Calculation of forecasted emissions in Norwegian agriculture

Technical description of the forecasting and mitigation tool

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CARBON LIMITS

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Carbon Limits works with public authorities, private companies, finance institutions and non-governmental organizations to reduce greenhouse gas emissions from a range of sectors. Our team supports clients in the identification, development, and financing of projects that mitigate climate change and generate economic value, in addition to providing advice on the design and implementation of climate and energy policies and regulations.

Abstract

This report provides an overview of the forecasting and mitigation tool developed by Carbon Limits for the Norwegian Environment Agency (NEA, or *Miljødirektoratet* in Norwegian). The main purpose of this collaboration was to provide a user-friendly Excel-based tool to support the forecasting of emissions from the agriculture sector and to evaluate the potential impact of mitigation measures implemented in the sector.

The tool provides a structured approach for users to model emissions trajectories under various scenarios and is designed to operate in combination with the existing agriculture models, used by NEA and Statistics Norway (SSB, or *Statistisk sentralbyrå* in Norwegian) for reporting to UNFCCC. The tool allows users to simulate both baseline (reference) and mitigation scenarios, providing outputs in the form of result tables and an emissions database.

The agriculture sector is a significant source of emissions, particularly methane (CH_4), nitrous oxide (N_2O) and ammonia (NH_3). Addressing these emissions requires targeted and well-planned strategies. The forecasting and mitigation tool allows users to test different assumptions about agricultural practices and quantify their impact on CH_4, N_2O, NH_3, all agriculture emissions of NMVOC (non-methane volatile organic compounds), as well as parts of the agricultural NO_x (nitrogen oxide) emissions, providing useful insights for designing effective mitigation strategies.

The forecasting tool is used on a regular basis by the Norwegian Environmental Agency for reporting purposes. Results are published and updated annually.

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Abbreviations

CH_4	Methane
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
EMEP/EEA	European Environment Agency/European Economic Area
IPCC	Intergovernmental Panel on Climate Change
MCF	Methane Conversion Factor
MMS	Manure Management Systems
NEA	Norwegian Environment Agency (*Miljødirektoratet* in Norwegian)
NH_3	Ammonia
NMVOC	Non-Methane Volatile Organic Compounds
N_2O	Nitrous oxide
NO	Nitric oxide
NO_x	Nitrogen oxide
N_2	Nitrogen
SSB	Statistics Norway (*Statistisk sentralbyrå* in Norwegian)
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

1.1 Aim of the forecasting and mitigation tool

The main objective of the forecasting and mitigation tool is to provide a structured and user-friendly way to develop forecasts of the emissions from agriculture and analyse the effect of emissions reduction activities in the sector. The tool allows to:

- combine input tables from the three agriculture models (See Section 1.2) into one spreadsheet, avoiding duplicate entries
- calculate and forecast emissions from additional emission sources not covered by the three agriculture models (see Table 3)
- forecast emissions from the agriculture sector up until 2065
- display results in a single spreadsheet in the correct format for reporting the emissions
- assess and compare the effect of various mitigation options.

The emissions calculated with the forecasting and mitigation tool are based on the same model framework used in the national emission inventory. This alignment ensures that any methodological updates made to the historical emission inventory are also incorporated into the forecasts. The methods and emission factors for greenhouse gases are documented in Norway's National Inventory Document (NID), while those for ammonia, NMVOC and NOx are detailed in the Informative Inventory Report (IIR). Both reports are updated annually and submitted to the UNFCCC, the EU and the UNECE. The forecasting and mitigation tool also applies the same definition of the agricultural sector as used in the national emission inventory.

1.2 The agriculture models ("Agri models")

Carbon Limits, Statistics Norway (SSB, or *Statistisk sentralbyrå* in Norwegian) and the Norwegian Environment Agency (NEA, or *Miljødirektoratet* in Norwegian) have developed several Excel-based models to estimate and report nitrogen and methane emissions to air from the Norwegian agriculture. Three of these models ("Agri models") are listed in Table 1. The models are described in separate model reports (footnote 3, 4 and 5), as well as in the yearly updated Norwegian National Inventory Document (NID)[1] and the Informative Inventory report (IIR)[2], where also the latest changes in the models are documented.

Table 1. Agri models

Model	Emission source	Pollutant	Short description
Methane biogas model[3]	Farm-level manure management systems	CH_4	The Excel model calculates methane (CH_4) emissions from manure management in Norway and is used for reporting for the Norwegian emission inventory. It covers all farm-based manure management systems (MMS), including (i) storage of manure which is to be spread to land, (ii) potential manure treatment by anaerobic digestion (with some pre-storage of manure and storage of digestate) and (iii) grazing on

[1] Miljødirektoratet (2025): Norway's National Inventory Document (NID) for the year 2025: Greenhouse Gas Emissions 1990-2023: National Inventory Document - miljodirektoratet.no

[2] Miljødirektoratet (2025). Norway's annual reporting of air pollutant emissions to the UN in 2025: Informative Inventory Report (IIR) 2025: Norway – Air Pollutant Emissions 1990-2023 - miljodirektoratet.no

[3] Miljødirektoratet (2020). *Greenhouse gas emissions from biogas production from manure in Norwegian agriculture*. https://www.miljodirektoratet.no/publikasjoner/2020/januar-2020/greenhouse-gas-emissions-from-biogas-production-from-manure-in-norwegian-agriculture/

Model	Emission source	Pollutant	Short description
			pastureland. The model follows the IPCC Tier 2 method for all animal categories, using updated national Methane Conversion Factor (MCF) for liquid manure and specific MMS distribution per animal category to better estimate CH_4 emissions reflecting national practices.
Nitrogen model[4]		Ammonia (NH_3), nitrous oxide (N_2O), nitric oxide (NO), nitrogen (in the form of N_2)	The Excel model calculates the agricultural nitrogen emissions to atmosphere related to animal manure and is used for reporting for the Norwegian emission inventory. The model closely follows the stepwise approach proposed in the EMEP/EEA 2019 guidebook, with all the 15 steps proposed in the former being followed in the Norwegian model. Although based on this Tier 2 technology-specific approach, the model includes certain aspects which are more in line with the EMEP/EEA Tier 3 approach. The effect of abatement measures and improved manure management and manure use practices are described in the revised model. The main manure management and use phases considered in the model are (i) animal housing, (ii) manure storage, (iii) manure spreading on agricultural land, and (iv) deposition as a result of animal grazing, plus (v) use of manure for biogas production.
Enteric fermentation model[5]	Enteric fermentation	CH_4	The Excel model calculates methane (CH_4) emissions from enteric fermentation in Norway and is used for reporting for the Norwegian emission inventory. The volume of CH_4 produced from enteric fermentation is dependent on several factors, like animal species, production level, quantity and quality of feed ingested and environmental conditions. The model considers all these parameters and allows to calculate methane emissions from various subgroups of the livestock population. The calculation follows Tier 2 methodology for the main emission sources – cattle, sheep and swine, and Tier 1 methodology for the other animal categories. In addition, several key mitigation measures for reduction of methane emissions from enteric fermentation have been implemented in the updated version of the model.

The models are developed as three separate Excel-based tools, but they share some common activity data, such as the number of animal heads per category, time spent on pasture, etc. Each model displays its calculation outputs in its own Results sheet. To consolidate and analyse these results, such as converting

[4] Miljødirektoratet (2020). *Calculation of atmospheric nitrogen emissions from manure in Norwegian agriculture*. https://www.miljodirektoratet.no/publikasjoner/2020/desember-2020/calculation-of-atmospheric-nitrogen-emissions-from-manure-in-norwegian-agriculture/

[5] Miljødirektoratet (2021). *Methane emissions from enteric fermentation in Norwegian agriculture*. https://www.miljodirektoratet.no/publikasjoner/2021/november-2021/methane-emissions-from-enteric-fermentation-in-norwegian-agriculture/

them into CO_2 equivalents, visualizing emission trends or tracking the impact of mitigation efforts, users must manually extract the data into a separate Excel workbook and reformat it for various types of analysis.

The Agri models are designed for annual emission estimation and reporting. However, they are not suitable for forecasting emission trends or comparing different scenarios (e.g., baseline versus mitigation scenarios).

2 Calculation of forecasted emissions

2.1 Overall approach and structure of the tool

The forecasting tool is an Excel-based model with different spreadsheets, as shown in Table 2 below.

Table 2. Forecasting tool main spreadsheets

Spreadsheet name	Description
NAV	Enables users to select the last historical year and the last year of the forecasting period. Additionally, it offers general information, such as the model version, and user guidance, including instructions on updating specific tables for each mitigation option and a step-by-step description of the approach (Figure 2).
REF	Provides an overview of supporting documents and references.
INPUT_MDIR	Contains tables with input parameters that need to be filled out to run the forecasting of a reference or a mitigation scenario.
Results	Contains results tables per emission category and per pollutant.
Database	Contains the data on all the emissions estimates, per emissions category, per year, per pollutant, etc.
Lists	Supporting sheet, which contains various lists of categories and parameters used in the tool, such as animal categories, manure types, housing types, bedding type, etc.

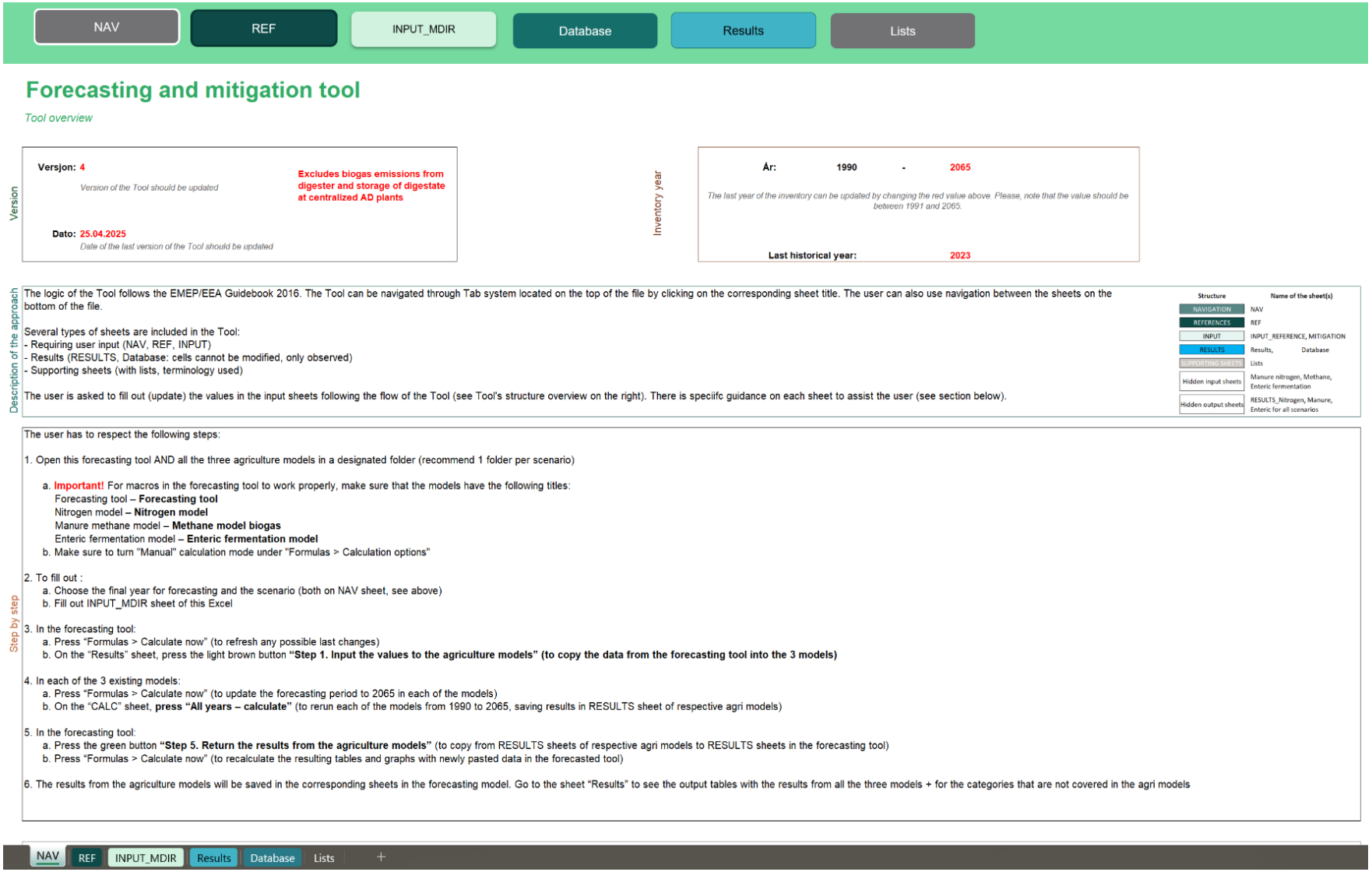
Note: There are also several hidden spreadsheets in the tool which are used to reorganise data.

The overall logic of the forecasting and mitigation tool is illustrated in Figure 1 below and described further in this section.

Figure 1. Overall functioning of the forecasting tool



Figure 2. NAV spreadsheet screenshot from the Forecasting tool



The structure of the tool is built around three sequential steps: data input, calculations performed in the existing Agri models and consolidation of the results.

2.2 Step 1: data inputs

The process begins with the user entering data into the input sheet of the tool ("INPUT_MDIR"), where 45 input tables, grouped into 10 categories reflecting different aspects of agricultural practices, need to be filled out. The tables correspond directly to input requirements of the three external agriculture models, ensuring that data entry is aligned with the structure of these models. The inputs in the tables cover both historical data and forecasted values, where the forecasting values are determined by the forecasting method as shown on Figure 3 below. The forecasting period can be selected in the tool ("NAV" sheet), with 2065 being the last possible year of the time series (see Figure 2).

Figure 3. An input table in the INPUT_MDIR spreadsheet

Please select below the option for forecasting

FORECASTING OPTION	Last available year

Manual input
Last available year
Average growth rate
Average between selected years

No	Animal type (28)	1990	2023	2024	2025	2026
1	Melkeku					
2	Ammeku					
3	Kvige til påsett					
4	Kvige slaktet<1 år					
5	Okse slaktet<1 år					
6	Kvige slaktet>1 år					
7	Okse slaktet>1 år					
8	Purke					

Note: Orange cells correspond to historical years (manual input, and blue cells correspond to forecasted years (calculated based on the selected option and historical years). The screenshot hides columns from 1991-2022, and years after 2026 are not shown.

The four available forecasting options are:

- Manual input: forecasted values are entered manually in the table.
- Last available year: the data from the last historical year is used as a constant for forecasted values.
- Average growth rate: the parameter is assumed to grow at a constant rate each year from the last historical year. The average growth rate must be entered into the forecasting tool.
- Average between selected years: instead of using the last historical year data that might not be representative, an average between specific historical years can be used and applied from the last historical year and up to 2065.

The selected forecasting option applies to all future values for all the parameters within each table, but the user can manually adjust the forecasted values for specific parameters and/or years.

2.3 Step 2: calculations

In the second step, the user activates a macro from the "Results" sheet of the tool to transfer the input values into the respective input tables of the three external agriculture models. These models are not embedded in the tool but are linked to it. After transferring the data, the user manually activates macros within each model to perform calculations. These models process the newly provided input data using their internal methodologies to generate emissions estimates for nitrogen- and methane-based sources.

For detailed information regarding the calculation methodologies applied in the Agri models, please refer to the corresponding model reports.

2.4 Step 3: outputs

The third and final step is results retrieval and consolidation. A second macro is activated from the "RESULTS" sheet, which retrieves the calculated outputs from the Agri models and transfers them into the forecasting and mitigation tool. The results are organized into tables for each pollutant (e.g., CH_4, N_2O, CO_2, NH_3, NO_x, NMVOC etc.). The tool also performs automatic conversion to CO_2-equivalent (CO_{2e}) values, providing a basis for comparing total emissions impacts.

Figure 4. Overview of result tables (in CO_{2e}) in the RESULTS spreadsheet.

CO2-ekvivalenter (tonn)

1 Jordbruk

Detaljert kildeinndeling	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	
3A11 Enterisk metan - Melkeku	1 083 045	1 061 813	1 063 302	1 058 986	1 034 629	1 032 319	1 043 567	1 018 383	998 644	1 002 521	935 407	912 166	895 630	8
3A121 Enterisk metan - Ammeku	19 729	22 881	28 773	33 322	41 733	48 964	55 832	66 090	74 381	83 909	101 916	109 123	110 361	1
3A122 Enterisk metan - Storfe ungdyr	887 637	878 616	894 265	892 356	902 550	897 144	911 447	912 938	927 279	959 207	882 618	862 223	863 272	8
3A2 Enterisk metan - Sau	492 838	498 254	496 233	475 800	532 184	536 536	528 609	500 166	501 461	489 109	509 962	530 362	523 472	5
3A3 Enterisk metan - Svin	16 294	16 222	17 605	16 728	16 498	16 833	17 561	17 817	17 612	17 944	16 805	17 394	17 630	
3A43 Enterisk metan - Hjort	0	0	0	0	0	0	0	445	441	974	1 277	1 041	1 523	
3A44 Enterisk metan - Geit	21 118	20 998	20 646	20 402	20 207	19 835	19 737	19 074	18 518	18 067	17 567	16 753	16 137	
3A45 Enterisk metan - Hest	15 841	16 626	17 310	18 115	18 836	19 159	19 849	20 770	22 264	23 437	25 783	26 712	26 828	
3A47 Enterisk metan - Fjørfe	1 978	2 426	2 400	2 352	2 352	2 304	2 201	2 062	2 078	1 995	2 042	1 921	1 989	
3A482 Enterisk metan - Tamrein	95 038	88 604	86 409	85 413	85 404	83 235	78 251	78 987	73 475	73 683	67 584	65 969	75 200	
3A484 Enterisk metan - Pelsdyr	450	469	361	404	458	466	526	499	412	361	433	439	432	
3B11 Gjødsellagring - Melkeku	260 096	260 195	259 482	250 699	248 834	243 226	247 396	234 860	233 072	231 852	213 739	214 174	207 918	2
3B121 Gjødsellagring - Ammeku	4 322	5 012	6 303	7 300	9 142	10 726	12 231	14 478	16 294	18 381	22 326	23 861	24 077	
3B122 Gjødsellagring - Storfe ungdyr	93 740	92 754	95 511	95 156	97 915	96 665	99 365	99 487	103 369	107 799	97 161	97 870	100 145	1
3B2 Gjødsellagring - Sau	32 436	33 827	33 831	31 348	35 024	35 594	35 102	33 449	33 934	33 875	34 643	35 990	35 164	
3B3 Gjødsellagring - Svin	52 482	52 033	56 132	53 080	52 163	53 079	55 185	55 793	55 075	55 894	52 276	54 119	54 711	
3B43 Gjødsellagring - Hjort	0	0	0	0	0	0	0	11	10	23	30	25	36	
3B44 Gjødsellagring - Geit	4 031	4 016	3 930	3 889	3 813	3 747	3 787	3 633	3 430	3 300	3 207	3 124	2 834	
3B45 Gjødsellagring - Hest	13 153	13 805	14 373	15 042	15 640	15 908	16 481	17 247	18 487	19 460	21 408	24 489	26 805	
3B47 Gjødsellagring - Fjørfe	8 677	9 932	9 999	9 787	9 926	10 064	10 007	9 538	9 182	9 276	9 823	9 346	9 714	
3B482 Gjødsellagring - Tamrein	574	535	534	516	516	502	472	477	444	445	408	398	454	
3B484 Gjødsellagring - Pelsdyr	5 548	5 866	4 527	5 044	5 832	6 055	6 802	6 307	5 045	4 208	5 042	5 106	4 943	
3B51 Indirekte N2O fra gjødsellager (fordamping av NH3)	51 542	52 142	52 895	48 231	47 749	47 819	48 873	48 128	49 190	51 050	49 779	50 662	50 922	
3B52 Indirekte N2O fra gjødsellager (avrenning)	14 530	15 441	15 299	14 955	15 563	15 787	16 046	15 503	15 192	15 272	15 793	15 265	14 768	
3D11 Spredning mineralgjødsel	718 985	720 392	721 186	711 608	705 083	721 914	729 156	734 941	731 252	690 102	699 877	655 279	659 533	6
3D12A Spredning husdyrgjødsel	122 241	123 798	125 288	118 827	119 480	119 233	121 812	119 603	120 845	124 405	120 323	121 331	121 398	1
3D12B Spredning avløpsslam	1 834	2 333	2 656	2 797	2 659	2 923	2 958	2 961	3 001	3 343	3 316	2 965	3 054	
3D12C Spredning annen organisk gjødsel (kompost mm)	0	0	0	0	0	0	17	17	17	17	427	435	624	
3D13 Gjødsel på beite	50 696	48 699	49 227	48 314	47 675	49 057	49 033	49 759	50 520	53 065	52 183	51 683	53 300	5
3D14 Dekomponering av restavling	74 237	70 397	59 584	72 549	63 694	65 012	67 800	64 704	65 544	59 536	61 464	58 502	51 370	5
3D16 N2O fra dyrket organisk jord	332 752	333 444	334 137	334 829	335 522	336 214	337 901	340 143	342 485	344 827	347 169	350 486	352 438	3
3D21 Indirekte N2O fra nedfall (NH3 og Nox fra gjødselspredning og beite)	97 567	97 362	98 345	91 117	89 138	89 443	90 694	89 871	91 256	92 915	89 801	89 668	90 894	9
3D22 Indirekte N2O fra avrenning	217 300	216 050	212 767	213 353	209 124	212 884	216 119	214 979	215 568	209 385	209 823	201 920	200 493	2
3F1 Halmbrenning	37 983	29 762	16 201	22 387	16 072	19 911	21 728	15 634	16 416	14 747	15 713	12 388	9 283	
3G.1 Kalking CaCO3	176 475	155 786	126 518	158 308	137 225	146 220	128 469	130 918	120 268	119 058	104 806	109 788	120 296	1
3G.1a Kalking CaCO3 (jordbruksjord)	166 355	143 908	114 638	146 428	121 883	127 416	103 939	103 688	97 033	93 013	78 372	85 976	101 776	9
3G.1a Kalking CaCO3 (sjøer)	10 120	11 880	11 880	11 880	15 342	18 805	24 531	27 230	23 233	26 045	26 433	23 812	18 519	
3G.2 Kalking CaMg(CO3)2	54 496	44 857	39 132	34 959	35 945	47 087	51 436	49 154	39 807	39 448	32 301	29 694	15 343	
3H Gjødsling Urea	553	553	553	553	553	553	553	553	553	553	112	75	426	
3I NH3-behandling av halm	0	0	0	0	0	0	0	0	0	0	0	0	0	

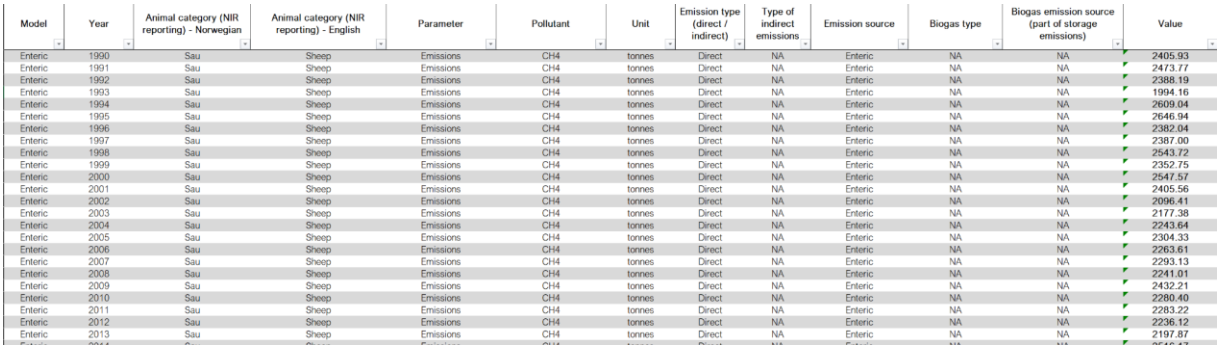
2 Jordbruk total

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	
7.1.1 Husdyr - tarmgass	2 633 966	2 606 909	2 629 305	2 603 879	2 654 850	2 656 794	2 677 580	2 637 231	2 636 565	2 671 206	2 561 393	2 544 104	2 532 474	2
7.1.2 Husdyrgjødsel	714 069	718 057	727 330	702 087	709 273	707 461	721 594	706 271	714 088	728 304	698 141	707 443	707 186	7
7.2.1 Kunstgjødsel	718 985	720 392	721 186	711 608	705 083	721 914	729 156	734 941	731 252	690 102	699 877	655 279	659 533	6
7.2.9 Jordbruk, annet og 9.9.9 kalking sjøer	1 169 552	1 106 319	1 016 411	1 089 159	1 027 156	1 066 468	1 046 044	1 039 853	1 015 177	1 002 887	969 738	965 709	964 517	9

Note: The result tables show results for all years, years after 2002 have been cut in this figure to increase readability.

Additionally, a database of more than 20 000 values (see Figure 5) consolidates results from the Agri models and the Forecasting and mitigation tool into a single spreadsheet. The database can be used for different types of analyses, as well as the basis for data visualisation through graphs using Excel or PowerBI, for example.

Figure 5. Overview of the database



Model	Year	Animal category (NIR reporting) - Norwegian	Animal category (NIR reporting) - English	Parameter	Pollutant	Unit	Emission type (direct / indirect)	Type of indirect emissions	Emission source	Biogas type	Biogas emission source (part of storage emissions)	Value
Enteric	1990	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2405.93
Enteric	1991	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2473.77
Enteric	1992	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2388.19
Enteric	1993	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	1994.16
Enteric	1994	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2609.04
Enteric	1995	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2646.94
Enteric	1996	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2382.04
Enteric	1997	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2387.00
Enteric	1998	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2543.72
Enteric	1999	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2352.75
Enteric	2000	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2547.57
Enteric	2001	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2405.56
Enteric	2002	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2096.41
Enteric	2003	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2177.38
Enteric	2004	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2243.64
Enteric	2005	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2304.33
Enteric	2006	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2263.61
Enteric	2007	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2293.13
Enteric	2008	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2241.01
Enteric	2009	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2432.21
Enteric	2010	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2280.40
Enteric	2011	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2283.22
Enteric	2012	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2236.12
Enteric	2013	Sau	Sheep	Emissions	CH4	tonnes	Direct	NA	Enteric	NA	NA	2197.87

2.5 Other emission sources

The forecasting and mitigation tool covers all emissions from the agricultural sector source categories included in Norway's national inventory, which is reported annually to the UN and the EU. Several other agriculture emission sources that are not estimated in the Agri models described in section 1.2 are forecasted directly in the forecasting and mitigation tool. These include, among others, emissions from application of sewage sludge and other organic waste, burning of straw, emissions from crop residues, application of mineral fertilizes, leaching, etc. (See Table 3 below)

The user is required to manually input the activity data and emission factors associated with the corresponding sources in the INPUT_MDIR sheet. The emissions are then calculated directly in the tool and consolidated with the outputs from the Agri models in the RESULTS sheet of the forecasting tool, as well as displayed in the emissions database.

Table 3. Other emission sources - not included in the Agri models

Emission type	Emission category (Forecasting and mitigation tool)	CRT code	NFR code	Pollutant
NMVOC from silage store, silage feed, housing, manure storage	3B11 – 3B484 Gjødsellagring – NMVOC		3B1a-3B4h	NMVOC
Emissions from inorganic N-fertilisers applied to soils	3D11 Spredning mineralgjødsel	3D1a	3Da1	N_2O, NH_3, NO_X
NMVOC from animal manure applied to soils	3D12A Spredning husdyrgjødsel		3Da2a	NMVOC
Emissions from spreading of sewage sludge and other organic fertilisers applied to soils	3D12B Spredning avløpsslam	3D1bii	3Da2b	N_2O, NH_3, NO_X
	3D12C Spredning annen organisk gjødsel (kompost mm)	3D1biii	3Da2c	N_2O, NH_3, NO_X
NMVOC from urine and dung deposited by grazing animals	3D13 Gjødsel på beite		3Da3	NMVOC
Emissions from crop residues returned to soils	3D14 Dekomponering av restavling	3D1d	3Da4	N_2O, NH_3
Emissions from cultivated organic soils	3D16 N_2O fra dyrket organisk jord	3D1f		N_2O

Emission type	Emission category (Forecasting and mitigation tool)	CRT code	NFR code	Pollutant
Indirect N_2O from managed soils - atmospheric deposition	3D21 Indirekte N_2O fra nedfall (NH_3 og NO_X fra gjødselspredning)	3D2a		N_2O
Indirect N_2O from managed soils – nitrogen leaching and run-off	3D22 Indirekte N_2O fra avrenning	3D2b		N_2O
NMVOC from cultivated crops	3De Cultivated crops		3De	NMVOC
Emissions from burning of straw, liming, urea application and ammonia treatment of straw	3F1 Halmbrenning	3F	3F	N_2O, CH_4, NH_3, NO_X, NMVOC
	3G.1a Kalking $CaCO_3$ (jordbruksjord)	3G1		CO_2
	3G.1b Kalking $CaCO_3$ (sjøer)[6]	3G1		CO_2
	3G.2 Kalking $CaMg(CO_3)2$	3G2		CO_2
	3H Gjødsling Urea	3H		CO_2
	3I NH_3-behandling av halm		3I	NH_3

2.6 Dependencies between input data and emission source categories in the Forecasting and mitigation tool calculations

Mineral fertilizers: The projected consumption of mineral fertilizers are adjusted in the forecasting tool based on the expected change in the availability and use of animal manure. The calculations use the assumption that changing amounts of animal manure affect the use of mineral fertilizers, with a replacement ratio of 1 kg of animal manure-N spread corresponding to 0.45 kg of mineral fertilizer-N spread.

The mineral fertilizer **urea**, in addition to N_2O and NH_3, also emits CO_2 (emission source 3H in reporting to the UN). In the projections, it is incorporated that the CO_2 emissions from the use of urea follow the same trend as the average use of all types of mineral fertilizers.

Projections of the nitrogen content in **crop residues** (the portion of the harvest returned to the soil) are calculated using the Crop residues model[7], which is also applied in the national emission inventory, together with projected annual crop yields (in tons). This model estimates N_2O and NH_3 emissions from crop residues. The development of NH_3 emissions from the ammonia treatment of straw, as well as emissions from straw burning, also depends on harvest trends. For these sources, the same trend is applied as for N_2O emissions from crop residues returned to soils.

3 Mitigation scenarios

The tool supports the development of both reference and mitigation scenarios. The reference scenario typically represents a continuation of current trends and practices, serving as a baseline against which the effects of proposed mitigation actions are measured. In order to estimate the effect from a specific mitigation measure, the user first needs to run the reference scenario in the tool.

[6] Liming of lakes is not included in the agriculture sector in the national emission statistics published by Statistics Norway but is part of the agriculture sector in the international reporting.

[7] Miljødirektoratet (2024). *Calculation of atmospheric nitrogen emissions from crop residues in Norwegian agriculture.* https://www.miljodirektoratet.no/publikasjoner/2024/oktober-2024/calculation-of-atmospheric-nitrogen-emissions-from-crop-residues-in-norwegian-agriculture/

Mitigation scenarios are then developed by modifying specific parameters that reflect the adoption of emission-reducing practices or technologies. These changes are entered in the "INPUT_MDIR" sheet, specifying only those values that differ from the reference scenario. If no changes are made, the tool automatically defaults to reference inputs.

The output of the mitigation options is then calculated in the tool following Steps 1 – 3 described above.

As of 2025, the effect of nine mitigation options can be estimated in the forecasting and mitigation tool. Table 4 provides the list and description of these mitigation options.

Table 4. Mitigation options

Mitigation option	Description
Diet *("Kosthold")*	The mitigation measure is a scenario where the Norwegian population follows the dietary guidelines. This means that consumption of red meat is reduced and substituted by plant-based food and fish.
Food waste *("Matsvinn")*	The mitigation measure involves a reduction in food waste, thereby reducing the need for production and the following emissions associated with the production of this food.
Biogas *("Biogass")*	The mitigation measure involves an increase in the share of manure going to biogas production. The measure assumes an allocation of farm scale and industrial biogas production. By reducing the storage time of manure, it reduces emissions.
Swine manure storage cover *("Dekke på lager")*	The mitigation measure involves covering open air swine manure pits with a porous cover such as straw or clay pellets. A porous cover reduces CH_4 and NH_3 emissions.
Environmentally friendly spreading *("Miljøvennlig spredning")*	The mitigation measure involves spreading the manure in ways that minimize emissions to air and water, so that more of the nutrients become available to the plants. The measure includes increasing the share of manure spread by band spreaders, as well as increasing the share of manure with added water content, and the share of manure that is quickly incorporated into the soil after spreading.
Better spreading time *("Bedre spredetid")*	The mitigation measure involves a reduction in the spreading of manure in autumn. By shifting the spreading of manure to spring and in the growing season, more of the nutrients will become available to the plants and reduce emissions to air and water.
Feed additives *("Tilsetningsstoffer")*	The mitigation measure includes methane inhibitors in feed, which affects bacteria in the rumen so that ruminants produce less methane.
Roughage quality *("Grovfôrkvalitet")*	In this measure the roughage quality is increased to obtain lower emission from enteric fermentation.
Increased grazing *("Økt beiting")*	The mitigation measure involves increasing the pasture use for dairy cows and young cattle. This reduces the emission from storage of manure.

4 Advantages and limitations

One of the core advantages of this tool is the integration of the results from three separate agriculture models into a single interface. The input structure has been simplified to allow users to enter data in a single unified format which is aligned with the format of the Agri models. These inputs are then distributed across the models using built-in macros.

Similarly, the outputs from each model, previously accessed and interpreted separately, are now consolidated into a single result sheet within the tool. These outputs are structured to combine key emission types and presented in both tabular format and as an emissions database.

The forecasting and mitigation tool has however several limitations. The most notable is the complexity involved in conducting calculations for multiple scenarios. Because the tool depends on sequential macro executions and data transfers between models, assessing the impact of small changes in input parameters requires running the entire process multiple times. This can be time-consuming and demands consistent user attention to avoid mistakes and track changes in outputs.

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