



L/-	key source by <b>L</b> evel only
-/T	key source by <b>T</b> rend only
L/T	key source by both <b>L</b> evel and <b>T</b> rend
-/-	no key source for this pollutant
IE	emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category)
NE	emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)
NA	specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable
*	no analysis done

## Country specifics



In 2024, NH<sub>3</sub> emissions from category 3.B (manure management) were 38.8 % from total agricultural emissions, which is equal to ~ 187.7 kt NH<sub>3</sub>. Within those emissions 42.7 % originate from cattle manure (~ 80.2 kt), 32.3 % from pig manure (ca. 60.7 kt), and 12.3 % from poultry manure (~ 23.1 kt). Calculations take into account the impact of anaerobic digestion of manure on the emissions.

NO<sub>x</sub> emissions from category 3.B (manure management) contribute only 1.6 % (~ 1.6 kt) to the total agricultural NO<sub>x</sub> emissions. They are calculated proportionally to N<sub>2</sub>O emissions, see Vos et al. (2026) <sup>1)</sup>.

NM VOC emissions from category 3.B (manure management) contributed 97.1 % (291.7 kt) from total agricultural NM VOC emissions (300.6 kt).

In 2024, manure management contributed, respectively, 61.6 % (37.2 kt), 33.3 % (11.6 kt) and 66.4 % (3.5 kt) to the total agricultural TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions (TSP: 60.4 kt, PM<sub>10</sub>: 34.7 kt, PM<sub>2.5</sub>: 5.3 kt, respectively).

### Activity data for all pollutants

The Federal Statistical Agency and the Statistical Agencies of the federal states carry out surveys in order to collect, along with other data, the head counts of animals. The results of these surveys are used for emission calculations, for details see Vos et al. (2026), Chapter 2.3.

The animal population figures used in the inventory are presented in Table 1. Buffaloes are included in the cattle population figures, mules and asses are included in the horse population figures (IE), see Vos et al. (2026), Chapter 2.3. In the first years after the German reunification in 1990 animal livestock decreased markedly. The head counts for cattle continued to decrease significantly until 2006/2007, followed by a more or less stable period until 2014. Since 2015 a slight decrease occurred. In 2024, dairy cattle numbers are 56.5 % of 1990 numbers, while the total population of other cattle is at 52.3 % of 1990. Swine numbers decreased until 1995 and then increased slightly. Since 2014 a new decrease occurred which became

significant between 2020 and 2022 (total swine numbers were reduced by around 18 % within two years). 2024 swine numbers are 66.6 % of 1990 numbers. The 2024 numbers of horses, sheep and goats are, respectively, at 99.6 %, 55.9 % and 183.5 % of 1990.

Figures for broilers and turkeys are showing a massive increase since 1990. Since the year 2013, there have been only minor changes of total poultry numbers. In total, 2024 poultry population figures are at 147.2 % of 1990.

Emissions of deer, rabbits, ostrich and fur-bearing animals are reported since submission 2024. The underlying animal numbers of these categories were estimated in different ways because there are no surveys which collect those animal numbers. However, the impact of those animal categories on the total emissions is small.

A detailed description of the animal numbers used can be found in Vos et al. (2026), chapter 2.3.

Table 1: Population of animals, in [1,000 individuals]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>dairy cattle</b>	6,354.6	5,229.4	4,569.8	4,236.4	4,183.1	4,284.6	4,217.7	4,199.0	4,100.9	4,011.7	3,921.4	3,832.7	3,809.7	3,712.8	3,589.4
<b>other cattle</b>	13,133.4	10,660.5	9,968.9	8,800.4	8,628.7	8,350.8	8,248.9	8,082.2	7,848.2	7,627.9	7,380.5	7,206.9	7,187.2	7,123.4	6,871.9
<b>buffalo</b>	NO	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
<b>mules and asses</b>	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
<b>horses</b>	1,373.5	1,743.9	1,373.7	1,398.1	1,269.9	1,233.1	1,215.4	1,223.4	1,231.5	1,239.5	1,247.6	1,277.8	1,308.0	1,338.2	1,368.3
<b>sheep</b>	3,266.1	2,990.7	2,743.3	2,643.1	2,245.0	1,866.9	1,851.0	1,863.2	1,846.0	1,813.6	1,780.3	1,794.8	1,805.7	1,847.6	1,824.5
<b>goats</b>	90.0	100.0	140.0	170.0	149.9	135.9	138.8	142.8	146.9	150.9	154.9	157.5	160.0	162.6	165.2
<b>swine</b>	26,502.5	20,387.3	21,767.7	22,742.8	22,244.4	22,978.5	22,761.2	22,920.8	22,019.2	21,625.8	21,622.0	19,728.6	17,692.3	17,525.3	17,642.7
<b>laying hens</b>	53,450.5	47,575.8	48,640.0	43,641.6	41,700.5	50,619.3	51,935.5	52,571.1	53,206.6	53,842.1	54,477.6	54,921.5	55,365.4	55,809.3	56,084.2
<b>broilers</b>	35,393.0	46,625.9	61,940.7	76,045.0	98,389.7	94,909.4	93,791.3	93,458.7	93,126.1	92,793.5	92,461.0	91,004.5	89,548.1	88,091.6	88,091.6
<b>turkeys</b>	5,029.2	6,742.0	8,893.1	10,611.1	11,344.0	12,658.5	12,359.9	12,164.7	11,969.5	11,774.3	11,579.1	10,718.9	9,858.6	8,998.3	8,998.3
<b>pullets</b>	17,210.8	16,149.2	17,284.1	16,050.9	14,827.0	13,828.3	12,921.8	12,736.3	12,550.7	12,365.1	12,179.6	12,253.0	12,326.5	12,399.9	12,399.9
<b>ducks</b>	2,013.7	1,933.7	2,055.7	2,352.2	3,164.3	2,410.8	2,236.4	2,209.1	2,181.9	2,154.6	2,127.4	1,949.3	1,771.2	1,593.1	1,593.1
<b>geese</b>	781.5	617.0	404.8	329.5	278.1	400.8	329.0	327.7	326.3	324.9	323.5	354.2	385.0	415.7	415.7
<b>deer</b>	155.8	204.0	252.3	261.5	270.0	277.4	278.9	280.4	281.9	283.3	284.8	286.3	287.8	289.3	290.8
<b>rabbits</b>	1,851.4	1,565.6	1,268.9	997.0	864.2	720.7	691.2	642.7	608.3	593.9	548.4	470.0	430.6	422.8	422.5
<b>ostrich</b>	NO	1.2	2.5	3.7	4.9	7.7	7.4	7.4	7.9	7.4	7.9	6.1	5.1	4.6	4.0
<b>fur animals</b>	179.9	179.9	179.9	153.5	121.7	34.4	24.7	15.0	5.3	5.3	NO	NO	NO	NO	NO

## Additional data

Emission calculations in accordance with a Tier 2 or Tier 3 method require data on animal performance (animal weight, weight gain, milk yield, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feeding details (phase feeding, feed components, protein and energy content, digestibility and feed efficiency). To subdivide officially recorded total numbers of turkeys into roosters and hens, the respective population percentages need to be known. Details on data requirements for the modelling of emissions from livestock husbandry in the German inventory can be found in Vos et al. (2026), Chapter 2.

Most of the data regarding feed and performance is not available from official statistics and was obtained from literature, from publications by agricultural associations, from guidelines for agricultural consulting in Germany and from expert judgments.

For 1991, 1995 and 1999, frequency distributions of feeding strategies, husbandry systems (shares of pasturing/stabling; shares of various housing methods), storage types as well as techniques of farm manure spreading were obtained with the help of the RAUMIS agricultural sector model (Regionalisiertes Agrar- und UmweltInformationssystem für Deutschland/ Regionalised agricultural and environmental information system for Germany). RAUMIS has been developed and is operated by the Institute of Rural Studies of the Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries). For an introduction to RAUMIS see Weingarten (1995)<sup>2)</sup>; a detailed description is provided in Henrichsmeyer et al. (1996)<sup>3)</sup>.

RAUMIS did not model complete time series but only selected years. RAUMIS data for the years 1991, 1995, and 1999 are used in the inventory for the respective years. For 1990, the data for 1991 is adopted, for the intervening years (1992-1994 and 1996-1998) data gaps were closed by linear interpolation on district level.

For the year 2009, respective data are used that were derived from the 2010 official agricultural census and the

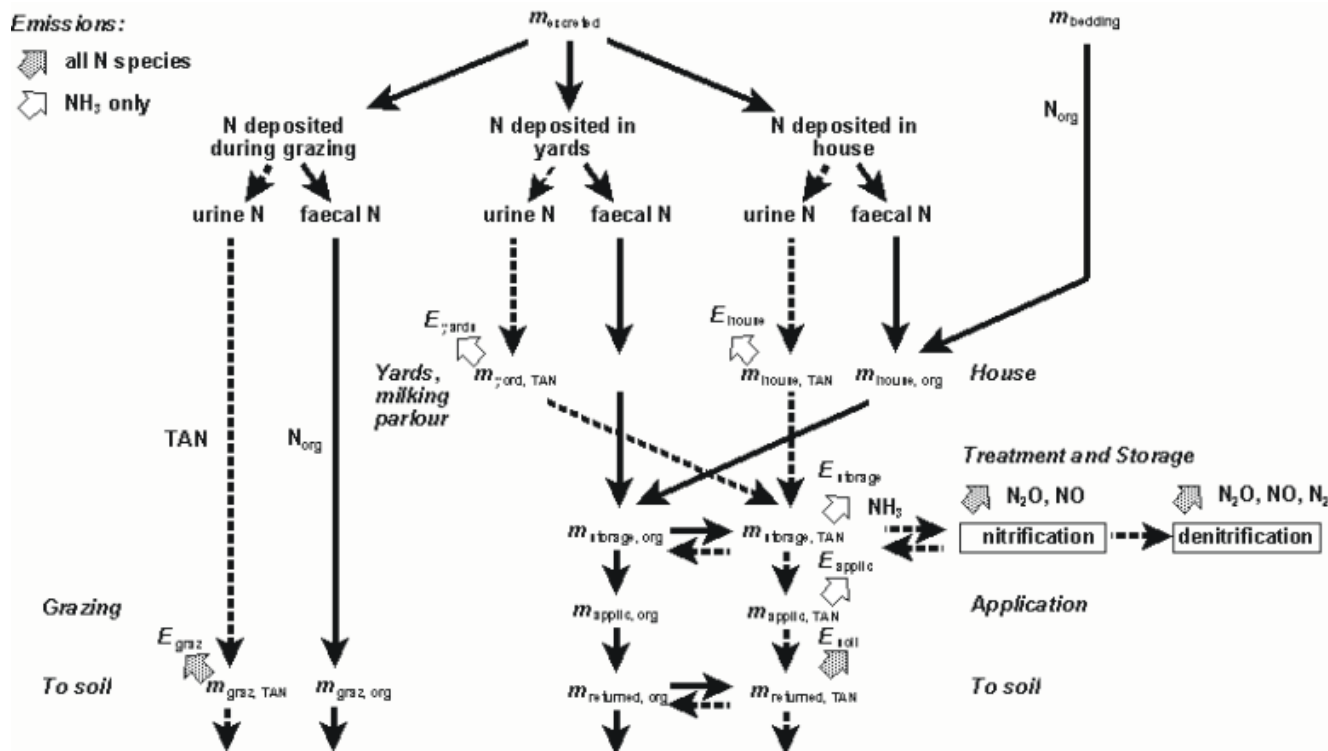


	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>swine</b>	12.8	13.1	13.0	12.8	12.6	12.4	12.4	12.3	12.2	12.1	12.1	12.3	12.2	12.2	12.3
<b>laying hens</b>	0.81	0.78	0.76	0.79	0.86	0.88	0.89	0.89	0.89	0.89	0.90	0.90	0.90	0.90	0.91
<b>broilers</b>	0.48	0.37	0.37	0.36	0.35	0.40	0.40	0.40	0.41	0.40	0.39	0.39	0.40	0.41	0.42
<b>turkeys</b>	2.0	2.0	2.0	2.2	2.2	2.3	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.1	2.1
<b>pullets</b>	0.38	0.35	0.32	0.33	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
<b>ducks</b>	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
<b>geese</b>	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
<b>deer</b>	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
<b>rabbits</b>	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
<b>ostrich</b>	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60
<b>fur animals</b>	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59
<b>mean TAN contents in %</b>															
<b>dairy cattle</b>	51.3	48.9	47.3	45.9	44.6	43.7	43.3	43.4	42.9	42.3	41.5	41.1	41.4	40.5	39.9
<b>other cattle</b>	65.5	65.7	65.7	65.7	66.0	66.3	66.4	66.4	66.4	66.4	66.4	66.3	66.3	66.3	66.3
<b>horses</b>	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
<b>sheep</b>	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
<b>goats</b>	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
<b>swine</b>	72.0	71.7	71.1	71.8	72.3	71.5	71.3	71.2	71.0	70.9	70.7	70.8	70.6	70.5	70.4
<b>laying hens</b>	70.2	69.6	69.0	69.3	70.0	70.2	70.1	70.1	70.2	70.2	70.1	70.1	70.2	70.3	70.2
<b>broilers</b>	60.8	58.9	56.4	53.5	50.0	46.9	46.5	46.1	45.7	45.2	44.8	44.8	44.8	44.8	44.8
<b>turkeys</b>	64.7	64.7	63.0	63.9	63.0	63.5	63.5	63.5	63.0	63.0	62.1	62.1	62.1	62.1	62.1
<b>pullets</b>	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4
<b>ducks</b>	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9
<b>geese</b>	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
<b>deer</b>	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
<b>rabbits</b>	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
<b>ostrich</b>	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
<b>fur animals</b>	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0

#### N mass flow and emission assessment

The calculation of the emissions of  $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  from German animal husbandry is based on the so-called N mass flow approach (e. g. Dämmgen and Hutchings, 2008<sup>7)</sup>). This approach differentiates between N excreted with faeces (organic nitrogen Norg, i. e. undigested feed N) and urine (total ammoniacal nitrogen TAN, i. e. fraction of feed N metabolized). The N flow within the manure management system is treated as depicted in the figure below. This method reconciles the requirements of both the Atmospheric Emission Inventory Guidebook for  $\text{NH}_3$  emissions (EMEP, 2023), and the IPCC guidelines for greenhouse gas emissions (IPCC (2006)<sup>8)</sup>. Reidy et al. (2008),<sup>9)</sup> showed for several European countries (Germany, the Netherlands, Switzerland, United Kingdom) that their N-flow based inventory models yielded, in spite of national peculiarities, comparable results as long as standardised data sets for the input variables were used.

Not explicitly shown in the N mass flow scheme is air scrubbing in housing and anaerobic digestion of manure. These issues are separately described further below. Note that emissions from grazing and application are reported in sector 3.D.



General scheme of N flows in animal husbandry

$m$ : mass from which emissions may occur. Narrow broken arrows: TAN (total ammoniacal nitrogen); narrow continuous arrows: organic N. The horizontal arrows denote the process of immobilisation in systems with bedding occurring in the house, and the process of mineralisation during storage, which occurs in any case. Broad arrows denote N-emissions assigned to manure management ( $E_{yard}$  NH<sub>3</sub> emissions from yards;  $E_{house}$  NH<sub>3</sub> emissions from house;  $E_{storage}$  NH<sub>3</sub>, N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> emissions from storage;  $E_{applic}$  NH<sub>3</sub> emissions during and after spreading;  $E_{graz}$  NH<sub>3</sub>, N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> emissions during and after grazing;  $E_{soil}$  N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> emissions from soil resulting from manure input).

The model allows tracing of the pathways of the two N fractions after excretion. The various locations where excretion may take place are considered. The partial mass flows through the livestock systems are represented. During storage  $N_{org}$  can be transformed into TAN and vice versa. Both, the way and the magnitude of such transformations may be influenced by manure treatment processes like, e. g., anaerobic digestion where a considerable fraction of  $N_{org}$  is mineralized to TAN. For details see Vos et al. (2026), Chapter 4.2. Wherever NH<sub>3</sub> is emitted, its formation is related to the amount of the TAN present. N<sub>2</sub>O emissions are related to the total amount of N available ( $N_{org} + TAN$ ). NO<sub>x</sub> emissions (i. e. NO emissions) are calculated proportionally to the N<sub>2</sub>O emissions, see section 'Emission factors'. Note that the N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> emissions from the various storage systems include the respective emissions from the related housing systems.

**Air scrubber systems in swine and poultry housings**

For pig and poultry production the inventory model considers the effect of air scrubbing. Data on frequencies of air scrubbing facilities and the removal efficiency are provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture) supplemented by data from the 2020 agricultural census. The average removal efficiency of NH<sub>3</sub> is 80 % for swine and 70 % for poultry, while for TSP and PM<sub>10</sub> the rates are set to 90 % and for PM<sub>2.5</sub> to 70 % for both animal categories. For swine two types of air scrubbers are distinguished: systems of “first class” that remove both NH<sub>3</sub> and particles, and “second class” systems that remove only particles reliably and have a NH<sub>3</sub> removal efficiency of 20%.

According to KTBL, 7.6 % of all pig places were equipped with “first class” systems in 2024, another 12.6 % were equipped with “second class” systems. For poultry 0.9 % of all laying hen places and 2.5 % of all broiler places were equipped with air scrubbers that remove both NH<sub>3</sub> and particles. The amounts of NH<sub>3</sub>-N removed by air scrubbing are completely added to the pools of total N and TAN for landspreading. For details see Vos et al. (2026), Chapter 4.2.2.

**Anaerobic digestion of manure**



	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>fur animals</b>	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123
<b>Nitrogen oxides</b>															
<b>dairy cattle</b>	0.163	0.154	0.163	0.168	0.158	0.146	0.146	0.147	0.148	0.148	0.143	0.137	0.136	0.140	0.142
<b>other cattle</b>	0.064	0.068	0.071	0.076	0.079	0.077	0.077	0.077	0.078	0.078	0.078	0.077	0.077	0.078	0.078
<b>horses</b>	0.169	0.169	0.172	0.171	0.171	0.184	0.187	0.190	0.193	0.196	0.198	0.198	0.198	0.198	0.198
<b>sheep</b>	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
<b>goats</b>	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
<b>swine</b>	0.013	0.015	0.015	0.016	0.016	0.014	0.014	0.013	0.013	0.013	0.012	0.012	0.012	0.012	0.012
<b>laying hens</b>	0.00027	0.00026	0.00026	0.00030	0.00035	0.00037	0.00036	0.00036	0.00023	0.00023	0.00024	0.00024	0.00023	0.00024	0.00024
<b>broilers</b>	0.00016	0.00012	0.00012	0.00013	0.00014	0.00016	0.00016	0.00016	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
<b>turkeys</b>	0.00068	0.00068	0.00070	0.00085	0.00095	0.00091	0.00094	0.00094	0.00069	0.00066	0.00061	0.00061	0.00060	0.00058	0.00060
<b>pullets</b>	0.00013	0.00012	0.00011	0.00013	0.00015	0.00014	0.00014	0.00014	0.00009	0.00009	0.00009	0.00009	0.00009	0.00010	0.00010
<b>ducks</b>	0.00024	0.00024	0.00024	0.00025	0.00026	0.00027	0.00028	0.00027	0.00021	0.00021	0.00022	0.00022	0.00021	0.00021	0.00021
<b>geese</b>	0.00025	0.00025	0.00025	0.00029	0.00032	0.00032	0.00030	0.00030	0.00023	0.00023	0.00024	0.00024	0.00023	0.00022	0.00022
<b>deer</b>	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>rabbits</b>	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269
<b>ostrich</b>	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126
<b>fur animals</b>	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508

#### Trend discussion for Key Sources

Dairy cattle, other cattle and swine are key sources of NH<sub>3</sub> emissions from manure management. The time series of the total NH<sub>3</sub> emissions from all three categories are predominantly driven by the development of the animal numbers, see Table 1. However, the effect of decreasing animal numbers is partly compensated by the continuously increasing animal performance. This leads to increasing N excretions per animal, see Table 2, which, in principle, is reflected by increasing implied emission factors, see Table 3. For swine the IEF is decreasing over time due to lower raw protein contents in feed and the use of air scrubbing systems that, to a high degree, remove NH<sub>3</sub> from the housings.

For NO<sub>x</sub> there are no key categories.

#### Recalculations

All timeseries of the emission inventory have completely been recalculated. Tables 4 and 5 compare the recalculated time series for NH<sub>3</sub> and NO<sub>x</sub> from 3B with the respective data of last year's submission.

For NH<sub>3</sub> there are many reasons for very different emissions compared to last year's submission. For dairy cows the new methodology to calculate N and TAN excretions (see [main page of the agricultural sector recalculation No. 3](#)) results in general in lower emissions. The upward correction of historic milk yields (**recalculation No. 4**) results in higher emissions. In combination these two recalculations result in lower emissions, especially in more recent years. The subdivision of the sows category in gilts and old sows (**recalculation No. 5**) is the main reason for lower emissions from swine. The adjusted N excretion for horses after 2010 (**recalculation No. 6**) is the main reason for higher emissions from other animals. The addition of substrate transports to biogas plants (**recalculation No. 1**) has a smaller impact on emissions than the other recalculations. This recalculation is the main reason for the changes for emissions from other cattle and poultry but it also affects dairy cattle and swine emissions. Many of the other recalculations have much smaller effects. Overall, the changes result in lower emissions compared with last year's submission.

The total emissions of NO<sub>x</sub> for all years up to 2019 are higher and thereafter a little bit lower than those of submission 2025. The main reasons for this are the recalculations done for dairy cattle (**recalculations No. 3 and No. 4**). Up to the year 2019 the effect of the adjusted milk yields (resulting in higher emissions) is higher than the effect of the new methodology to calculate N emissions which leads to lower N excretions especially in more recent years. All other reasons listed above regarding NH<sub>3</sub> have similar effects on NO<sub>x</sub> emissions. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3.

Table 4: Comparison of NH<sub>3</sub> emissions [kt] with previous submission

		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>Total</b>	<b>current submission</b>	297.22	250.13	245.22	244.46	235.19	231.40	227.54	226.84	220.30	215.27	209.68	199.90	190.21	188.78	187.67
	<b>previous submission</b>	300.67	252.12	248.41	248.80	242.06	237.98	233.87	231.70	224.95	220.40	216.51	208.17	197.88	196.54	
	<b>absolute change</b>	-3.45	-1.99	-3.20	-4.33	-6.87	-6.58	-6.33	-4.86	-4.65	-5.14	-6.83	-8.27	-7.67	-7.76	
	<b>relative change [%]</b>	-1.15	-0.79	-1.29	-1.74	-2.84	-2.76	-2.71	-2.10	-2.07	-2.33	-3.15	-3.97	-3.88	-3.95	
<b>Dairy cattle</b>	<b>current submission</b>	58.81	50.52	46.08	45.56	44.83	46.63	46.48	47.61	46.96	46.11	43.41	40.83	40.65	39.50	38.05
	<b>previous submission</b>	60.08	50.88	47.58	47.96	49.01	51.16	50.96	50.81	50.34	50.41	49.61	48.53	48.11	47.56	
<b>Other cattle</b>	<b>current submission</b>	75.09	61.37	58.84	54.44	57.03	52.31	51.04	49.59	47.76	46.24	44.92	43.89	43.75	43.65	42.16
	<b>previous submission</b>	75.09	61.37	58.84	54.43	57.07	52.45	51.18	49.73	47.86	46.37	45.09	44.10	43.95	43.75	
<b>Swine</b>	<b>current submission</b>	118.02	88.90	92.30	94.41	87.70	84.59	82.66	82.07	78.05	75.42	74.52	68.60	59.81	59.50	60.67
	<b>previous submission</b>	120.20	90.53	93.99	96.33	90.18	87.72	85.80	85.33	81.27	78.46	77.66	71.70	62.66	62.12	
<b>poultry</b>	<b>current submission</b>	23.31	22.67	26.15	28.06	25.82	27.64	27.13	26.92	26.51	26.09	25.03	24.31	23.25	22.86	23.06
	<b>previous submission</b>	23.31	22.67	26.16	28.07	26.00	27.82	27.37	27.17	26.72	26.32	25.23	24.50	23.43	22.93	
<b>Other animals</b>	<b>current submission</b>	22.00	26.67	21.85	22.00	19.81	20.24	20.23	20.64	21.02	21.42	21.80	22.27	22.75	23.27	23.74
	<b>previous submission</b>	22.00	26.67	21.85	22.00	19.81	18.82	18.56	18.66	18.75	18.84	18.92	19.32	19.73	20.18	

Table 5: Comparison of NO<sub>x</sub> emissions [kt] with previous submission

		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>Total</b>	<b>current submission</b>	2.537	2.211	2.087	2.062	1.997	1.891	1.867	1.854	1.800	1.762	1.710	1.633	1.597	1.607	2.537
	<b>previous submission</b>	2.403	2.119	2.023	2.014	1.980	1.878	1.848	1.822	1.783	1.750	1.716	1.658	1.619	1.621	
	<b>absolute change</b>	0.13	0.09	0.06	0.05	0.02	0.01	0.02	0.03	0.02	0.01	-0.01	-0.02	-0.02	-0.01	
	<b>relative change [%]</b>	5.60	4.35	3.20	2.38	0.84	0.67	1.01	1.77	0.97	0.65	-0.40	-1.48	-1.39	-0.86	
thereof: <b>Dairy cattle</b>	<b>current submission</b>	1.036	0.807	0.743	0.712	0.660	0.623	0.618	0.618	0.608	0.593	0.562	0.523	0.519	0.520	0.508
	<b>previous submission</b>	0.892	0.708	0.672	0.658	0.634	0.607	0.600	0.590	0.585	0.580	0.570	0.549	0.544	0.545	
thereof: <b>Other cattle</b>	<b>current submission</b>	0.843	0.726	0.711	0.668	0.683	0.647	0.637	0.625	0.609	0.595	0.576	0.557	0.553	0.556	0.537
	<b>previous submission</b>	0.843	0.726	0.711	0.668	0.684	0.652	0.642	0.630	0.613	0.600	0.582	0.565	0.561	0.558	
thereof: <b>Swine</b>	<b>current submission</b>	0.351	0.313	0.326	0.366	0.358	0.316	0.308	0.303	0.286	0.271	0.266	0.241	0.208	0.209	0.213
	<b>previous submission</b>	0.360	0.319	0.332	0.372	0.367	0.332	0.322	0.318	0.300	0.286	0.281	0.258	0.224	0.222	
thereof: <b>Poultry</b>	<b>current submission</b>	0.026	0.025	0.029	0.035	0.043	0.048	0.048	0.048	0.033	0.032	0.032	0.032	0.030	0.030	0.030
	<b>previous submission</b>	0.026	0.025	0.029	0.034	0.042	0.048	0.047	0.047	0.046	0.044	0.042	0.040	0.040	0.039	
thereof: <b>Other animals</b>	<b>current submission</b>	0.282	0.340	0.279	0.281	0.253	0.256	0.256	0.261	0.265	0.270	0.275	0.280	0.286	0.293	1.249
	<b>previous submission</b>	0.282	0.340	0.279	0.281	0.253	0.240	0.236	0.238	0.239	0.240	0.241	0.246	0.251	0.257	

### Planned improvements

No improvements are planned at present.

## NMVOG

In 2024, NMVOG emissions from manure management amount to 291.7 kt which is 97.1 % of total NMVOG emissions from the agricultural sector. 84.1 % thereof originate from cattle, 15.9 % from other animals.

### Method

The Tier 2 methodology provided by EMEP (2023)-3B-26 was used to assess the NMVOG emissions from manure management for dairy cattle and other cattle. For all other animals the Tier 1 methodology (EMEP (2023)-3B-17) was used. The use of the Tier 2 methodology yields NMVOG emissions which formally could be reported in the sectors 3.D.a.2.a (application of manure to soils) and 3.D.a.3 (grazing emissions). However, to be congruent with the NMVOG emissions for other animal categories, Germany reports these emissions in the NMVOG emissions reported from manure management (3.B). For the NFR codes 3.D.a.2.a and 3.D.a.3 the key note IE is used for NMVOG emissions.

### Activity data

Animal numbers serve as activity data, see Table 1.

### Emission factors

For the Tier 2 methodology applied to dairy cattle and other cattle the following data was used:

- gross feed intake in MJ per year, country specific data from the annual reporting of greenhouse gas emissions, see NID 2026, Chapter 5.1.3.3,
- proportion  $x_{\text{house}}$  of the year the animals spend in the livestock building: country specific data, being equal to  $1 - x_{\text{graz}}$  with  $x_{\text{graz}}$  the proportion of the year spent on pasture, see NID 2026, Chapter 17.3.1,
- $\text{FRAC}_{\text{silage}}$ : 1 as proposed by EMEP (2023)-3B-27, since silage feeding for cattle is considered dominant in Germany
- $\text{FRAC}_{\text{silage store}}$ : 0.25 as proposed by EMEP (2023)-3B-27 for European conditions
- $\text{EF}_{\text{NMVOG, silage feeding}}$ ,  $\text{EF}_{\text{NMVOG, house}}$ ,  $\text{EF}_{\text{NMVOG, graz}}$  are taken from EMEP (2023)-3B-31, table 3.11 as 0.0002002, 0.0000353 and 0.0000069 kg NMVOG/MJ feed intake, respectively,
- $\text{EF}_{\text{NH}_3, \text{storage}}$ ,  $\text{EF}_{\text{NH}_3, \text{building}}$  and  $\text{EF}_{\text{NH}_3, \text{application}}$  are taken from the  $\text{NH}_3$  reporting (see above and 3.D).

For all other animal categories the Tier 1 emission factors for NMVOG were used as provided in EMEP (2023)-3B-17, Table 3.4. For horses the emission factors for feeding with silage was chosen, for all other animals the emission factors for feeding without silage. Due to missing country-specific emission factors or emission factors that do not correspond to the inventory's animal categories, the emission factors provided in EMEP (2023)-3B-17, Table 3.4, were used to define specific emission factors for weaners, boars, lambs, ponies/light horses and pullets, ostriches, and deer see Vos et al. (2026), Chapter 4.3.3. The implied emission factors given in Table 4 relate the overall NMVOG emissions to the number of animals in each animal category. The IEFs for dairy cattle and other cattle are much higher than the EMEP Tier 1 EF, which are 17.937 kg NMVOG for dairy cattle and 8.902 kg NMVOG for other cattle. The only possible explanation for those huge differences is that the EMEP Tier 2 and Tier 1 methods are not consistent.

The IEFs for the other categories provided in Table 6 correspond to the EMEP Tier 1 emission factors, except for horses, sheep and swine. These categories comprise subcategories with different emission factors so that their overall IEFs in Table 4 represent subpopulation-weighted national mean values. Note that other poultry in Germany includes not only geese and ducks but also pullets. For pullets no default EF is given in the EMEP guidebook (EMEP, 2023), hence the EF of broilers has been adopted (because of similar housing). This assumption significantly lowers the overall IEF of other poultry (in Table 6 the IEFs are listed separately for each poultry category). The IEF of the sheep category is significantly lower than the EMEP Tier 1 emission factor, because for lambs the EF is assumed to be 40% lower compared to an adult sheep in accordance with the difference in N excretion between lambs and adult sheep.

Table 6: IEF for NMVOG from manure management, in [kg NMVOG per animal place]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>dairy cattle</b>	32.914	35.430	38.490	39.726	40.290	40.898	41.328	41.220	41.988	42.823	43.405	43.556	43.173	44.716	45.579
<b>other cattle</b>	12.400	12.298	12.406	12.247	12.207	11.835	11.763	11.730	11.703	11.732	11.791	11.866	11.848	11.880	11.905
<b>horses</b>	6.497	6.491	6.688	6.660	6.644	6.646	6.648	6.651	6.654	6.657	6.660	6.659	6.658	6.657	6.656
<b>sheep</b>	0.131	0.131	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
<b>goats</b>	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542
<b>swine</b>	0.695	0.698	0.690	0.682	0.669	0.651	0.649	0.648	0.648	0.647	0.642	0.645	0.643	0.644	0.644
<b>laying hens</b>	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
<b>broilers</b>	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
<b>turkeys</b>	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
<b>pullets</b>	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
<b>ducks</b>	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
<b>geese</b>	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
<b>deer</b>	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
<b>rabbits</b>	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
<b>ostrich</b>	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
<b>fur animals</b>	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941	1.941

**Trend discussion for Key Sources**

Dairy cattle and other cattle are key sources of NMVOC emissions from manure management. The total NMVOC emissions from both animal categories strongly correlate with the animal numbers given in Table 1 (dairy cattle: R<sup>2</sup> = 0.90; other cattle: R<sup>2</sup> = 0.99).

**Recalculations**

All timeseries of the emission inventory have completely been recalculated. Table 7 compares the recalculated time series of the NMVOC emissions from 3.B with the respective data of last year’s submission. The recalculated total emissions are higher. For dairy cattle and other cattle emissions are higher due to changes of NH<sub>3</sub> emissions which have impact on the Tier 2 methodology which is applied for cattle NMVOC emissions. For other animals there are no changes compared with the previous submission. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3.

Table 7: Comparison of NMVOC emissions [kt] with previous submission

		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>NFR-Total: NMVOC</b>	<b>current submission</b>	418.62	362.01	346.77	325.36	324.20	325.33	322.01	318.62	314.16	311.13	306.95	300.63	296.10	296.66	291.74
	<b>previous submission</b>	415.22	357.45	342.28	320.98	320.35	322.59	318.93	315.55	311.20	307.95	303.73	297.43	293.26	292.11	
	<b>absolute change</b>	3.39	4.56	4.49	4.38	3.85	2.74	3.07	3.07	2.96	3.18	3.22	3.20	2.84	4.55	
	<b>relative change [%]</b>	0.82	1.27	1.31	1.36	1.20	0.85	0.96	0.97	0.95	1.03	1.06	1.07	0.97	1.56	
thereof: <b>Dairy cattle</b>	<b>current submission</b>	209.16	185.28	175.89	168.29	168.54	175.23	174.31	173.08	172.19	171.79	170.21	166.94	164.48	166.02	163.60
	<b>previous submission</b>	205.77	180.73	171.39	163.89	164.40	171.96	170.78	169.61	168.80	168.25	166.61	163.33	161.27	161.23	
thereof: <b>Other cattle</b>	<b>current submission</b>	162.85	131.10	123.68	107.78	105.33	98.83	97.03	94.80	91.85	89.49	87.02	85.52	85.15	84.63	81.81
	<b>previous submission</b>	162.85	131.10	123.68	107.80	105.62	99.36	97.49	95.21	92.27	89.86	87.40	85.93	85.52	84.87	
thereof: <b>Other animals</b>	<b>current submission</b>	46.61	45.63	47.21	49.29	50.33	51.27	50.67	50.73	50.12	49.84	49.72	48.17	46.47	46.01	46.33
	<b>previous submission</b>	46.61	45.63	47.21	49.29	50.33	51.27	50.67	50.73	50.12	49.83	49.72	48.17	46.47	46.01	

## Planned improvements

No improvements are planned at present.

## Particle emissions

In 2024, TSP emissions from manure management amount to 60.4 % of total emissions from the agricultural sector. Of these emissions 23.9 % originate from cattle, 32.9 % from pigs, and 41.6 % from poultry.

34.7 % of total PM<sub>10</sub> emissions from the agricultural sector are caused by manure management, where 33.3 % originate from cattle, 15.3 % from pigs, and 47.0 % from poultry.

66.4 % of total PM<sub>2.5</sub> emissions from the agricultural sector are caused by manure management, where 76.5 % originate from cattle, 2.4 % from pigs, and 16.7 % from poultry.

## Method

EMEP (2013-3B-26) provided a Tier 2 methodology. In the 2023 Guidebook (EMEP, 2023), this methodology has been replaced by a Tier 1 methodology. However, EF for cattle derived with the EMEP 2013 Tier 2 methodology remained unchanged. Therefore, the EMEP 2013<sup>11)</sup> methodology was kept for cattle. For swine the EMEP 2013 methodology was formally kept but the EMEP 2023 Tier 1 EF was used both for slurry and solid based manure management systems. In case the EMEP 2023 EFs are simply rounded EMEP 2013 EFs, the unrounded EMEP 2013 EFs were kept. For rabbits the EFs from The Netherlands' inventory were adopted (Huis In't Veld et al, 2011)<sup>12)</sup>, for ostriches the EFs of goats were used. The inventory considers air scrubber systems in swine and poultry husbandry. For animal places equipped with air scrubbing the emission factors are reduced according to the removal efficiency of the air scrubber systems (90 % for TSP and PM<sub>10</sub>, 70 % for PM<sub>2.5</sub>). For details see Vos et al. (2026), Chapter 4.2.2.

## Activity data

Animal numbers serve as activity data, see Table 1.

## Emission factors

Tier 1 emission factors for TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from livestock husbandry are provided in EMEP (2023)-3B-18, Table 3.5 and 55, Table A1.7. For cattle the Tier 2 emission factors provided in EMEP (2013)-3B-29, Table 3-11 were used, because they differentiate between slurry and solid manure systems and were also used to develop the EMEP 2023 Tier 1 emissions factors. They are also provided in EMEP (2023)-3B-53, Table A1.7.

The implied emission factors given in Table 8 relate the overall TSP and PM emissions to the number of animals in each animal category. The Guidebook does not indicate whether EFs have considered the condensable component (with or without).

Table 8: IEF for TSP, PM<sub>10</sub> & PM<sub>2.5</sub> from manure management

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
<b>Total suspended particles (TSP)</b>															
<b>dairy cattle</b>	1.2124	1.4016	1.4542	1.4727	1.4969	1.5360	1.5455	1.5541	1.5630	1.5721	1.5721	1.5723	1.5722	1.5723	1.5730
<b>other cattle</b>	0.5194	0.5107	0.5014	0.4903	0.4798	0.4762	0.4759	0.4756	0.4755	0.4748	0.4746	0.4750	0.4755	0.4744	0.4737
<b>horses</b>	0.3514	0.3512	0.3558	0.3552	0.3548	0.3549	0.3549	0.3550	0.3551	0.3551	0.3552	0.3552	0.3551	0.3551	0.3551
<b>sheep</b>	0.0484	0.0478	0.0489	0.0486	0.0489	0.0482	0.0482	0.0482	0.0480	0.0482	0.0482	0.0481	0.0478	0.0480	0.0482
<b>goats</b>	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914
<b>swine</b>	0.8260	0.8366	0.8320	0.8218	0.7928	0.7503	0.7453	0.7390	0.7316	0.7231	0.7243	0.7070	0.6881	0.6884	0.6938



## Trend discussion for Key Sources

Swine and laying hens are key sources of TSP emissions from manure management. The total TSP emissions from swine mainly follow the animal numbers given in Table 1 for the earlier years of the time series. However, due to increases in places equipped with air scrubbing and different emission factors of the different housing systems of the five swine subcategories (sows (divided in gilts and old sows), weaners, fattening pigs, boars) and the varying population shares in those housing systems the  $R^2$  of the linear regression is lower than 1 (0.79). For laying hens ( $R^2 = 0.98$ ) and broilers ( $R^2 = 0.99$ ), due to the low prevalence of air scrubbing systems TSP emissions almost perfectly correlate with the animal numbers provided in Table 1.

## Recalculations

The following table 9 shows the effects of recalculations on emissions of particulate matter. Minimal differences compared with the previous submission are due to the correction of the number of animal places equipped with air scrubbers (**recalculation No. 11**), see [main page of the agricultural sector](#). Further details on recalculations are described in Vos et al. (2026), Chapter 1.3.

Table 9: Comparison of particle emissions (TSP, PM<sub>10</sub> & PM<sub>2.5</sub>) [kt] with previous submission

		TSP, PM <sub>10</sub> , PM <sub>2.5</sub> emissions from manure management, in kt														
		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
TSP	current submission	50.36	43.31	44.13	43.37	42.70	43.91	43.56	43.53	42.51	41.85	41.67	39.64	37.71	37.32	37.23
	previous submission	50.36	43.31	44.13	43.37	42.70	43.91	43.57	43.54	42.51	41.80	41.67	39.63	37.71	37.32	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	
	relative change [%]	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.13	0.00	0.00	0.00	0.00	
PM <sub>10</sub>	current submission	14.50	13.12	13.25	13.09	13.32	13.60	13.42	13.37	13.12	12.93	12.79	12.32	11.91	11.69	11.58
	previous submission	14.50	13.12	13.25	13.09	13.32	13.60	13.42	13.37	13.12	12.93	12.79	12.32	11.91	11.69	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	
PM <sub>2.5</sub>	current submission	5.11	4.61	4.32	4.04	4.03	4.10	4.05	4.03	3.95	3.88	3.79	3.70	3.66	3.58	3.49
	previous submission	5.11	4.61	4.32	4.04	4.03	4.10	4.05	4.03	3.95	3.88	3.79	3.70	3.66	3.58	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

## Uncertainty

Details are described in [chapter 1.7](#).

<sup>1)</sup>

Vos, C., Rösemann, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, B., Döhler, H., Steuer, B., Osterburg, B., & Fuß, R. (2026) Calculations of gaseous and particulate emissions from German agriculture 1990 - 2024 : Report on methods and data (RMD) Submission 2026. [www.eminv-agriculture.de](http://www.eminv-agriculture.de)

2)

Weingarten, 1995: Das „Regionalisierte Agrar- und Umweltinformationssystem für die Bundesrepublik Deutschland“ (RAUMIS). Berichte über die Landwirtschaft Band 73, 272-302.

3)

Henrichsmeyer, W.; Cypris, Ch.; Löhe, W.; Meuth, M.; Isermeyer F; Heinrich, I.; Schefski, A.; Neander, E.; Fasterding, F.; Neumann, M.; Nieberg, H., 1996: Entwicklung des gesamtdeutschen Agrarsektormodells RAUMIS96. Endbericht zum Kooperationsprojekt. Forschungsbericht für das BMELF (94 HS 021), Bonn, Braunschweig.

4)

Statistisches Bundesamt (2020): LW20, Landwirtschaftszählung 2020.

<https://www-genesis.destatis.de/datenbank/online/statistic/41141/details>

5)

NID (2026): National Inventory Report 2026 for the German Greenhouse Gas Inventory 1990-2024. Available in April 2026.

6)

EMEP/EEA air pollutant emission inventory guidebook 2023, EEA Report No 06/2023,

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023>.

7)

Dämmgen U., Hutchings N.J. (2008): Emissions of gaseous nitrogen species from manure management - a new approach. Environmental Pollution 154, 488-497.

8)

IPCC – Intergovernmental Panel on Climate Change (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use.

9)

Reidy B. et al. (2008): Reidy B., Dämmgen U., Döhler H., Eurich-Menden B., Hutchings N.J., Luesink H.H., Menzi H., Misselbrook T.H., Monteny G.-J., Webb J. (2008): Comparison of models used for the calculation of national NH<sub>3</sub> emission inventories from agriculture: liquid manure systems. Atmospheric Environment 42, 3452-3467.

10)

IPCC – Intergovernmental Panel on Climate Change (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use.

11)

EMEP (2013): EMEP/EEA air pollutant emission inventory guidebook – 2013

12)

Huis In't Velt, J.W.H., Dousma, F., Nijboer, G.M. (2011): Gaseous Emissions and fine dust from rabbit housing systems. Livestock research Wageningen, Report 459.