18–30 months)	Male	235.8	277.4	361.7	457.4	198.0	264.2	374.9	549.2	188.0	255.7	395.0	544.1
		Female	205.7	240.5	310.0	439.7	192.1	243.4	309.7	442.4	170.7	214.3	308.6	242.5
	Breeding stage (>30 months)	Male	278.3	343.2	439.2		123.6	313.4	486.8		229.3	342.0	462.3	
		Female	236.7	297.2	366.3	240.0	253.6	293.7	372.6	253.2	195.8	264.3	377.0	

Reproductive Performance of Cattle

Key reproduction performance indicators, such as age at first calving, calving interval, and calf suckling duration, remain incomplete and require further investigation. These indicators vary between household farming and farm-scale operations. Farms generally have better technical support, breeding management, and care protocols, leading to higher productivity compared to household farms. In contrast, household farmers mainly rely on experience, which often results in lower livestock productivity.

While reproduction performance differs by breed and farming scale (farm vs. household), there was no significant variation across different regions (Table 11).

Typically, reproduction performance data is meticulously recorded by livestock establishments, especially in farm-scale operations. As a result, data collected directly from these farms is highly reliable. Due to the longer reproductive cycle of cattle compared to other livestock species, reproductive performance surveys are generally conducted every 2–3 years.

Table 11. Reproductive performance of beef cattle (in months)

Criteria	North		Central		South	
	Household	Farm	Household	Farm	Household	Farm
Local cattle						
Age at first calving	26.3	27	30.2	24.5	20.5	24
Calving interval	12.5	14	12	13.5	13.25	18
Duration of calf suckling	6.3	5.2	6.2	5.5	6.4	6.0
Lai Sind cattle						
Age at first calving	27.2	27.3	26.5	27.7	28.6	24.3
Calving interval	13.9	14.9	13.5	14.1	14.3	12.4
Duration of calf suckling	5.6	5.5	6.0	5.4	5.9	6.0
Other Zebu crossbreeds						
Age at first calving	28.8	29.5	29.5	28.1	29.6	24.8
Calving interval	13.6	14.2	14.3	14.7	14.3	14.4
Duration of calf suckling	5.8	5.7	6.0	5.7	5.6	6.3
Other specialized beef cattle						
Age at first calving	27.8	31.3	28.6	24.9	28.0	28.4
Calving interval	14.0	14.0	15.5	13.9	13.8	14.9
Duration of calf suckling	5.8	5.6	6.0	6.0	5.6	6.4

Source: On-farm surveys (2024)

Farm Types of Other Cattle

By analyzing the proportion of beef cattle raised under different farming systems and the total cattle population, it is possible to estimate the number of cattle kept in farms and household settings. Between 1994 and 2015, household farming accounted for a high proportion of beef cattle production across all three regions: North, Central, and South. However, as the livestock industry developed, the proportion of cattle raised in households and farms has gradually shifted, with farm-scale operations expanding significantly.

This indicator varies based on provincial livestock development strategies or national livestock policies. Therefore, collecting data every five years is considered appropriate to track changes in cattle farming structures over time.

Table 12 presents the distribution of beef cattle rearing across different farm types in various regions over different periods.

Table 12. Proportion of beef cattle by farming type

Period	Farm type	Unit	North	Central	South
1994-2000	Household	%	100	97.5	100
	Farm	%	0	2.5	0
2001-2015	Household	%	95	92.5	87.5
	Farm	%	5	7.5	12.5
2016-present	Household	%	76.5	89.5	70
	Farm	%	23.5	10.5	30

Source: FGDs with Provincial experts

Classification of Beef Cattle Production Systems:

Cattle rearing methods are categorized into three main types: free grazing, supplemented grazing, and confined housing. Data on these rearing methods were obtained from three main sources: (1) Expert consultations, (2) Provincial expert group discussions, (3) Surveys conducted at livestock farms. The reported figures represent the average values from these sources. During the 1994–2000 period, data were collected from sources (1) and (2). In the 2001–2015 period, data were obtained primarily from provincial expert group discussions (source 2).

From 2016 onwards, a comparison of the three data sources revealed that expert consultation data and on-site survey data were closer to the average values. Additionally, surveys provided insights into daily grazing duration and seasonal variations. As a result, on-site surveys are considered the most reliable method for collecting data on cattle rearing practices (table 13).

Table 13. Proportion of beef cattle by rearing method in farms and region

Period	Rearing method	Unit	North		Central		South	
			Household	Farm	Household	Farm	Household	Farm
1994-2000	Free grazing	%	85	32.5	65	60	64	28.5
	Semi- grazing	%	13.5	15	30.75	33.5	19.5	14
	Stall feeding	%	1.5	2.5	4.25	6.5	16.5	7.5
2001-2015	Free grazing*	%	95	0	15	5	50	0
	Semi-grazing*	%	5	100	60	40	20	20
	Stall feeding*	%	0	0	25	55	30	80
2016-present	Free grazing	%	48.3	21.7	31.5	20.5	23.4	19.0
	Semi- grazing	%	30.0	49.5	38.1	40.3	24.3	16.0
	Stall feeding	%	21.7	28.8	30.3	39.2	52.3	65.0

(source from FGDs with Provincial experts)*

Classification of Cattle Feeding Practices

Cattle feed is categorized into different groups, including Total Mixed Ration (TMR), concentrate feed, fresh forages, dry roughage, and supplementary feed. The type and quantity of feed vary by season and between household and farm-scale operations.

Household farms tend to use a more diverse range of feed types, often relying on agricultural by-products such as peanut stems, legume stalks, and sugarcane tops and leaves. This is due to the household farming system's focus on utilizing available resources efficiently.

In contrast, farm-scale operations provide more optimized and nutritionally balanced rations. Farms make greater use of TMR and concentrate on high-quality fresh forages such as cultivated grasses and silage corn, which offer superior nutritional value (table 14).

Data on cattle feed were collected through surveys conducted at livestock farms, with annual data collection being a suitable frequency.

Table 14. Feeding practices for other cattle in households and farms by season

Criteria	Unit	Local cattle				Lai Sind cattle				Other Zebu crossbreeds				Other specialized beef cattle			
		Rainy season		Dry season		Rainy season		Dry season		Rainy season		Dry season		Rainy season		Dry season	
		Farm	Household	Farm	Household	Farm	Household	Farm	Household	Farm	Household	Farm	Household	Farm	Household	Farm	Household
Growing cattle 0-17 months																	
TMR	kg	2.43		0.87		2.56		0.87						2.10	1.58	1.18	1.67
Concentrate	kg	1.07	0.77	1.07	0.64	1.60	1.27	1.57	1.27	2.37	1.65	2.51	1.57			1.74	
Roughage	kg		9.44		8.08		13.26		8.55	14.67	9.50	12.33	5.11	3.58	2.51	3.69	2.58
- Natural grass (cut and carry)	kg	8.33	12.67	10.00	12.00		7.83	8.00	7.22		4.00	6.67	4.83	10.30	9.73	9.48	7.86
- Growing grass	kg	12.17	9.67	12.33	6.17	12.11	9.12	11.55	8.76	10.73	11.28	10.97	10.75	8.84	9.34	7.56	7.90
- Maize stalk/ leaves	kg								8.00					10.68	11.73	10.83	11.52
- Sugar cane top/ leaves	kg				8.33										11.00		8.67
Dried roughage	kg		5.33	5.28	13.39	4.14	3.08	5.53	4.80	3.43	2.47	4.27	3.39				
Silage feed	kg		4.00		3.67		2.67	3.00	3.76		1.89		3.89	3.98	4.39	4.74	4.99
Mineral premix, lick stone (yes/no)	%	16.67	44.44	16.67	27.78	20.00	30.56	20.00	30.56	-	35.54	-	36.51	4.71	17.52	4.56	17.16
Others....	kg		0.23		0.47	0.27	0.37	0.28	5.31	3.00	1.70	2.00	1.54	2.93	25.86	3.67	27.99
Fattening cattle 18-30 months of age																	
TMR	Kg	2.75		1.50		4.00		1.50									
Concentrate	Kg	2.25		2.25		2.00		2.50		5.57	5.25	5.75	5.75	3.00	4.50	2.50	4.00
Roughage	Kg					30.00	15.00	20.00	15.00					3.91	3.10	4.07	3.04
- Natural grass (cut and carry)	Kg	10.00		10.00		10.00		10.00						15.00	17.00	13.33	24.00
- Growing grass	Kg	17.67		20.00		17.67		25.00		22.50	21.67	22.50	21.67	10.40	40.00	13.33	10.00
- Maize stalk/ leaves	Kg													23.81	20.61	24.00	26.42
- Sugar cane top/ leaves	Kg													15.00		15.00	
Dried roughage	Kg	5.00		9.00		7.50		7.50		8.50	7.50	8.50	7.50				
Silage feed	Kg	20.00		20.00		5.00		10.00		9.00	10.00	9.00	12.75	4.91	4.50	6.33	3.77
Mineral premix, lick stone (yes/no)	%	33.33		33.33		33.33	-	25.00	-	-	-	-	-	8.33	10.00	10.00	40.00
Others....	Kg	0.23		0.25		1.15		0.83						10.00	30.77	11.76	30.77
Breeding cattle >30 months of age																	
TMR	Kg	2.63		2.10		2.73		2.00			1.00		1.00				
Concentrate	Kg	2.00	0.83	1.00	0.95	2.65	1.72	2.68	1.74	2.50	2.21	2.67	2.03	4.00	4.00		
Roughage	Kg		31.75		17.50	15.00	18.70	15.00	16.25	22.50	23.33	9.00	10.00	4.39	3.12	4.23	2.92
- Natural grass (cut and carry)	Kg	10.00	17.40	12.50	25.00	18.00	13.33	15.83	13.33	15.00	21.67	17.67	25.00	12.50	27.93	15.00	21.00
- Growing grass	Kg	20.75	15.00	25.00	13.33	20.46	16.45	24.67	15.19	21.42	21.04	23.82	19.77	5.00	17.86	20.00	20.00
- Maize stalk/ leaves	Kg			25.00		10.00	10.00	17.50	12.50			10.00		18.80	22.05	22.10	26.67
- Sugar cane top/ leaves	Kg		30.00		20.00		30.00		30.00							15.00	
Dried roughage	Kg	3.25	12.00	6.50	16.40	5.25	4.98	5.81	6.94	7.00	5.45	7.63	6.33		40.00		30.00
Silage feed	Kg	30.00	5.00	30.00	6.67	10.50	4.25	9.33	4.63	7.40	2.00	8.00	15.80	6.20	6.73	6.78	6.72
Mineral premix, lick stone (yes/no)	%	25.00	33.33	25.00	33.33	18.75	38.89	17.65	45.16	-	33.33	-	30.77	15.00	10.00	8.63	6.00
Others....	Kg	0.15	0.51		0.68	1.73	8.01	2.15	10.11	5.00	1.53	3.00	2.26	-	27.59	-	27.59

Source: On-farm surveys

Manure Management Practices in Other Cattle Farms

Data on manure management practices were collected from two sources: (1) Provincial expert group discussions and (2) Surveys conducted at livestock facilities.

The figures in table 16 represent the average values from both sources. A comparison of the data collected from these two sources and their average values shows that discrepancies are minimal. Therefore, data from both sources can be considered reliable for analysis.

However, organizing expert group discussions is a faster and less labor-intensive process than conducting farm-level surveys. Given this, manure management data can be effectively collected through provincial expert group discussions (Table 15).

Table 15. Manure management practices for other cattle (1994–present) (in percentage %)

Period	Manure Management Method	North		Central		South	
		Household	Farm	Household	Farm	Household	Farm
1994-2000	Stored in piles/bags (no additional treatment)	51.3	14.3	40.4	135.7	54.8	40.0
	Stored in piles/bags with additives (straw, microbial fermentation, lime, etc.)	40.0	71.4	22.1	28.6	10.0	22.5
	Use of biological bedding	0.0	0.0	0.0	0.0	0.0	10.0
	Use of stall bedding material (without microbial additives)	0.0	0.0	10.0	0.0	5.0	0.0
	Biogas system	0.0	0.0	0.0	0.7	7.5	12.5
	Drying manure	0.0	0.0	15.4	0.0	42.3	0.0
	Lagoon system (large covered ponds/tanks)	0.0	0.0	0.0	0.0	0.0	0.0
	Ponds, ditches, or tanks for slurry waste storage	0.0	14.3	0.0	0.0	1.3	0.0
	Collection of fresh manure for daily field application	15.0	0.0	17.5	0.0	0.8	0.0
	Direct discharge into public ditches, canals, or rivers	13.8	0.0	7.3	0.0	0.9	0.0
	Other methods	0.0	0.0	2.5	5.7	0.0	30.0
	Total	100	100	100	100	100	100
2001-2015	Stored in piles/bags (no additional treatment)	7.4	13.2	17.0	39.6	23.4	36.3
	Stored in piles/bags with additives (straw, microbial fermentation, lime, etc.)	31.3	15.7	44.5	30.0	25.9	27.5
	Use of biological bedding	0.0	7.1	0.0	0.0	0.0	0.0
	Use of stall bedding material (without microbial additives)	23.8	35.0	20.5	0.0	18.8	0.0
	Composting with aeration (without turning) / Hot composting	0.0	0.0	1.3	0.0	1.8	0.0

Period	Manure Management Method	North		Central		South	
		Household	Farm	Household	Farm	Household	Farm
	Composting with turning (without aeration) / Hot composting	0.0	0.0	3.0	0.0	0.0	0.0
	Biogas system	34.2	42.1	3.1	0.8	1.8	3.8
	Drying manure	0.0	7.1	14.1	0.0	43.4	48.5
	Lagoon system (large covered ponds/tanks)	0.0	0.0	0.0	0.0	0.1	0.3
	Ponds, ditches, or tanks for slurry waste storage	0.0	8.6	1.9	0.0	0.3	0.0
	Collection of fresh manure for daily field application	20.0	0.0	2.9	47.7	5.6	1.3
	Direct discharge into public ditches, canals, or rivers	10.6	0.0	2.3	1.5	0.7	0.0
	Other methods	0.0	7.1	1.1	10.8	1.1	15.0
	Total	100	100	100	100	100	100
2016-present	Stored in piles/bags (no additional treatment)	45.6	15.9	29.7	88.3	36.5	27.5
	Stored in piles/bags with additives (straw, microbial fermentation, lime, etc.)	19.0	22.9	38.3	43.3	7.2	0.0
	Use of biological bedding	0.0	0.0	0.0	0.0	5.0	0.0
	Use of stall bedding material (without microbial additives)	0.0	0.0	0.0	0.0	0.0	0.0
	Composting with aeration (without turning) / Hot composting	0.0	0.0	0.0	0.0	0.0	0.0
	Composting with turning (without aeration) / Hot composting	0.0	0.0	2.1	0.0	0.0	0.0
	Composting with aeration and turning / Hot composting	0.0	0.0	0.0	0.0	0.0	0.0
	Biogas system	19.5	42.9	3.2	12.8	1.8	2.6
	Drying manure	11.2	5.9	34.9	6.7	47.1	54.5
	Lagoon system (large covered ponds/tanks)	0.0	0.0	0.0	0.0	0.1	0.1
	Ponds, ditches, or tanks for slurry waste storage	3.3	6.5	1.3	0.0	0.3	0.0
	Collection of fresh manure for daily field application	14.3	0.0	8.8	34.4	10.2	11.6
	Direct discharge into public ditches, canals, or rivers	10.8	0.0	2.1	1.1	0.4	0.0
	Other methods	0.0	5.9	3.2	13.3	1.0	7.5
	Total	100	100	100	100	100	100

Manure was handled through multiple systems, with distinct differences between smallholders and commercial farms:

Smallholder farms: predominantly drying (40–50%), direct field application (5–15%), and simple storage (15–30%).

Commercial farms: higher adoption of biogas digesters (10–15%), controlled drying (60–80%), and limited lagoon or slurry storage (<5%).

Regional patterns show biogas use concentrated in the South (up to 10–12% of farms), while drying remains dominant in the North and Central regions (>60%).

Each manure management system (MMS) corresponds to specific methane conversion factors (MCFs) under IPCC Tier 2 guidelines:

Lagoon/discharge systems: highest MCFs (up to 80%), leading to substantial CH_4 emissions.

Biogas digesters: reduce net emissions by up to 60–70%, though leakage risks remain.

Drying and composting: lower CH_4 emissions but increase potential N_2O release under poor aeration.

Direct field application: a common smallholder practice, associated with elevated N_2O emissions.

Quantifying the fraction of manure in each system enables country-specific emission factor adjustments. Applying default Tier 1 assumptions would underestimate emissions from smallholder systems, where lagoon/discharge and uncontrolled drying are still widespread. Integrating these distributions reduces inventory uncertainty and aligns reporting with IPCC (2019) recommendations.

Improved manure management provides substantial opportunities for emission reduction:

Expanding adoption of biogas systems in dairy farms, coupled with leakage control.

Promoting improved composting and drying techniques to balance CH_4 and N_2O trade-offs.

Reducing direct discharge into waterways through targeted policy and extension programs.

These measures, combined with periodic monitoring (every 3–5 years), will enhance the accuracy of Tier 2 inventories and support Vietnam's national GHG mitigation strategies.

Feedlot

Number of Fattened Cattle in Feedlots

Data on beef cattle fattening in feedlots were collected from survey sources. From these surveys, the total number of cattle undergoing fattening, the duration of the fattening period, and the weight gain during this period were obtained (Table 16). Since the number of fattened cattle varies annually, it is necessary to collect these data once per year.

Table 16. Number of fattened cattle in the feedlots by region

	Imported			Domestic		
	North	**Central**	**South**	**North**	**Central**	**South**
Castrated Males						
Number of animals			1547.5			
Age at entry (months)			25.57			
Age at sale (months)			34.43			
Weight at entry (kg)			445.33			
Weight at sale (kg)			654.67			

	Imported			Domestic		
	North	Central	South	North	Central	South
Uncastrated Males						
Number of animals		350	2283.33			590
Age at entry (months)		10.5	24.84			25.33
Age at sale (months)		14.5	29.41			31.67
Weight at entry (kg)		260	454.53			291.67
Weight at sale (kg)		420	586.33			466.67
Females						
Number of animals						240
Age at entry (months)						24
Age at sale (months)						28.5
Weight at entry (kg)						225
Weight at sale (kg)						365

Source: Survey data from livestock farms.

The feed used for feedlot beef cattle fattening consists entirely of Total Mixed Ration (TMR) and Fermented Total Mixed Ration (FTMR). Fattening cattle are fed high-nutrient diets for a short rearing period. Data on the daily feed intake of concentrated fattening cattle were collected from farm surveys (Table 17). These data must also be updated annually.

Table 17. Feed for cattle in the feedlots

Breed	Feed Type	North	Central	South
Brahman	TMR		28.5	20.7
	FTMR			
Droughtmaster	TMR			21.3
	FTMR			
Angus	TMR			19.5
	FTMR			
Charolais	TMR			15
	FTMR			
BBB	TMR			17
	FTMR			
Wagyu	TMR			25
	FTMR			
Lai Sind	TMR			12
	FTMR			
Local cattle	TMR			
	FTMR			15

Source: Survey data from livestock farms

Classification of the manure management in feedlots:

Manure management data were collected through surveys conducted at livestock farms (table 18).

Table 18. Manure management methods in the feedlots (in percentage %)

Manure management practice	North	Central	South
Stored in piles/bags (without additives)			21.2
Stored in piles/bags with additives (straw, microbial fermentation, lime, etc.)			
Use of biological bedding		100	30.3
Composting with aeration and turning / Hot composting			30.3
Biogas system			
Drying manure			18.2
Ponds, ditches, or tanks for slurry waste storage			
Collection of fresh manure for daily field application			
Direct discharge into public ditches, canals, or rivers			
Other methods			
Total		100	100

Source: Survey data from livestock farms

Conclusions and recommendation

Conclusion

This study provided a country-specific dataset for the Tier 2 greenhouse gas emission inventory in dairy and beef cattle farming in Vietnam. Important parameters collected included breed structure, herd structure, live weight, milk yield, growth rate, diet, and manure management system. The results showed marked differences between regions and production types, as well as heterogeneity in manure management – factors that directly affect CH_4 and N_2O emission coefficients.

The combination of three data sources – farm surveys (n = 222), provincial group discussions, and expert opinions – increased reliability, while allowing for the reconstruction of the historical data series (1994–2023). Compared to the Tier 1 methodology, the application of national parameters in Tier 2 will significantly reduce inventory errors and more accurately reflect the actual emissions of the cattle industry.

The study proposes periodic data collection cycles: 2–3 years for dairy cow productivity; 3–5 years for herd structure, beef cattle growth and manure management; and update as soon as there are changes in the production system. At the same time, it is necessary to promote the expansion of biogas, improve composting, and limit direct discharges in order to both improve inventory accuracy and reduce actual emissions.

These results create a solid scientific basis for Vietnam to implement Tier 2 inventory, improve the transparency of emission reporting, and develop policies to mitigate emissions in livestock, contributing to achieving the goal of net zero emissions by 2050.

Recommendation

To ensure accurate Tier 2 inventories, we recommend establishing regular data collection cycles: every 2–3 years for dairy productivity, every 3–5 years for beef cattle growth, herd structure, and manure management, with immediate updates when production systems change. Particular attention should be given

to manure management, where expanding biogas adoption, improving composting and drying practices, and discouraging direct discharge can substantially reduce CH_4 and N_2O emissions. Integrating disaggregated data from smallholder and commercial systems into national inventories will enhance precision and reduce uncertainty compared to Tier 1. Finally, closer collaboration among research institutes, government agencies, and local authorities is essential to maintain updated datasets, support transparent emission reporting, and design effective mitigation strategies aligned with Vietnam's net-zero 2050 target.

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