FINLAND's INFORMATIVE INVENTORY REPORT 2019

Air Pollutant Emissions 1980-2017

under the UNECE CLRTAP and the EU NECD

Part 5

Agriculture

FINNISH ENVIRONMENT INSTITUTE

Centre for Sustainable Consumption and Production

Environmental Management in Industry – Air Emissions Team

Finland's IIR
Part 5
Agriculture

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FINLAND'S IIR PART 5 - AGRICULTURE

5 AGRICULTURE (NFR 3)

Sub-chapters included under each NFR subcategory
  Source category description
  Emission trend
  Methodological issues
  Uncertainty and time series' consistency
  Source-specific QA/QC and verification
  Source-specific recalculations including changes in response to the review
  Source-specific planned improvements

AGRICULTURE (NFR 3)

5.1 Overview of the sector

Changes in chapter	
Update of text	March 2019 KS & JM & JMP

Agricultural activities in Finland

Agriculture in Finland is characterized by the northern climate and self-sufficiency in most major agricultural products. Its economic role is declining in terms of GDP and employment in primary production, but together with the food industry and forestry with which it is linked, it forms a significant part of the Finnish economy. The majority of farms and agricultural land in Finland lie between the 60th and 65th parallel, making it the only country in the world with a significant agricultural sector so far in the north. The percentage of farms concentrating on animal production increases towards the north and east.

Since 1990 there have been structural changes in agriculture, which have resulted in an increase in farm size and a decrease in the numbers of domestic livestock. The number of farms has steadily declined for the last decades. Between 2000 and 2012 their number fell from almost 80,000 to about 60,000 while the amount of arable land slightly increased to a total of almost 2.3 million hectares. As another example, the number of cattle was more than 33 per cent less in 2013 than in 1990. Agriculture employed 125,000 people in 2010 with a drop of 30 percent from 2000.

Although the decrease in the number of livestock cannot be seen in the development of ammonia emissions it is visible in CH_4 emissions from enteric fermentation and N_2O emissions from manure management. For ammonia, the specific ammonia emissions grow simultaneously with the decrease of animal numbers. Specifically this can be seen in the emissions from dairy cows. However, the emissions have not decreased in proportion to the drop in the number of livestock, because milk and meat output and emissions per animal have increased.

Emission trends

Changes in chapter	
February 2019	KS, JM

The Finnish inventory of air pollutants from agriculture includes emissions from animal husbandry (including manure management, manure application and grazing), application of mineral fertilizers, harvesting, field preparation, storage and handling of agricultural crops, field burning of agricultural wastes, use of pesticides and sewage sludge application to soils (Table 5.1)

Table 5.1 Activities and emissions reported under NFR 3 Agriculture.

NFR	SNAP	NH3	NOx	TSP	PM10	PM2.5	NMVOC	Activities
		Pollutants				**Activities**		
3B1a	100501	x	x	x	x	x	x	Dairy cattle
3B1b	100502	x	x	x	x	x	x	Non-dairy cattle: including sukcler cows, bulls, calves
3B2	100505	x	x	x	x	x	x	Sheep with lambs
3B3	100503 100504	x	x	x	x	x	x	Swine, incl. fattening pigs, sows with piglets, veaned pigs (20-50 kg)
3B4a	100514	NO	NO	NO	NO	NO	NO	Buffalo
3B4d	100511	x	x	x	x	x	x	Goat
3B4e	100506	x	x	x	x	x	x	Horses and ponies
3B4f	100512	NO	NO	NO	NO	NO	NO	Mules and asses
3B4gi	100507	x	x	x	x	x	x	Laying hens
3B4gii	100508	x	x	x	x	x	x	Broilers, broiler hens
3B4giii	100509a	x	x	x	x	x	x	Turkeys
3B4giv	100509b	x	x	x	x	x	x	Other Poultry, incl. cockerels, broiler hens, chicken and other poultry
3B4h	100515 100516	x	x	x	x	x	x	Fur animals, reindeer

NFR	SNAP	Pollutants	Activities
3Da1	100101 100106	NH3, NOx	Inorganic N fertilisers (includes urea) ; Application of nitrogen fertilizers (NH3), harvesting and field preparation (PM)
3Da2a	100905	NH3 (calculated in 3B), NOx, NMVOC	Animal manure applied to soils
3Da2b	100906	NH3, NOx	Sewage sludge applied to soils
3Da2c	100907		Other organic fertilisers applied to soils
3Da3	100517	NH3 (calculated in 3B),NOx, NMVOC	Urine and dung deposited by grazing animals
3Da4	100207	-	Crop residues applied to soils
3Db	100208	-	Indirect emissions from managed soils
3Dc	100901,100904, 101000	TSP, PM10, PM2.5	Farm-level storage, handling and transport of agricultural products; Storage and handling of agricultural crops and fertilizers
3Dd	101100	-	Off-farm storage, handling and transport of agricultural products
3De	100201,100206, 100700	NMVOC	Cultivated crops, crops
3Df	100601,100604	emissions of spesific pestiside (HCB)	Use of pesticides
3F	100301,100305	NOx, CO, NMVOC, SOx, TSP, PM10 PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, PAH-4	Field burning of agricultural residues

Ammonia

Ammonia emissions are generated from manure management, application of nitrogen fertilizers, sewage sludge applied to soils and field burning of agricultural wastes. The total agricultural NH_3 emissions in 2016 were 28.1 Gg, out of which 17.8 Gg originated in manure management, 9.4 Gg in fertilizer use and manure applied to soils, 0.9 kt in deposits by grazing, and 0.1 in field burning of agricultural wastes. The contribution of NFR sub-sectors to agricultural ammonia emissions is presented in Figure 5.1 and in Table 5.2.
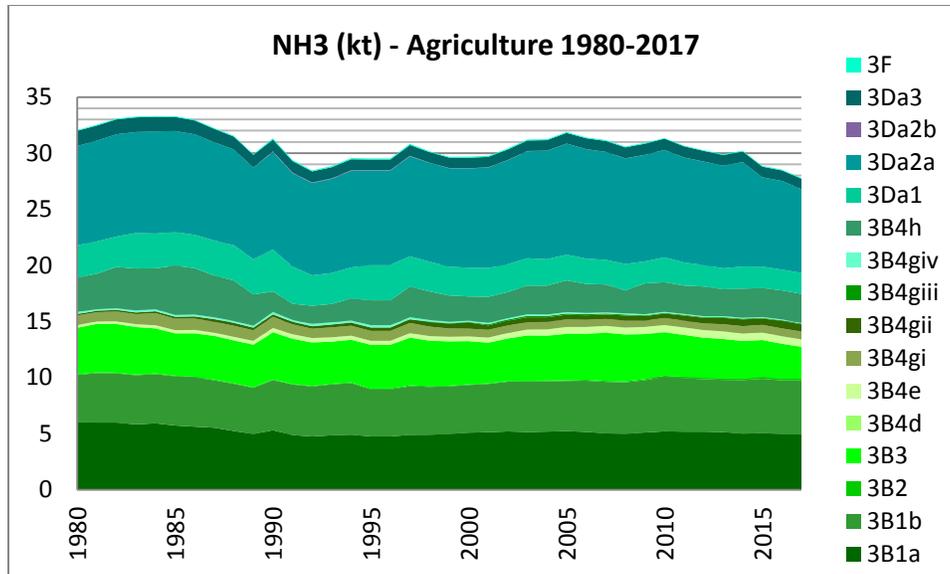
Figure 5.1. Ammonia emissions 1980-2017

Agricultural ammonia emissions have been decreased over the period of 1980-2017 (Figure 5.1 and Table 5.2) partly due to changes in the economic structure in agriculture followed by an increase in the average farm size and the decrease in the number of small farms. Those changes resulted in the decrease of livestock numbers for all other animals than horses. The number of horses increased in the recent years due to the increasing interest in equitation. In addition, the use of nitrogen fertilisers has been reduced, while manure management has been improved sue to measures taken by the farmers as part of an agro-environmental programme aiming at minimising nutrient load to surface waters.

Table 5.2 Ammonia emissions from agricultural sources (Gg) 1980-2017.

Year	NFR 3B	NFR 3D1a	NFR 3Da2a	NFR 3Da2b	NFR 3Da3	NFR 3F	Total
1980	18.91	2.89	8.83	0.000	1.35	0.07	31.99
1981	19.25	2.88	8.98	0.000	1.34	0.07	32.46
1982	19.86	2.71	9.11	0.000	1.32	0.07	33.00
1983	19.72	3.16	9.00	0.000	1.31	0.07	33.19
1984	19.74	3.10	9.10	0.000	1.30	0.07	33.23
1985	19.98	3.00	9.00	0.000	1.25	0.07	33.22
1986	19.75	2.97	8.95	0.000	1.24	0.07	32.91
1987	19.10	3.12	8.75	0.000	1.19	0.07	32.16
1988	18.65	3.14	8.53	0.000	1.15	0.07	31.47
1989	17.41	3.15	8.16	0.000	1.13	0.07	29.84
1990	17.68	3.73	8.69	0.060	1.05	0.11	31.21
1991	16.58	3.32	8.32	0.048	1.02	0.10	29.29
1992	16.40	2.71	8.22	0.042	0.99	0.08	28.37
1993	16.56	2.76	8.39	0.038	0.99	0.10	28.74
1994	17.04	2.77	8.60	0.056	0.98	0.10	29.46
1995	16.89	3.16	8.41	0.036	0.94	0.09	29.43
1996	17.41	2.86	8.57	0.042	0.95	0.10	29.84
1997	18.11	2.69	8.92	0.046	0.96	0.10	30.72
1998	17.67	2.66	8.80	0.016	0.94	0.07	30.09
1999	17.32	2.57	8.77	0.018	0.93	0.07	29.60

2000	17.23	2.56	8.84	0.014	0.93	0.10	29.59
2001	17.20	2.57	8.95	0.020	0.93	0.09	29.67
2002	17.62	2.48	9.27	0.017	0.94	0.09	30.33
2003	18.20	2.44	9.53	0.021	0.93	0.08	31.13
2004	18.19	2.36	9.65	0.012	0.94	0.08	31.16
2005	18.66	2.30	9.89	0.004	0.95	0.08	31.80
2006	18.35	2.26	9.75	0.004	0.97	0.07	31.33
2007	18.30	2.20	9.62	0.004	0.97	0.08	31.09
2008	17.76	2.37	9.40	0.007	0.98	0.08	30.51
2009	18.40	1.96	9.48	0.007	0.99	0.07	30.84
2010	18.50	2.22	9.56	0.009	1.00	0.05	31.29
2011	18.20	2.06	9.35	0.004	0.99	0.06	30.60
2012	18.11	1.92	9.21	0.007	0.95	0.06	30.20
2013	17.87	1.87	9.15	0.006	0.94	0.08	29.83
2014	17.92	1.98	9.30	0.002	0.94	0.07	30.14
2015	17.98	1.91	7.95	0.002	0.95	0.07	28.79
2016	17.77	1.86	7.90	0.002	0.94	0.07	28.46
2017	17.46	1.87	7.46	0.002	0.93	0.07	27.72

NMVOC

NMVOC emissions are generated in manure management, manure applied to soils, deposits during grazing, cultivated crops and field burning of agricultural waste. A summary of agricultural emissions is presented in Figure 5.2 and in Table 5.3.
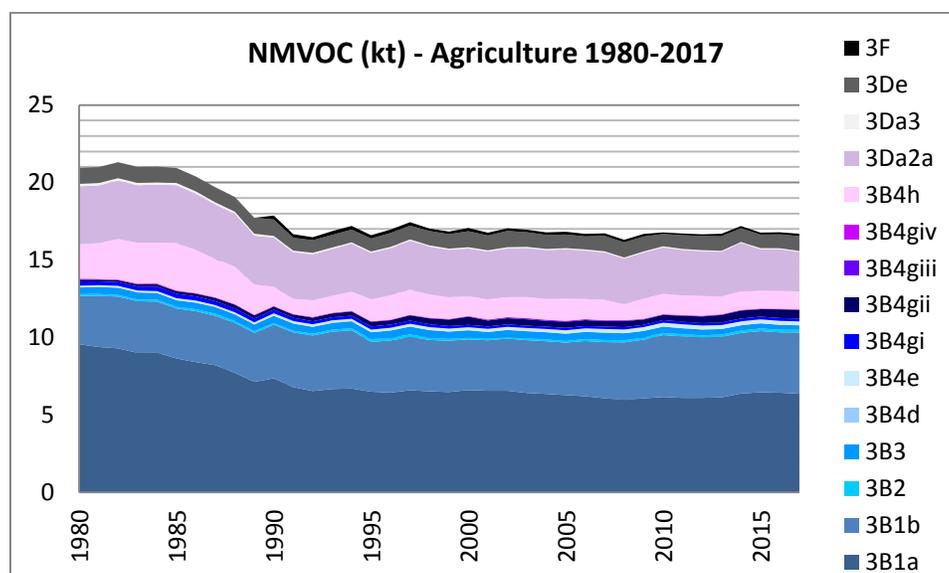
Figure 5.2. NMVOC emissions 1980-2017

Agricultural NMVOC emissions (Figure 5.2 and Table 5.3) have been decreased over the period 1980–2017 partly due to changes in the economic structure followed by an increase in the average farm size and a decrease in the number of small farms. Those changes resulted in the decrease of livestock numbers except for the number of horses that has increased in the recent years due to the increasing interest in equitation.

Table 5.3 NMVOC emissions from agricultural sources (Gg) 1980-2017.

Year	NFR 3B	NFR 3Da2a	NFR 3Da3	NFR 3De	NFR 3F	Total
1980	16.04	3.72	0.16	1.03	NE	20.95
1981	16.08	3.73	0.16	1.03	NE	21
1982	16.35	3.77	0.16	1.03	NE	21.31
1983	16.12	3.71	0.15	1.03	NE	21.01
1984	16.12	3.75	0.15	1.01	NE	21.03
1985	16.10	3.73	0.14	0.97	NE	20.94
1986	15.64	3.64	0.14	0.96	NE	20.38
1987	15.06	3.52	0.14	0.98	NE	19.7
1988	14.58	3.41	0.13	0.95	NE	19.07
1989	13.41	3.16	0.12	1.03	NE	17.72
1990	13.27	3.18	0.10	1.06	0.25	17.86
1991	12.49	3.01	0.10	0.83	0.23	16.66
1992	12.40	2.97	0.09	0.82	0.19	16.47
1993	12.68	3.03	0.09	0.82	0.24	16.86
1994	12.96	3.09	0.09	0.82	0.23	17.19
1995	12.46	3.00	0.09	0.84	0.21	16.6
1996	12.72	3.05	0.08	0.90	0.22	16.97
1997	13.10	3.14	0.08	0.89	0.22	17.43
1998	12.77	3.09	0.08	0.93	0.15	17.02
1999	12.59	3.06	0.08	0.93	0.17	16.83
2000	12.65	3.09	0.08	1.03	0.21	17.06
2001	12.46	3.08	0.08	0.96	0.18	16.76
2002	12.60	3.14	0.08	1.05	0.17	17.04
2003	12.61	3.17	0.07	0.94	0.16	16.95
2004	12.48	3.16	0.07	0.90	0.16	16.77
2005	12.50	3.19	0.07	0.88	0.18	16.82
2006	12.49	3.13	0.07	0.84	0.16	16.69
2007	12.43	3.06	0.07	1.00	0.16	16.72
2008	12.14	2.96	0.07	0.98	0.17	16.32
2009	12.50	2.98	0.07	0.97	0.16	16.68
2010	12.82	3.00	0.07	0.79	0.10	16.78
2011	12.71	2.93	0.07	0.89	0.11	16.71
2012	12.68	2.89	0.07	0.91	0.11	16.66
2013	12.64	2.89	0.07	0.94	0.16	16.7
2014	12.99	3.11	0.07	0.89	0.14	17.2
2015	13.04	2.66	0.07	0.87	0.13	16.77
2016	13.03	2.66	0.06	0.89	0.13	16.77
2017	12.99	2.53	0.06	0.96	0.15	16.69

NOx

NOx emissions are generated in manure management, use of fertilizers, manure applied to soils, deposits during grazing and field burning of agricultural waste. A summary of agricultural emissions is presented in Table 5.4 and in Figure 5.3.
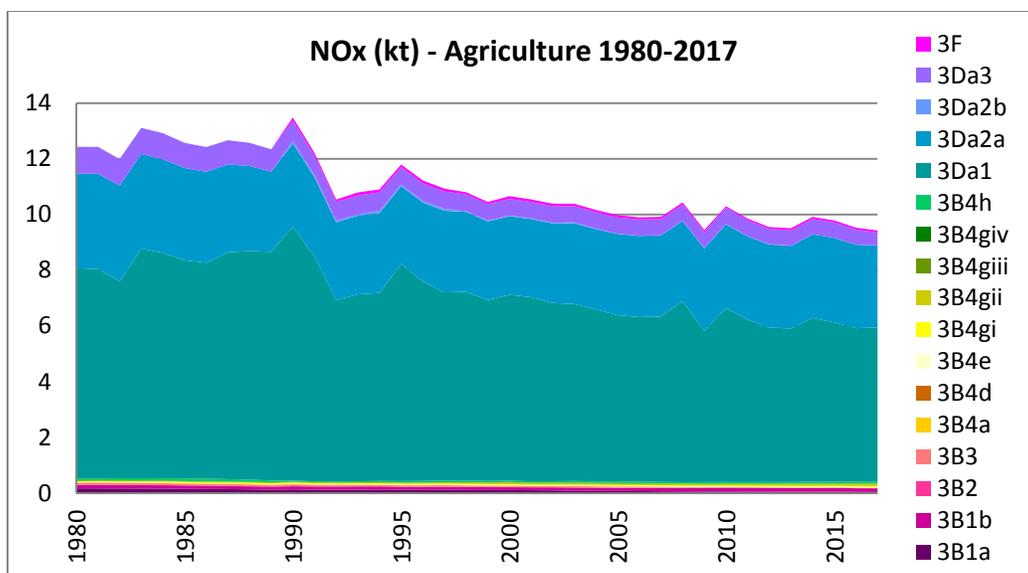
Figure 5.3. NOx emissions 1980-2017

The decreasing trend in NOx emissions from agriculture is mainly a result of decreased use of mineral fertilisers (see Table 5.22), and decrease in grazing.

Table 5.4 NOx emissions from agricultural sources (Gg) 1980-2017

Year	NFR 3B	NFR 3Da1	NFR 3Da2a	NFR 3Da3	NFR 3F	Total
1980	0.53	7.54	3.39	0.97	NE	12.43
1981	0.53	7.52	3.42	0.96	NE	12.43
1982	0.53	7.07	3.44	0.95	NE	11.99
1983	0.54	8.24	3.39	0.94	NE	13.11
1984	0.53	8.09	3.36	0.94	NE	12.92
1985	0.53	7.83	3.31	0.90	NE	12.57
1986	0.52	7.75	3.26	0.89	NE	12.42
1987	0.50	8.14	3.16	0.87	NE	12.67
1988	0.49	8.20	3.05	0.83	NE	12.57
1989	0.45	8.21	2.87	0.81	NE	12.34
1990	0.45	9.11	2.99	0.73	0.113	13.39
1991	0.42	8.07	2.84	0.70	0.103	12.13
1992	0.42	6.51	2.79	0.67	0.085	10.48
1993	0.43	6.71	2.82	0.67	0.106	10.74
1994	0.44	6.75	2.87	0.66	0.102	10.82
1995	0.43	7.80	2.79	0.62	0.094	11.73
1996	0.44	7.16	2.83	0.63	0.102	11.16
1997	0.45	6.75	2.93	0.62	0.101	10.85
1998	0.45	6.78	2.87	0.61	0.075	10.79
1999	0.44	6.49	2.83	0.60	0.071	10.43
2000	0.44	6.67	2.82	0.60	0.100	10.63
2001	0.43	6.61	2.81	0.59	0.087	10.53
2002	0.43	6.40	2.85	0.59	0.090	10.36
2003	0.43	6.35	2.90	0.59	0.084	10.35
2004	0.42	6.17	2.88	0.59	0.084	10.14
2005	0.42	5.96	2.92	0.59	0.083	9.97
2006	0.41	5.91	2.91	0.58	0.074	9.88

2007	0.40	5.93	2.92	0.58	0.080	9.91
2008	0.39	6.50	2.88	0.57	0.078	10.42
2009	0.40	5.42	2.96	0.57	0.076	9.43
2010	0.40	6.24	3.01	0.58	0.051	10.28
2011	0.40	5.83	2.99	0.57	0.060	9.85
2012	0.40	5.54	2.99	0.55	0.059	9.54
2013	0.40	5.51	2.96	0.55	0.080	9.50
2014	0.41	5.88	3.01	0.55	0.073	9.92
2015	0.41	5.72	3.03	0.55	0.071	9.78
2016	0.41	5.51	2.99	0.54	0.070	9.52
2017	0.40	5.54	2.94	0.46	0.076	9.42

CO, SO$_x$

Emissions presented in Table 5.5 and in Figure 5.4 originate from field burning of agricultural waste (see NFR 3F).
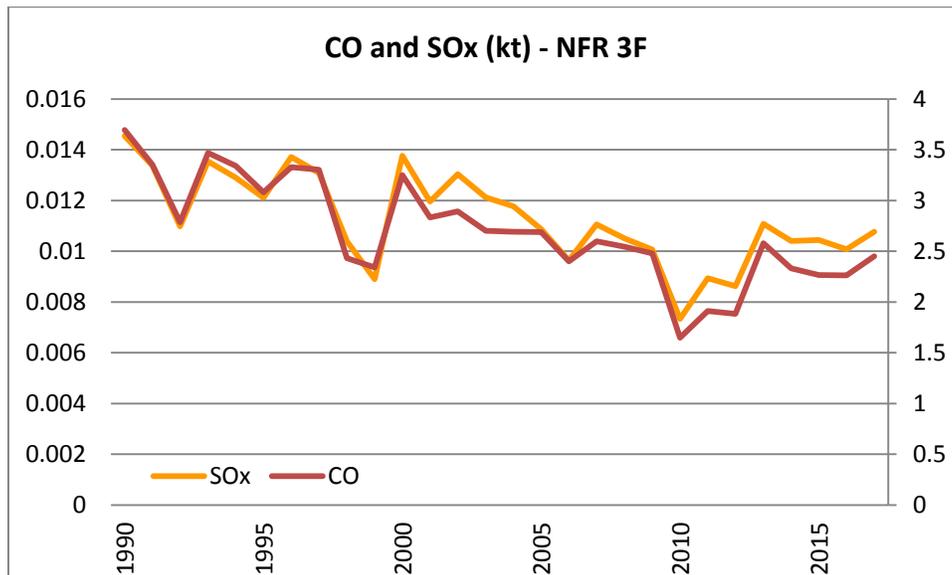
Figure 5.4. CO and SO2 emissions 1980-2017

The CO and SO2 emission trends presented in Figure 5.4 depend on the volume of annually burned biomass, which is calculated using different grain species and specific emission factors.

Table 5.5 CO and Sox emissions from field burning of agricultural waste (wheat and other grain) in 1990-2017

Year	CO, NFR 3F	SOx, NFR 3F	Year	CO, NFR 3F	SOx, NFR 3F
1990	3.69	0.015	**2010**	1.65	0.007
1991	3.35	0.013	**2011**	1.91	0.009
1992	2.79	0.011	**2012**	1.88	0.009
1993	3.47	0.014	**2013**	2.58	0.011
1994	3.34	0.013	**2014**	2.33	0.010
1995	3.08	0.012	**2015**	2.27	0.010
1996	3.33	0.014	**2016**	2.26	0.010
1997	3.30	0.013	**2017**	2.45	0.011

1998	2.43	0.010
1999	2.34	0.009
2000	3.25	0.014
2001	2.83	0.012
2002	2.89	0.013
2003	2.70	0.012
2004	2.69	0.012
2005	2.69	0.011
2006	2.40	0.010
2007	2.60	0.011
2008	2.54	0.010
2009	2.48	0.010

Particles

TSP, PM10, PM2.5 and BC emissions (Figure 5.5) are generated in animal husbandry, grain fields, storage and handling of agricultural crops and fertilizers as well as from field burning of agricultural waste as presented in Tables 5.6a. The fluctuation in emissions reflects the fluctuations in animal numbers.
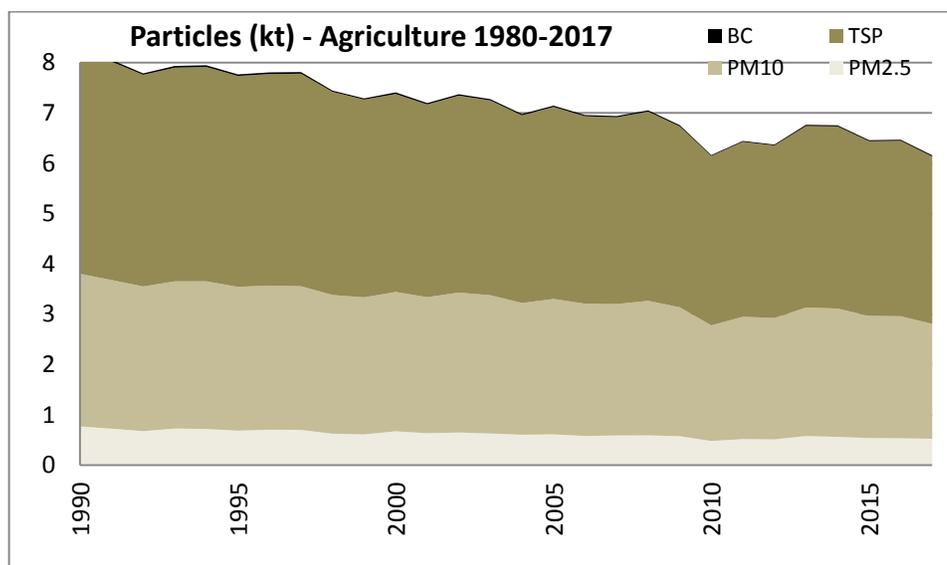
Figure 5.5. Particle emissions 1980-2017

Table 5.6a TSP emissions (kt) by NFR category 1990-2017

TSP (kt)	3B1a	3B1b	3B2	3B3	3B4e	3B4gi	3B4gii	3B4giii	3B4giv	3B4h	3B4d	3Dc	3F
1990	0.445	0.142	0.005	0.518	0.014	0.897	0.060	0.003	0.012	0.059	0.0003	1.805	0.305
1991	0.406	0.139	0.005	0.489	0.014	0.765	0.065	0.004	0.012	0.047	0.0003	1.683	0.277
1992	0.390	0.139	0.005	0.458	0.014	0.732	0.070	0.004	0.012	0.051	0.0002	1.703	0.230
1993	0.389	0.140	0.006	0.436	0.013	0.741	0.075	0.004	0.013	0.052	0.0002	1.731	0.286
1994	0.380	0.140	0.006	0.431	0.012	0.751	0.080	0.004	0.013	0.059	0.0003	1.807	0.276

	3B1a	3B1b	3B2	3B3	3B4e	3B4gi	3B4gii	3B4giii	3B4giv	3B4h	3B4d	3Dc	3F
1995	0.364	0.115	0.008	0.442	0.012	0.766	0.086	0.004	0.013	0.067	0.0003	1.923	0.254
1996	0.356	0.122	0.008	0.448	0.013	0.767	0.081	0.005	0.011	0.075	0.0003	1.961	0.276
1997	0.352	0.123	0.008	0.478	0.013	0.761	0.098	0.006	0.010	0.078	0.0004	2.018	0.273
1998	0.343	0.118	0.007	0.443	0.014	0.697	0.110	0.008	0.009	0.071	0.0004	1.991	0.202
1999	0.331	0.118	0.006	0.437	0.014	0.616	0.120	0.012	0.008	0.067	0.0004	2.046	0.193
2000	0.321	0.115	0.005	0.420	0.014	0.570	0.158	0.012	0.007	0.060	0.0004	2.040	0.270
2001	0.307	0.112	0.005	0.397	0.015	0.587	0.108	0.025	0.006	0.062	0.0004	2.091	0.235
2002	0.295	0.113	0.005	0.408	0.016	0.589	0.115	0.029	0.006	0.061	0.0003	2.079	0.241
2003	0.277	0.113	0.005	0.434	0.017	0.553	0.121	0.033	0.006	0.065	0.0004	2.089	0.225
2004	0.263	0.110	0.006	0.426	0.018	0.563	0.111	0.029	0.004	0.064	0.0004	2.030	0.224
2005	0.253	0.108	0.005	0.438	0.019	0.573	0.109	0.027	0.005	0.068	0.0004	1.991	0.222
2006	0.246	0.111	0.006	0.427	0.020	0.559	0.107	0.027	0.004	0.062	0.0004	2.026	0.199
2007	0.236	0.109	0.007	0.443	0.020	0.554	0.101	0.024	0.005	0.063	0.0004	2.134	0.215
2008	0.231	0.109	0.007	0.431	0.021	0.554	0.113	0.023	0.005	0.049	0.0004	2.052	0.211
2009	0.232	0.109	0.007	0.417	0.021	0.498	0.098	0.017	0.004	0.062	0.0004	1.811	0.205
2010	0.232	0.112	0.008	0.399	0.022	0.567	0.092	0.015	0.004	0.063	0.0003	1.936	0.137
2011	0.229	0.109	0.009	0.386	0.022	0.541	0.108	0.017	0.005	0.060	0.0003	1.998	0.160
2012	0.228	0.107	0.009	0.377	0.022	0.509	0.121	0.016	0.005	0.061	0.0003	2.025	0.157
2013	0.226	0.108	0.009	0.371	0.022	0.551	0.137	0.015	0.005	0.055	0.0003	2.025	0.214
2014	0.227	0.107	0.009	0.353	0.021	0.585	0.147	0.016	0.005	0.058	0.0003	1.943	0.194
2015	0.227	0.106	0.011	0.350	0.021	0.562	0.137	0.014	0.006	0.056	0.0003	1.929	0.189
2016	0.222	0.104	0.011	0.336	0.021	0.588	0.163	0.014	0.006	0.056	0.0003	1.896	0.188
2017	0.215	0.105	0.011	0.309	0.021	0.601	0.161	0.016	0.008	0.056	0.0004	1.898	0.204

Table 5.6b PM2.5 emissions by NFR 1990-2017

PM2.5 (kt)	3B1a	3B1b	3B2	3B3	3B4e	3B4gi	3B4gii	3B4giii	3B4giv	3B4h	3B4d	3Dc	3F
1990	0.132	0.043	0.0007	0.004	0.004	0.014	0.003	0.0006	0.0005	0.013	0.0000	0.221	0.287
1991	0.120	0.043	0.0008	0.004	0.004	0.012	0.003	0.0006	0.0006	0.010	0.0000	0.203	0.261
1992	0.116	0.042	0.0008	0.004	0.004	0.012	0.004	0.0007	0.0008	0.011	0.0000	0.204	0.216
1993	0.116	0.043	0.0009	0.004	0.004	0.012	0.004	0.0007	0.0010	0.012	0.0000	0.208	0.269
1994	0.113	0.043	0.0009	0.003	0.004	0.012	0.004	0.0008	0.001	0.013	0.0000	0.215	0.259
1995	0.108	0.035	0.001	0.004	0.004	0.012	0.004	0.0008	0.001	0.015	0.0000	0.234	0.239
1996	0.106	0.037	0.001	0.004	0.004	0.012	0.004	0.0010	0.0009	0.017	0.0000	0.240	0.259
1997	0.105	0.037	0.001	0.004	0.004	0.012	0.005	0.001	0.0006	0.017	0.0001	0.248	0.257
1998	0.102	0.036	0.0010	0.004	0.004	0.011	0.006	0.001	0.0006	0.016	0.0001	0.245	0.190
1999	0.098	0.036	0.0008	0.004	0.004	0.010	0.006	0.002	0.0007	0.015	0.0001	0.252	0.182
2000	0.095	0.035	0.0007	0.004	0.004	0.009	0.008	0.002	0.0006	0.013	0.0001	0.252	0.253
2001	0.091	0.034	0.0007	0.003	0.004	0.009	0.005	0.005	0.0006	0.014	0.0001	0.261	0.221
2002	0.088	0.035	0.0007	0.003	0.005	0.009	0.006	0.005	0.0007	0.014	0.0000	0.259	0.226
2003	0.082	0.034	0.0007	0.004	0.005	0.009	0.006	0.006	0.0007	0.014	0.0001	0.261	0.211

2004	0.078	0.033	0.0008	0.003	0.005	0.009	0.006	0.005	0.0003	0.014	0.0001	0.252	0.210
2005	0.075	0.033	0.0007	0.004	0.006	0.009	0.005	0.005	0.0004	0.015	0.0001	0.247	0.209
2006	0.073	0.034	0.0009	0.003	0.006	0.009	0.005	0.005	0.0003	0.014	0.0001	0.250	0.187
2007	0.070	0.033	0.0010	0.004	0.006	0.009	0.005	0.004	0.0004	0.014	0.0001	0.265	0.202
2008	0.069	0.033	0.001	0.003	0.006	0.009	0.006	0.004	0.0004	0.011	0.0001	0.254	0.198
2009	0.069	0.033	0.001	0.003	0.006	0.008	0.005	0.003	0.0003	0.014	0.0001	0.220	0.193
2010	0.069	0.034	0.001	0.003	0.006	0.009	0.005	0.003	0.0002	0.014	0.0000	0.238	0.129
2011	0.068	0.033	0.001	0.003	0.006	0.009	0.005	0.003	0.0003	0.013	0.0000	0.247	0.150
2012	0.068	0.033	0.001	0.003	0.006	0.008	0.006	0.003	0.0003	0.014	0.0000	0.251	0.147
2013	0.067	0.033	0.001	0.003	0.006	0.009	0.007	0.003	0.0003	0.012	0.0000	0.251	0.201
2014	0.067	0.033	0.001	0.003	0.006	0.009	0.007	0.003	0.0003	0.013	0.0000	0.240	0.182
2015	0.068	0.032	0.002	0.003	0.006	0.009	0.007	0.002	0.0004	0.012	0.0000	0.236	0.177
2016	0.066	0.032	0.002	0.002	0.006	0.009	0.008	0.003	0.0003	0.012	0.0000	0.230	0.177
2017	0.064	0.032	0.002	0.002	0.006	0.009	0.008	0.003	0.0008	0.012	0.0001	0.231	0.191

Table 5.6c PM10 emissions (kt) by NFR 1990-2017

PM10 (kt)	3B1a	3B1b	3B2	3B3	3B4e	3B4gi	3B4gii	3B4giii	3B4giv	3B4h	3B4d	3Dc	3F
1990	0.203	0.065	0.002	0.086	0.006	0.189	0.030	0.003	0.004	0.026	0.0001	1.805	0.301
1991	0.185	0.064	0.002	0.082	0.006	0.161	0.032	0.004	0.005	0.021	0.0001	1.683	0.273
1992	0.178	0.064	0.002	0.077	0.006	0.154	0.035	0.004	0.006	0.023	0.0001	1.703	0.227
1993	0.178	0.064	0.003	0.073	0.006	0.156	0.038	0.004	0.007	0.023	0.0001	1.731	0.282
1994	0.174	0.064	0.003	0.073	0.006	0.158	0.040	0.004	0.008	0.026	0.0001	1.807	0.272
1995	0.166	0.053	0.004	0.074	0.006	0.161	0.043	0.004	0.009	0.030	0.0001	1.923	0.251
1996	0.163	0.056	0.003	0.076	0.006	0.161	0.041	0.005	0.007	0.033	0.0001	1.961	0.271
1997	0.161	0.056	0.003	0.081	0.006	0.160	0.049	0.006	0.005	0.035	0.0002	2.018	0.269
1998	0.157	0.054	0.003	0.076	0.006	0.147	0.055	0.008	0.005	0.032	0.0002	1.991	0.199
1999	0.151	0.054	0.002	0.074	0.006	0.130	0.060	0.012	0.005	0.030	0.0002	2.046	0.190
2000	0.147	0.053	0.002	0.072	0.006	0.120	0.079	0.012	0.004	0.027	0.0002	2.040	0.265
2001	0.140	0.051	0.002	0.068	0.007	0.124	0.054	0.025	0.004	0.028	0.0002	2.091	0.231
2002	0.135	0.052	0.002	0.070	0.007	0.124	0.058	0.029	0.005	0.027	0.0001	2.079	0.237
2003	0.126	0.052	0.002	0.073	0.008	0.116	0.061	0.033	0.005	0.029	0.0002	2.089	0.222
2004	0.120	0.050	0.002	0.072	0.008	0.118	0.056	0.029	0.002	0.028	0.0002	2.030	0.220
2005	0.116	0.049	0.002	0.074	0.009	0.121	0.055	0.027	0.003	0.030	0.0002	1.991	0.219
2006	0.112	0.051	0.003	0.071	0.009	0.118	0.054	0.027	0.002	0.028	0.0002	2.026	0.196
2007	0.108	0.050	0.003	0.074	0.009	0.117	0.051	0.024	0.003	0.028	0.0002	2.134	0.212
2008	0.105	0.050	0.003	0.071	0.009	0.117	0.057	0.023	0.003	0.022	0.0002	2.052	0.208
2009	0.106	0.050	0.003	0.068	0.010	0.105	0.049	0.017	0.002	0.028	0.0002	1.811	0.202
2010	0.106	0.051	0.003	0.064	0.010	0.119	0.046	0.015	0.002	0.028	0.0001	1.936	0.135
2011	0.105	0.050	0.004	0.061	0.010	0.114	0.054	0.017	0.002	0.027	0.0001	1.998	0.157
2012	0.104	0.049	0.004	0.059	0.010	0.107	0.060	0.016	0.002	0.027	0.0001	2.025	0.154

2013	0.103	0.049	0.004	0.058	0.010	0.116	0.069	0.015	0.002	0.024	0.0001	2.025	0.211
2014	0.104	0.049	0.004	0.055	0.010	0.123	0.073	0.016	0.002	0.026	0.0001	1.943	0.191
2015	0.104	0.049	0.005	0.055	0.010	0.118	0.068	0.014	0.003	0.025	0.0001	1.929	0.186
2016	0.101	0.047	0.005	0.052	0.010	0.124	0.082	0.014	0.003	0.025	0.0001	1.896	0.185
2017	0.098	0.048	0.005	0.048	0.010	0.127	0.080	0.016	0.006	0.025	0.0002	1.898	0.201

Heavy metals

Emissions are generated in field burning of agricultural waste as described under NFR 3F.

The emission trends presented in Figure 5.6 and Table 5.7 are impacted by the volume of field burning of straw which has a declining trend.
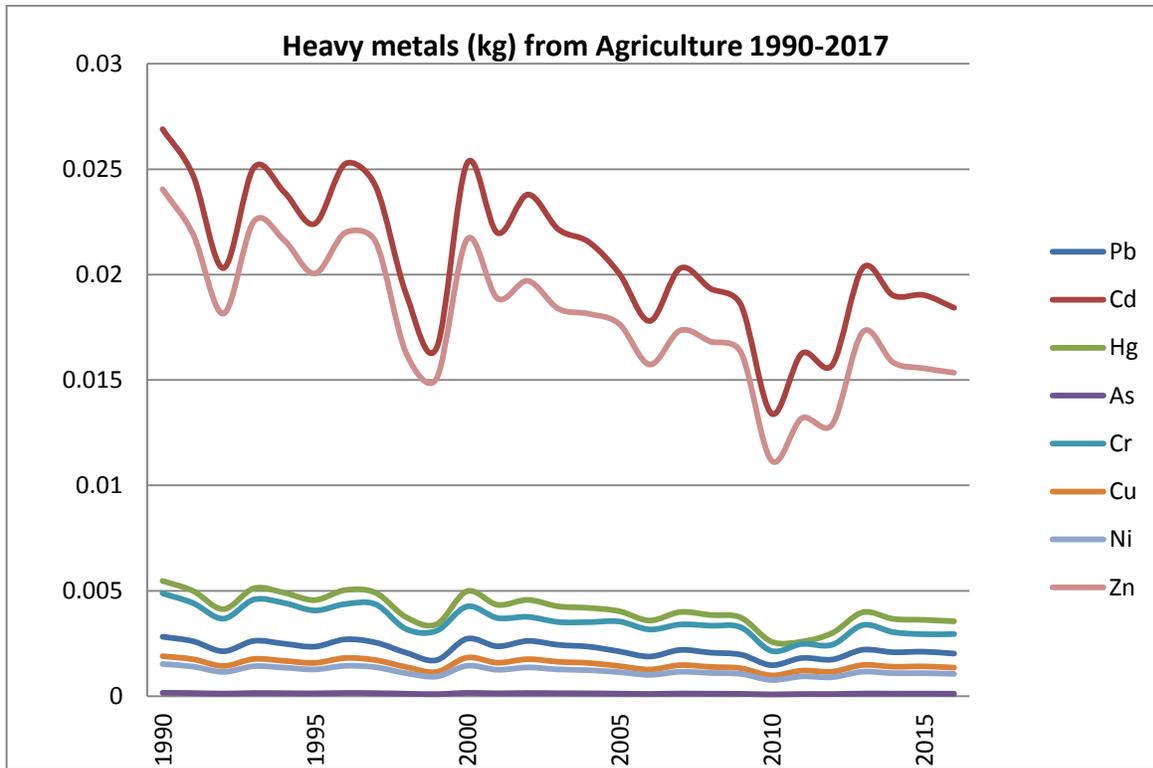

Figure 5.6 Heavy metals from agriculture 1980-2017.(NOTE: the peak in Hg for 1994 is due to an incorrect value (0.024) for 3F in the NFR tables, the correct value of 0.005 is presented in Table 5.7 below)

Table 5.7 Heavy metal emissions from field burning of agricultural waste 1990-2017

Year	NFR 3F Heavy Metals (g)								
	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1980	NE	NE	NE	NE	NE	NE	NE	NE	NE
1981	NE	NE	NE	NE	NE	NE	NE	NE	NE
1982	NE	NE	NE	NE	NE	NE	NE	NE	NE
1983	NE	NE	NE	NE	NE	NE	NE	NE	NE
1984	NE	NE	NE	NE	NE	NE	NE	NE	NE
1985	NE	NE	NE	NE	NE	NE	NE	NE	NE
1986	NE	NE	NE	NE	NE	NE	NE	NE	NE
1987	NE	NE	NE	NE	NE	NE	NE	NE	NE
1988	NE	NE	NE	NE	NE	NE	NE	NE	NE
1989	NE	NE	NE	NE	NE	NE	NE	NE	NE
1990	0.003	0.027	0.005	0.000	0.005	0.002	0.002	0.001	0.024
1991	0.003	0.025	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1992	0.002	0.020	0.004	0.000	0.004	0.001	0.001	0.001	0.018
1993	0.003	0.025	0.005	0.000	0.005	0.002	0.001	0.001	0.023
1994	0.002	0.024	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1995	0.002	0.022	0.005	0.000	0.004	0.002	0.001	0.001	0.020
1996	0.003	0.025	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1997	0.003	0.024	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1998	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
1999	0.002	0.017	0.003	0.000	0.003	0.001	0.001	0.001	0.015
2000	0.003	0.025	0.005	0.000	0.004	0.002	0.001	0.001	0.022
2001	0.002	0.022	0.004	0.000	0.004	0.002	0.001	0.001	0.019
2002	0.003	0.024	0.005	0.000	0.004	0.002	0.001	0.001	0.020
2003	0.002	0.022	0.004	0.000	0.004	0.002	0.001	0.001	0.018
2004	0.002	0.022	0.004	0.000	0.004	0.002	0.001	0.001	0.018
2005	0.002	0.020	0.004	0.000	0.004	0.001	0.001	0.001	0.018
2006	0.002	0.018	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2007	0.002	0.020	0.004	0.000	0.003	0.001	0.001	0.001	0.017
2008	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.017
2009	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2010	0.001	0.013	0.003	0.000	0.002	0.001	0.001	0.001	0.011
2011	0.002	0.016	0.003	0.000	0.002	0.001	0.001	0.001	0.013
2012	0.002	0.016	0.003	0.000	0.002	0.001	0.001	0.001	0.013
2013	0.002	0.020	0.004	0.000	0.003	0.001	0.001	0.001	0.017
2014	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2015	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2016	0.002	0.018	0.004	0.000	0.003	0.001	0.001	0.001	0.015
2017	0.002	0.020	0.004	0.000	0.003	0.001	0.001	0.001	0.017

POPs

HCB emissions originate from the use of pesticides while PAH and PCDD/F emissions originate from field burning of agricultural waste (NFR 3F) (Figure 5.7).
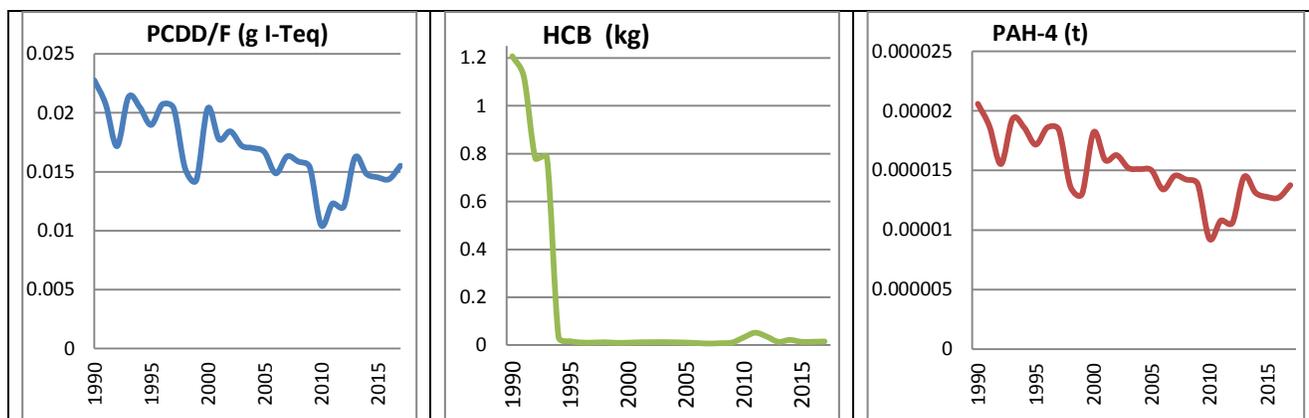

Figure 5.7. POP emissions from agricultural sources 1990-2017

Emission trends presented in Figure 5.7 and Table 5.8 are impacted by the volume of field burning of straw and agricultural waste, which both have a declining trend. The decrease in HCB emissions in early 1990's is due to the strong decrease in the use of Simazine, which was forbidden in 2005, and the slight increase in 2011 due to the replacement by a new herbicide which came into market (selling permit granted 12.4.2011).

Table 5.8 POP emissions from agriculture 1990-2017

	PCDD/F	HCB	B(a)P	B(b)F	B(k)F	I(1,2,3-cdP
3F, 3Df	g I-Teq	kt	t	t	t	t
1990	0.023	1.2	0.004	0.011	0.004	0.002
1991	0.021	1.1	0.003	0.01	0.003	0.002
1992	0.017	0.78	0.003	0.008	0.003	0.002
1993	0.021	0.78	0.003	0.01	0.003	0.002
1994	0.020	0.034	0.003	0.01	0.003	0.002
1995	0.019	0.02	0.003	0.009	0.003	0.002
1996	0.021	0.011	0.003	0.01	0.003	0.002
1997	0.020	0.01	0.003	0.01	0.003	0.002
1998	0.015	0.012	0.002	0.007	0.002	0.002
1999	0.014	0.01	0.002	0.007	0.002	0.001
2000	0.020	0.01	0.003	0.01	0.003	0.002
2001	0.018	0.01	0.003	0.008	0.003	0.002
2002	0.018	0.012	0.003	0.009	0.003	0.002
2003	0.017	0.012	0.003	0.008	0.003	0.002
2004	0.017	0.012	0.003	0.008	0.003	0.002
2005	0.017	0.01	0.003	0.008	0.003	0.002
2006	0.015	0.008	0.002	0.007	0.002	0.001
2007	0.016	0.006	0.003	0.008	0.003	0.002
2008	0.016	0.008	0.003	0.008	0.003	0.002
2009	0.015	0.01	0.002	0.007	0.002	0.002
2010	0.010	0.032	0.002	0.005	0.002	0.001
2011	0.012	0.052	0.002	0.006	0.002	0.001

2012	0.012	0.036	0.002	0.006	0.002	0.001
2013	0.016	0.014	0.003	0.008	0.003	0.002
2014	0.015	0.022	0.002	0.007	0.002	0.001
2015	0.015	0.014	0.002	0.007	0.002	0.001
2016	0.014	0.014	0.002	0.007	0.002	0.001
2017	0.016	0.015	0.002	0.007	0.002	0.002

5.2 Manure Management (NFR 3B)

Changes in chapter	
Update of text	February 2019 KS, JMP, JG

Source category description

This sector covers management of manure from domestic livestock.

Figure 5.8 K. Inha: Finnish agriculture, series of photographs, 1899, photographed scenes of Finnish agricultural work for the World´s Fair (Exposition Universelle) in Paris in 1900.

Finland reports emissions from manure management of cattle (including dairy cows, suckler cows, heifers, bulls and calves), swine, horses, goats, sheep, poultry, fur animals and reindeer. Mules, asses, camels and buffalos are not farmed in Finland (Table 5.9).

Table 5.9 Animal categories in Finland

NFR	Animal category
3B1a	Cattle, dairy
3B1b	Cattle, non-dairy
3B2	Sheep
3B3	Swine
3B4a	Buffalo - not farmed in Finland
3B4d	Goats
3B4e	Horses

NFR	Animal category
3B4f	Mules and asses - not farmed in Finland
3B4gi	Laying hens
3B4gii	Broilers
3B4giii	Turkeys
3B4giv	Other poultry - cockerels, broiler hens, chicken and other poultry
3B4h	Other - reindeer and fur animals

Methodological issues

Documentation of the revised method is presented below and in a separate document Grönroos et al 2017 (saved in the submission folder).

Calculation model for agricultural emissions

Since 1998, ammonia emissions originating from manure have been calculated by using the national nitrogen model, which is based on the nitrogen flow approach. In this approach, flow of total ammoniacal nitrogen (TAN) and total nitrogen (tot-N) are followed through the manure management system so that the more NH3 and other nitrogen compounds are emitted at the previous stage of the manure management system the less TAN and tot-N remain available for emissions later. The model includes also ammonia emission calculation for mineral N-fertilisers. The documentation of the previous calculation systems were published by Grönroos et al. in 1998 (in Finnish) and in 2009 (in English). Originally, the model was used only for ammonia emission modelling, but it was supplemented later with N2O and NO and N2 emission calculation.

The model was revised in 2016-2017 (Figure 5.9) and includes currently gaseous nitrogen emissions (N_2, NH_3, N_2O and NO) thus integrating the calculation of nitrogen emissions between the greenhouse gas and air pollutant emission inventories. It also enables reporting of emissions at the level of detail in the reporting guidelines of the UNECE CLRTAP and the UNFCCC.

The revision of the model included updating and expanding the model to meet the most recent requirements of the emission inventory guidelines of UNECE (EMEP/EEA 2016) and UNFCCC (IPCC 2006). The revision included change of the nitrogen flow approach to a entirely total ammoniacal nitrogen (TAN) based approach. In the previous model version, the approach was mainly based on the total nitrogen.

Nitrogen from bedding materials was also included into the calculation. In addition to the ammonia (NH_3) and direct and indirect nitrous oxide (N_2O) emissions (originating from manure management and managed soils), emissions of nitric oxide (NO) and di-nitrogen (N_2) from manure management are calculated, as well as NO emissions from application of manure and mineral fertilisers.

NMVOC emission calculation for manure management, manure applied to soils, urine and dung deposited by grazing animals and cultivated crops was added to the calculation system (see Table 5.6 and Chapter 2.2 in Grönroos et al., 2017). Further, the changes enabled the establishment of the Finnish normative manure system (see Luostarinen et al. 2017), which was built simultaneously with the revision of this model. Particle emissions from animal husbandry and field operations (cultivation, harvesting, cleaning and drying) were added to the model in 2019.

Atmospheric emissions (NO, NH$_3$, N$_2$, N$_2$O)
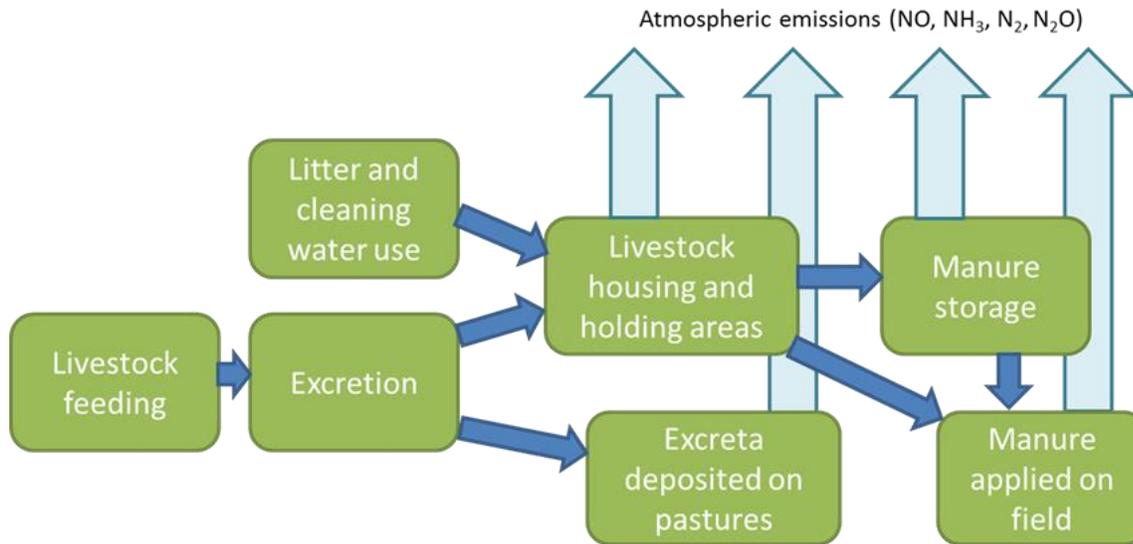
Figure 5.9 Revised calculation model for agriculture (Grönroos et al., 2017)

Table 5.10 Source categories and emissions included in the Finnish Agricultural Emissions Calculation System in 2019.

NFR	Category name	NH$_3$	NOx	N$_2$O direct	N$_2$O indirect	N$_2$	NMVOC	PM
3B	Manure management (animal categories: see chapter 2.1.1.1)	x	x	x	x	x	x	x
3Da1	Inorganic N-fertilizers (includes also urea application)	x	x	x	x		x	
3Da2a	Animal manure applied to soils	x		x	x		x	
3Da3	Urine and dung deposited by grazing animals	x		x	x		x	
3De	Cultivated crops						x	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products							x

The model is updated yearly, a new reporting year is added every year and the previous years are updated when new information is available.

Basis of calculation

Calculation of the gaseous nitrogen emissions from manure management is based on the mass or nitrogen flow approach, as described in the previous Finnish ammonia and nitrous oxide emission calculation documentations (Grönroos et al. 1998; Grönroos et al. 2009), and in the UNECE and UNFCCC emission inventory guidebooks. In the method used, the pathways of nitrogen are followed starting from the nitrogen excretion of the livestock and ending at the application of manure to the fields (Figure 5.10). In each manure management stage the gaseous losses of nitrogen are calculated. The calculation is carried out per each animal category (Table 5.11.a and 5.11.b) and for each manure management system.

In general, the Finnish agricultural ammonia emission calculation system follows the principles of the Tier 2 method described in the EMEP/EEA Guidebook 2016. However, it has some features, which move it towards the Tier 3 method, such as the greater number of animal and manure categories than listed under Tier 2, and the inclusion of the emission abatement measures.

The manure management systems considered are (manure type acronym in brackets):
- slurry (S)
- deep litter (DL)
- solid manure system (SMS), divided into two separate systems:
  - o farm yard manure system (FYM; urine absorbed in bedding material)
  - o solid separation system (SS; urine and faeces managed separately, produces two kind of manure: dung with bedding (SSD), and urine (SSU)).

In contrast to the previous calculation systems, nitrogen flow approach is applied to total ammoniacal nitrogen (TAN) of manure in each stage of the manure management system instead of total nitrogen. This means that also the emissions of gaseous nitrogen compounds (except nitrous oxide emissions) are estimated based on the TAN content of manure. Because the effects of dietary changes or nitrogen transformation during the manure management chain affect the TAN content of manure and TAN is the basis of ammonia and other forms of gaseous N emissions, more precise emission estimates are now attained.

Due to the needs of nitrous oxide emission calculation, total nitrogen content of manure was also included in the nitrogen flow approach, as well as nitrogen from bedding materials. Moreover, the revised system considers also the transformation of manure nitrogen during manure storage: immobilisation of solid manure TAN to organic form and mineralisation of slurry organic nitrogen to TAN.

The main manure management phases considered in the calculation system are:
- animal housing,
- manure storing,
- manure spreading (included in the managed soils category in GHG emission inventory),
- outdoor yards.

Emissions from grazing are included in the model. In the GHG emission inventory, emissions from grazing are included in the category of managed soils.

The emission calculation model is part of the Finnish normative manure system (Luostarinen et al. 2017). The normative manure system is used to calculate normative manure quality and quantity data for various livestock animal categories, to be used e.g. in policymaking, research, technology development and manure fertilisation plans on farms. Major inputs from normative manure system to the agricultural emissions calculation system are nitrogen excretion rates for each animal category (divided between faeces and urine), and effects of the nitrogen transformation processes to quantity of TAN in a manure management system.
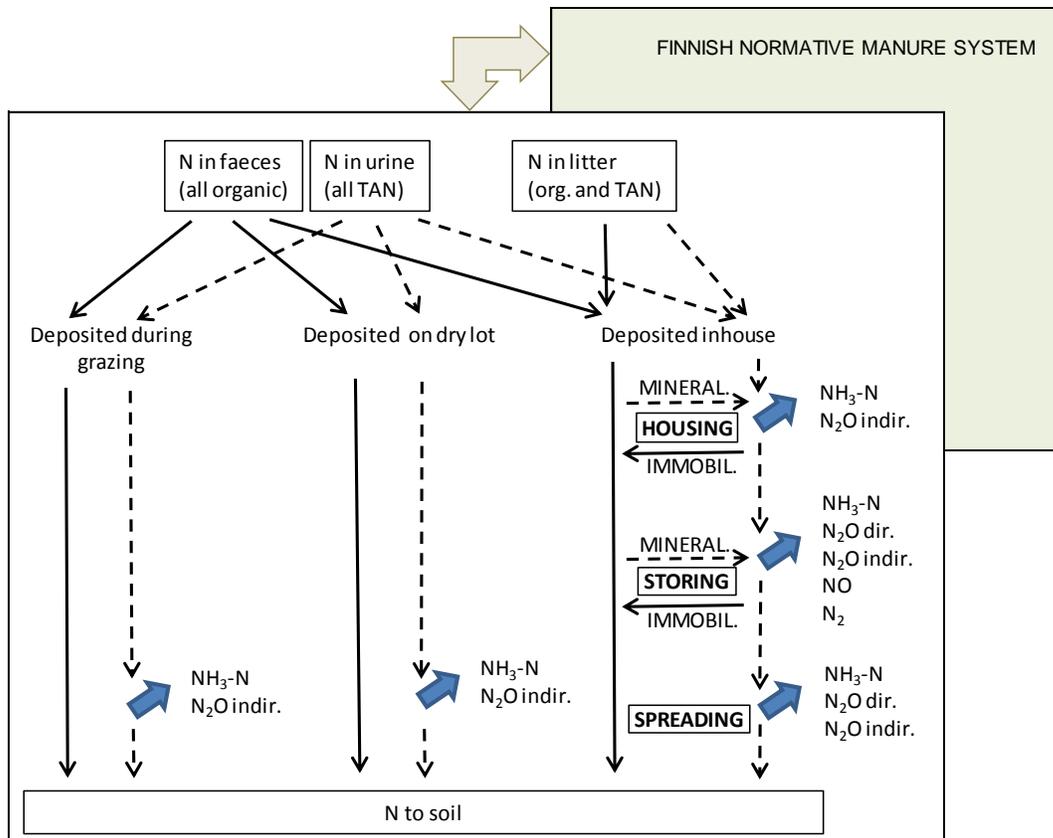
Figure 5.10. Schematic diagram of the N flows in manure management (incl. manure application, grazing and dry lots) and the related gaseous nitrogen emission calculation system used for calculating the NH_3, N_2O, NO and N_2 emissions from manure management in Finland. Nitrogen transformation processes (immobilisation and mineralisation) are shown, as well as the link between emission calculation system and the Finnish normative manure system (see text for more information). Broad blue arrows: emissions of N-compounds to the atmosphere. Emissions are calculated separately for each animal category and manure management system. For clarity, all manure management systems are not shown in the figure.

Table 5.11.a. Animal categories considered in the emission calculation system; the detailed categorisation. The animal categories are the same as those in the Finnish normative manure system (Luostarinen et al. 2017).

CATTLE	PIGS	POULTRY	OTHER ANIMALS
Dairy cow, high yielding	Farrowing sow + piglets (<10-12 kg)	Laying hen breeder	Horse
Dairy cow, indigenous	Gestating sow	Cockerel (laying hen breeder, male)	
	Mating sow	Broiler	Pony (120-140)
Suckler cow, high yielding	Boar (50- kg)	Broiler breeder hen	Pony, little (<120)
Suckler cow, indigenous	Fattening pig (50- kg)	Broiler breeder, male	
		Chicken	Ewe
Heifer, beef (2- yrs)	Weaned pig (<30 kg)		Ram
Heifer, beef (1-2 yrs)	Weaned pig (<50 kg)	Groving turkey	Lamb
Heifer, dairy (2- yrs)		Turkey breeder hen	
Heifer, dairy (1-2 yrs)		Turkey breeder male	Female goat
Heifer, small (>2 yrs)		Other poultry	Male goat
Heifer, small (1-2 yrs)			Goatling
Bull, beef (>2 yrs)			Fox breeder, female

			Fox breeder, male
Bull, beef (1-2 yrs)			Fox grover
Bull, dairy (>2 yrs)			
Bull, dairy (1-2 yrs)			
Bull, indigenous (1-2 yrs)			Mink breeder, female
Bull, indigenous (>2 yrs)			Mink breeder, male
			Mink grover
Calf, female, beef (< 6 m)			Reindeer
Calf, female, beef (6-12 m)			
Calf, female, dairy (< 6 m)			
Calf, female, dairy (6-12 m)			
Calf, female, indigenous (< 6 m)			
Calf, female, indigenous (6-12 m)			
Calf, male, beef (< 6 m)			
Calf, male, beef (6-12 m)			
Calf, male, dairy (< 6 m)			
Calf, male, dairy (6-12 m)			
Calf, male, indigenous (< 6 m)			
Calf, male, indigenous (6-12 m)			

Table 5.11.b. Animal categories in the calculation system; the simpler categorisation. The animal categories are the same as those in the Finnish normative manure system (Luostarinen et al. 2017).

CATTLE	PIGS	POULTRY	ALS
Dairy cow	Sow (with piglets)	Laying hen breeder (female)	Horse
Suckler cow	Boar (50- kg)	Cockerel (laying hen breeder, male)	Pony
Heifer >1 yr	Fattening pig (50- kg)	Broiler	Sheep
Bull >1 yr	Weaned pig (20-50 kg)	Broiler breeder hen	Goat
Calf <1 yr		Broiler breeder, male	Fox and racoon
		Chicken	Mink and fitch
		Turkey	Reindeer
		Other poultry	

A detailed description of the calculation of emissions is provided in the document Grönroos et al., 2017, Chapter 2.1.1.2 (available in the 2018 EIONET CDR submission folder).

Activity data

Animal numbers are received from TIKE (Information Centre of the Ministry of Agriculture and Forestry) (TIKE, 2016), the Finnish Trotting and Breeding Association of horses (Suomen Hippos, 2017) and from the statistics of Finnish Fur Sales (Finnish Fur Sales, 2017), as presented in Table 5.12.

The number of reindeer in the model is from the Yearbook of Farm Statistics (TIKE, 2017) and corresponds to the number of reindeer left alive during the reindeer herding year.

Emission factors

Ammonia

The domestic emission factors calculated on basis of national studies (Grönroos et al 2017) are presented in Table 5.12 and the tables are updated for the Informative Inventory Report of 2019. The emission factures include emissions from animal shelter, storing, spreading, pasturing and dry lot.

Due to the cold climate, grazing period is relatively short in Finland. For example for sheep the pasturing period is averagely 153 days (2016) whereas in the EMEP/EEA (2016) guidebook, the housing period for sheep is 30 days thus implicating a grazing period of 335 days. In Finland, the short grazing period might lead to the higher manure management IEFs of some animal categories.

For sheep, the reason for increase in IEF (manure management) is in manure management data: in 2000 it was assumed that 90% of sheep manure is managed as deep litter and 10% as FYM. However, manure survey in 2013 provided new data on manure management practices. Based on the survey results, only 50% of sheep manure was managed as deep litter in 2013. Due to the deep litter TAN immobilisation processes during housing, ammonia evaporation potential is much lower than that of FYM. So the decrease in the share of deep litter system explains the increase of emissions. Additionally, N excretion of sheep has slightly increased from 2000 to 2016 (9.32 -> 9.97 kg tot-N/head/a). (Grönroos et al. 2017).
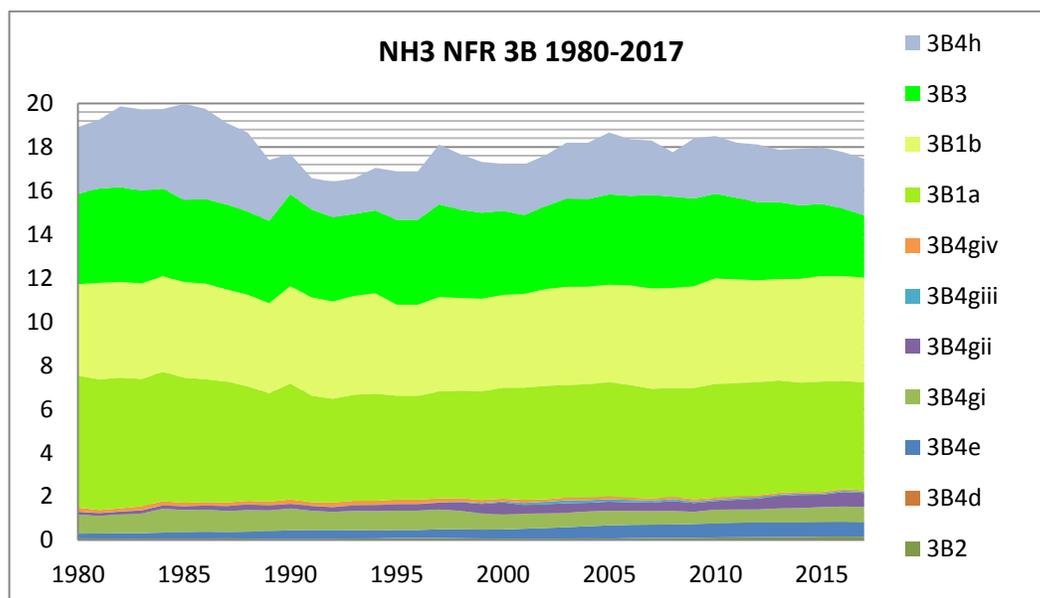

Figure 5.11 Ammonia emissions from NFR 3B categories 1980-2017

Table 5.12a NH3 emissions factors for Cattle and swine (kg NH$_3$ / animal) (Grönroos et al., 2017).

Year	Dairy	Suckler	Heifer	Bull >1 yr	Calf <1 yr	Sow (with	Boar (50-	Fattening pig (50-	Veaned pig (20-
1980	14.84	10.25	7.24	11.23	5.73	9.64	7.19	6.58	2.81
1981	15.12	10.23	7.27	11.41	5.85	9.73	7.17	6.55	2.79
1982	15.40	10.21	7.31	11.58	5.98	9.83	7.14	6.52	2.77
1983	15.57	10.21	7.31	11.72	6.07	9.88	7.11	6.47	2.75
1984	15.96	10.18	7.39	11.94	6.25	10.02	7.09	6.45	2.72
1985	16.24	10.16	7.42	12.11	6.39	10.11	7.06	6.42	2.70
1986	16.52	10.18	7.46	12.22	6.54	10.25	7.05	6.40	2.68
1987	16.76	10.21	7.51	12.30	6.74	10.45	7.23	6.24	2.60
1988	17.02	10.23	7.55	12.34	6.79	10.55	7.28	6.26	2.59
1989	17.54	10.26	7.76	12.82	7.05	10.59	7.22	6.25	2.58
1990	19.24	10.29	8.01	13.34	7.30	10.59	7.31	6.26	2.57
1991	19.43	10.30	8.16	13.62	7.43	10.44	7.37	6.17	2.54
1992	19.69	10.31	8.21	13.67	7.53	10.52	7.28	6.12	2.52
1993	20.21	10.32	8.62	14.10	7.87	10.50	7.24	6.06	2.52
1994	20.89	10.34	8.81	14.46	8.07	10.41	7.19	6.04	2.52
1995	21.18	10.35	8.88	14.55	8.20	10.19	7.23	6.01	2.45
1996	21.49	10.55	8.96	14.73	8.27	10.18	7.19	5.98	2.41
1997	22.34	10.75	9.10	14.89	8.40	10.18	7.47	5.98	2.43
1998	22.92	10.95	9.18	15.08	8.52	10.23	7.50	6.02	2.43
1999	23.96	11.15	9.28	15.29	8.73	10.25	6.75	6.02	2.45
2000	25.17	11.36	9.57	15.77	9.04	10.29	6.71	6.02	2.46
2001	26.31	11.47	9.82	16.35	9.31	10.22	7.11	6.04	2.48
2002	27.41	11.58	10.09	17.24	9.62	10.48	7.24	6.08	2.50
2003	28.53	11.64	10.32	18.02	9.96	10.66	7.30	6.05	2.52
2004	29.81	11.95	10.60	18.58	10.28	10.83	7.40	6.05	2.53
2005	30.83	11.92	10.68	18.76	10.43	10.90	7.56	6.07	2.56
2006	31.12	11.70	11.00	19.07	10.41	10.95	7.66	6.03	2.54
2007	31.45	11.47	11.37	19.57	10.48	10.99	7.61	5.94	2.51
2008	31.63	11.37	11.68	19.59	10.42	11.03	7.45	5.87	2.48
2009	32.07	11.24	12.01	19.56	10.46	10.91	7.36	5.77	2.45
2010	32.52	11.34	12.48	19.98	10.59	10.94	7.36	5.69	2.41
2011	32.49	11.32	12.67	19.73	10.48	11.16	7.33	5.58	2.38
2012	32.39	11.03	12.72	19.24	10.23	10.71	7.10	5.46	2.34
2013	32.22	11.06	12.64	19.11	10.19	10.88	7.08	5.44	2.33
2014	31.96	11.46	12.57	19.79	10.40	10.97	7.14	5.38	2.32
2015	29.73	11.50	11.93	19.03	10.03	10.38	6.68	5.01	2.17
2016	29.49	11.45	11.91	19.05	10.01	10.47	6.59	4.92	2.15
2017	29.43	11.35	11.93	18.99	10.05	10.28	6.57	4.82	2.12

Table 5.12b NH3 emissions factors for Poultry (kg NH$_3$ / animal) (Grönroos et al., 2017).

Year	Laying hen breeder (female)	Cockerel (laying hen breeder, male)	Broilers	Broiler hens	Chicken	Turkey	Other poultry
1980	0.20	0.39	0.08	0.00	0.09	0.19	0.20
1981	0.21	0.39	0.08	0.00	0.09	0.19	0.20
1982	0.22	0.39	0.08	0.00	0.10	0.19	0.20
1983	0.22	0.39	0.08	0.00	0.10	0.19	0.20
1984	0.24	0.39	0.08	0.00	0.11	0.19	0.20
1985	0.23	0.39	0.08	0.00	0.11	0.19	0.20
1986	0.24	0.39	0.08	0.00	0.12	0.19	0.20
1987	0.24	0.39	0.08	0.00	0.13	0.19	0.20
1988	0.24	0.39	0.08	0.00	0.13	0.19	0.20
1989	0.25	0.39	0.08	0.00	0.14	0.19	0.20
1990	0.26	0.39	0.08	0.18	0.14	0.19	0.20

1991	0.27	0.39	0.08	0.18	0.14	0.21	0.20
1992	0.27	0.39	0.07	0.18	0.14	0.22	0.20
1993	0.28	0.39	0.07	0.18	0.15	0.24	0.21
1994	0.28	0.39	0.07	0.18	0.15	0.22	0.21
1995	0.27	0.39	0.07	0.18	0.15	0.24	0.21
1996	0.28	0.39	0.07	0.18	0.15	0.23	0.21
1997	0.28	0.39	0.07	0.18	0.15	0.24	0.21
1998	0.29	0.39	0.08	0.18	0.15	0.24	0.22
1999	0.29	0.39	0.07	0.18	0.15	0.25	0.21
2000	0.29	0.39	0.07	0.18	0.16	0.26	0.22
2001	0.28	0.39	0.07	0.18	0.16	0.26	0.21
2002	0.27	0.39	0.07	0.18	0.16	0.27	0.21
2003	0.28	0.39	0.08	0.18	0.16	0.26	0.21
2004	0.29	0.39	0.08	0.18	0.16	0.27	0.22
2005	0.28	0.39	0.08	0.18	0.16	0.27	0.21
2006	0.27	0.37	0.07	0.18	0.15	0.26	0.20
2007	0.26	0.36	0.08	0.18	0.15	0.27	0.20
2008	0.25	0.34	0.08	0.18	0.14	0.27	0.20
2009	0.25	0.33	0.09	0.18	0.14	0.28	0.20
2010	0.24	0.31	0.08	0.18	0.13	0.29	0.20
2011	0.24	0.30	0.08	0.18	0.13	0.28	0.20
2012	0.25	0.28	0.08	0.18	0.12	0.29	0.20
2013	0.24	0.28	0.08	0.18	0.12	0.29	0.20
2014	0.23	0.28	0.08	0.18	0.12	0.28	0.20
2015	0.25	0.28	0.08	0.18	0.12	0.29	0.20
2016	0.25	0.28	0.08	0.18	0.12	0.29	0.20
2017	0.24	0.28	0.08		0.12	0.30	0.20

Table 5.12c NH3 emissions factors for other animals (kg NH$_3$ / animal) (Grönroos et al., 2017).

Year	Horse	Pony	Sheep	Goat	Fox and racoon	Mink and fitch	Reindeer
1980	15.76	11.07	1.42	1.80	0.84	0.49	0.50
1981	15.79	11.12	1.41	1.78	0.84	0.49	0.50
1982	15.83	11.18	1.40	1.77	0.84	0.49	0.50
1983	15.74	11.15	1.39	1.76	0.84	0.49	0.50
1984	15.89	11.29	1.37	1.73	0.84	0.49	0.50
1985	15.92	11.34	1.36	1.72	0.84	0.49	0.50
1986	16.02	11.35	1.34	1.70	0.84	0.49	0.50
1987	15.96	11.58	1.33	1.69	0.84	0.49	0.50
1988	16.08	11.63	1.32	1.67	0.84	0.49	0.50
1989	16.19	11.74	1.31	1.66	0.84	0.49	0.50
1990	16.25	11.79	1.30	1.64	0.84	0.49	0.50
1991	16.21	11.74	1.32	1.66	0.85	0.49	0.50
1992	16.16	11.74	1.35	1.68	0.86	0.50	0.50
1993	16.21	11.74	1.38	1.70	0.87	0.50	0.50
1994	16.23	11.80	1.40	1.72	0.87	0.50	0.50
1995	16.20	11.82	1.41	1.74	0.88	0.50	0.50
1996	16.20	11.77	1.44	1.74	0.89	0.51	0.50
1997	16.13	11.81	1.44	1.74	0.90	0.51	0.50
1998	16.06	11.79	1.46	1.74	0.91	0.51	0.50
1999	16.07	11.77	1.49	1.74	0.92	0.51	0.50
2000	16.09	11.74	1.51	1.74	0.92	0.52	0.50
2001	16.45	11.96	1.54	1.74	0.96	0.52	0.50
2002	16.83	12.22	1.55	1.74	0.99	0.52	0.50
2003	17.20	12.44	1.56	1.74	1.02	0.52	0.50

2004	17.57	12.59	1.57	1.74	1.05	0.52	0.50
2005	17.87	12.70	1.60	1.74	1.09	0.52	0.50
2006	17.73	12.56	1.65	1.77	1.12	0.52	0.50
2007	17.66	12.45	1.69	1.81	1.15	0.52	0.50
2008	17.58	12.39	1.73	1.85	1.18	0.52	0.50
2009	17.63	12.41	1.76	1.89	1.18	0.52	0.50
2010	17.61	12.45	1.81	1.94	1.18	0.52	0.50
2011	17.73	12.49	1.85	1.99	1.18	0.52	0.50
2012	17.81	12.56	1.90	2.04	1.18	0.52	0.50
2013	17.89	12.60	1.90	2.04	1.18	0.52	0.50
2014	17.92	12.70	1.90	2.04	1.18	0.52	0.50
2015	17.97	12.78	1.90	2.04	1.18	0.52	0.50
2016	18.08	12.90	1.90	2.04	1.18	0.52	0.50
2017	17.36	12.89	1.90	2.04	1.18	0.52	0.50

Particle emissions

Note: the calculation of particle emissions in the 2019 submission has been updated according to the Guidebook of 2016. This chance includes emission factor changes and minor methodological changes.

Particle emissions are generated in manure management, harvesting and field preparation, storage and handling of agricultural crops and fertilizers and field burning of agricultural wastes and have been included in the inventory since the submission in 2004. Figure 5.12 below presents the PM2.5 emissions from manure management.
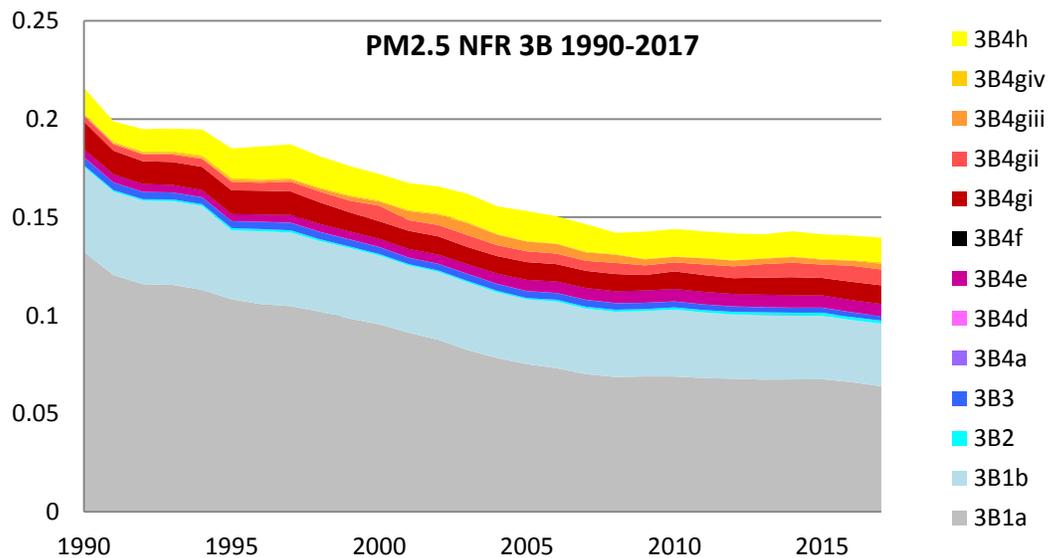

Figure 5.12 PM2.5 emissions from NFR 3B categories 1990-2017

According to the Guidebook, particle emissions occur from both housed and free-range animals while the emission factors presented are for housed animals only. The most important parameters impacting particle emissions are feeding conditions, animal activity and bedding material.

In the 2019 submission the calculation of particulate matter emissions for manure management was revised to the Tier 2 method presented in Guidebook 2016, and implemented as Equation 1 below describes.

Equation 1. Particle emissions from animal husbandry for a single animal category

$$E_{PM\ i,j} = AAP_{i,j} * x_{i,j,house} * \sum \left(x_{mms,i,j} * EF_{mms,j} \right)$$

where
i	= Inventory year
j	= Animal categor
E_{PM}	= PM emissions (TSP, PM10, PM2.5) for an animal category (in kg/a)
AAP	= Annual average population
x_{house}	= Share of time the animals spend in the animal house (in a/a)
x_{mms}	= Portion of manure that is handled as slurry, deep litter or solid manure.
EF	= Emission factor (kg AAP–1 a–1)

The methodology remains by principle the same as in previous submissions, but the revised calculation introduces deep litter and previously absent animal categories into calculation. Emission factors are updated to correspond to the Guidebook of 2016 and presented in Table 5.13. Livestock numbers for 1990-2017 are presented in Table 5.14.

Table 5.13a Tier 1 particle emission factors for animal husbandry (Guidebook 2016, Table 3.5) and portions of manure handled as slurry, deep litter and solid manure per animal category for 2017.

Animal Category	Tier 1 Emission factor (kg AAP^{-1} a^{-1})			Portion of manure handled as:		
	TSP	PM10	PM2.5	Slurry	Deep litter	Solid manure
Dairy cow	1.38	0.63	0.41	0.72	0.00	0.28
Suckler cow	0.59	0.27	0.18	0.06	0.31	0.63
Heifer >1 yr	0.59	0.27	0.18	0.56	0.08	0.36
Bull >1 yr	0.59	0.27	0.18	0.58	0.11	0.32
Calf <1 yr	0.34	0.16	0.1	0.42	0.16	0.42
Sow (with piglets)	0.62	0.17	0.01	0.85	0.00	0.15
Boar (50- kg)	0.62	0.17	0.01	0.85	0.00	0.15
Fattening pig (50- kg)	1.05	0.14	0.006	0.98	0.01	0.01
Veaned pig (20-50 kg)	0.27	0.05	0.002	0.90	0.04	0.06
Laying hen breeder (female)	0.19	0.04	0.003	0.09	0.22	0.69
Cockerel (laying hen breeder, male)	0.19	0.04	0.003	0.00	0.50	0.50
Broiler	0.04	0.02	0.002	0.00	1.00	0.00
Broiler breeder hen	0.04	0.02	0.002	0.00	1.00	0.00
Broiler breeder, male	0.04	0.02	0.002	0.00	1.00	0.00
Chicken	0.14	0.14	0.02	0.00	0.40	0.60
Turkey	0.11	0.11	0.02	0.00	1.00	0.00

Other poultry	0.14	0.14	0.02		0.00	0.40	0.60
Horse	0.48	0.22	0.14		0.00	0.13	0.87
Pony	0.48	0.22	0.14		0.00	0.13	0.87
Sheep	0.14	0.06	0.02		0.00	0.50	0.50
Goat	0.14	0.06	0.02		0.00	0.50	0.50
Fox and racoon	0.018	0.008	0.004		0.00	0.00	1.00
Mink and fitch	0.018	0.008	0.004		0.00	0.00	1.00
Reindeer	0.018	0.008	0.004		0.00	0.00	1.00

The parameter EF_{mms} of Equation 1 for technology specific emission factors are derived by applying the Tier 1 emission factor to the share of manure management systems present for each animal category with the assumption of slurry and deep litter systems having PM emission rates half of those in solid manure systems. This assumption is based on notes in the Guidebook 2016 section A1.2.1 for particulate matter. The relative difference between slurry and solid manure hereby differs from the corresponding figures presented in Guidebook 2013, for which some animal categories suggested higher emission rates for slurry based systems.

Data on grazing times (pasturing period in days), manure handling systems (deep litter, slurry or solid manure) and indoor/outdoor times (% of pastured animals, animals inside in nights during pasturing period, house inside in nights) presented in Table 5.6 were updated 2014 according to domestic studies (Grönroos et al., 2009/2014) for the years 2006-2012 . Detailed information on these are available in Grönroos al., 2009/2015 for years the 1990, 1995, 2000 and 2005. The values for the year 1990 are used over the period of 1990-1994 and the year 1995 values over the period of 1996-1999 etc.

Table 5.14a Parameters by animal category in five year intervals: grazing times, manure handling and outdoor/ indoors times

	Grazing times, pasturing period (days)				
	1990	1995	2000	2005	2015
Dairy cows	125	125	125	125	112
Suckler cows	140	140	140	140	171
Bulls	0	0	0	0	161
Calves < 1 yr	100	100	100	100	127
Heifers >1 yr	140	140	140	140	134
Horses	140	140	140	140	180
Ponies	140	140	140	140	180
Sheep with lambs	140	130	130	130	153
Goat with gilts	140	130	130	130	153
Fattening pigs	0	0	0	0	0
Sows (with piglets)	90	0	0	0	0
Boars	90	0	0	0	0
Weaned pigs (20-50kg)	0	0	0	0	0
Reindeer	365	365	365	365	365

	Percentage of pastured animals (%)				
	1990	1995	2000	2005	2015
Dairy cows	90	90	90	90	69
Suckler cows	90	95	95	95	92
Bulls	0	0	0	0	9
Calves < 1 yr	30	25	25	25	31
Heifers >1 yr	95	90	90	90	69
Horses	95	95	95	95	97

Ponies	95	95	95	95	97
Sheep with lambs	95	90	90	90	90
Goat with gilts	95	90	90	90	90
Reindeer	100	100	100	100	100
	Animals inside in nights during pasturing period (%)				
	1990	**1995**	**2000**	**2005**	**2015**
Dairy cows	60	75	90	100	100
	Hours inside in nights (hours)				
	1990	**1995**	**2000**	**2005**	**2015**
Dairy cows	12	12	12	12	11

The parameters of Table 5.14a contribute to the formation of the parameter x_{house} of equation 1. The complete series of the share of time the animals spend in housing is presented in Table 5.14b below.

Table 5.14b Share of time the animals spend in the animal house (in a/a) for animal categories with annual variation.

ear	Dairy cow	Suckler cow	Heifer >1 yr	Bull >1 yr	Calf <1 yr	Sow (with piglets)	Horse	Pony	Sheep	Goat
1980	0.74	0.65	0.65	0.96	0.86	0.90	0.64	0.64	0.68	0.68
1981	0.74	0.65	0.65	0.96	0.87	0.91	0.64	0.64	0.68	0.68
1982	0.74	0.65	0.65	0.96	0.87	0.92	0.64	0.64	0.67	0.67
1983	0.74	0.65	0.65	0.96	0.88	0.93	0.64	0.64	0.67	0.67
1984	0.74	0.65	0.65	0.96	0.88	0.94	0.64	0.64	0.66	0.66
1985	0.74	0.65	0.65	0.96	0.89	0.95	0.64	0.64	0.66	0.66
1986	0.74	0.65	0.64	0.96	0.90	0.96	0.64	0.64	0.65	0.65
1987	0.74	0.65	0.64	0.96	0.90	0.97	0.64	0.64	0.65	0.65
1988	0.74	0.65	0.64	0.96	0.91	0.98	0.64	0.64	0.64	0.64
1989	0.74	0.65	0.64	0.96	0.91	0.99	0.64	0.64	0.64	0.64
1990	0.78	0.65	0.64	0.96	0.92	0.99	0.64	0.64	0.64	0.64
1991	0.79	0.65	0.64	0.96	0.92	0.99	0.64	0.64	0.64	0.64
1992	0.79	0.65	0.64	0.96	0.92	1.00	0.64	0.64	0.65	0.65
1993	0.80	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.66	0.66
1994	0.80	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.67	0.67
1995	0.81	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
1996	0.81	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
1997	0.82	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
1998	0.82	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
1999	0.83	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2000	0.83	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2001	0.83	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2002	0.84	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2003	0.84	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2004	0.84	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2005	0.85	0.64	0.65	0.96	0.93	1.00	0.64	0.64	0.68	0.68
2006	0.85	0.63	0.67	0.96	0.93	1.00	0.64	0.64	0.68	0.68

2007	0.86	0.62	0.68	0.96	0.92	1.00	0.64	0.64	0.67	0.67
2008	0.86	0.61	0.70	0.96	0.92	1.00	0.64	0.64	0.67	0.67
2009	0.87	0.61	0.71	0.96	0.91	1.00	0.64	0.64	0.67	0.67
2010	0.87	0.60	0.73	0.96	0.91	1.00	0.64	0.64	0.66	0.66
2011	0.88	0.59	0.74	0.96	0.90	1.00	0.64	0.64	0.66	0.66
2012	0.88	0.58	0.76	0.96	0.90	1.00	0.64	0.64	0.65	0.65
2013	0.88	0.58	0.76	0.96	0.90	1.00	0.64	0.64	0.65	0.65
2014	0.88	0.59	0.76	0.96	0.90	1.00	0.64	0.64	0.65	0.65
2015	0.88	0.59	0.76	0.96	0.90	1.00	0.64	0.64	0.65	0.65
2016	0.89	0.59	0.77	0.96	0.90	1.00	0.64	0.64	0.65	0.65
2017	0.89	0.59	0.77	0.96	0.90	1.00	0.64	0.64	0.65	0.65

Fur animals and poultry are considered to stay always indoors ($x_{house} = 1$) and reindeer always outdoors ($x_{house} = 0$).

NMVOC emissions

Emissions of NMVOC in manure management originate from silage store and feed, manure in the barns, outdoor manure stores, field application of manure and grazing of animals. In-house emissions are reported under NFR 3B (Figure 5.13) and emissions of field application of manure and grazing under NFRs 3Da2a and 3Da3, respectively.
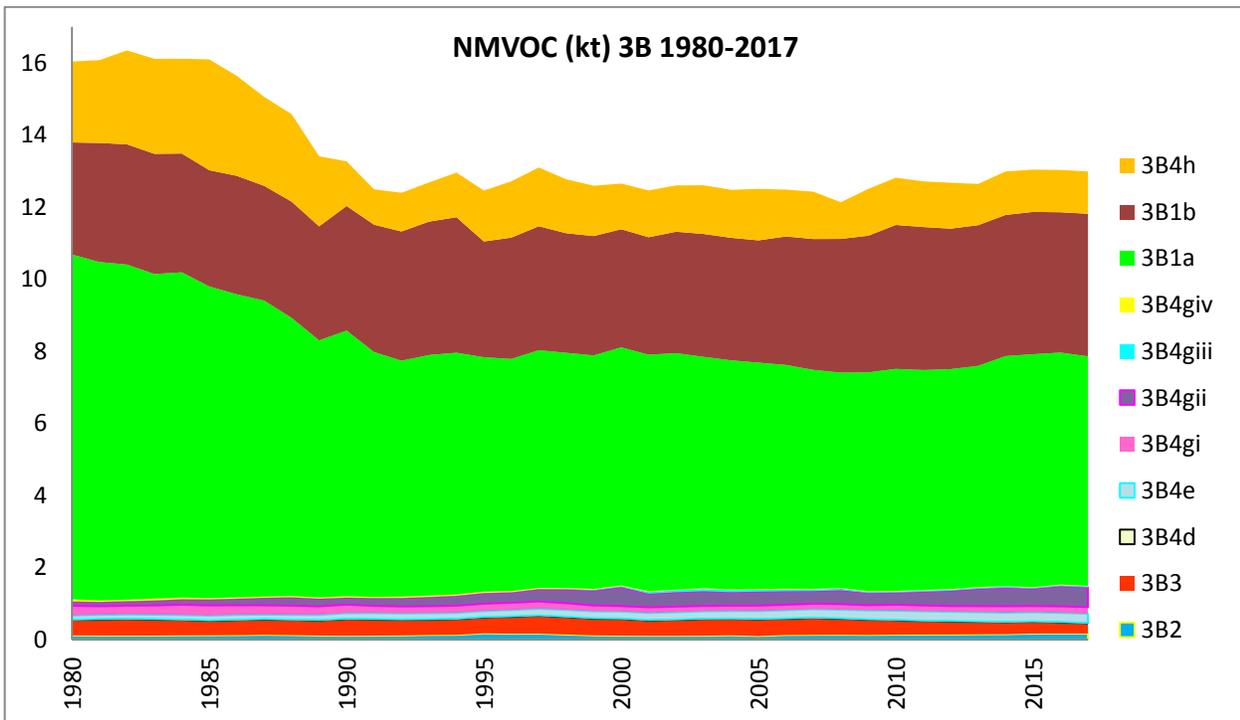

Figure 5.13 NMVOC emissions from NFR 3B categories 1980-2017

The calculation method for NMVOC emissions is presented in details in Grönroos et al., 2017 (in the reporting folder).

The main parameters for calculation are gross energy intake (GEI as megajoules MJ/a), volatile solids excreted (VS), annual average population (AAP) which are provided by Natural Resources Institute Finland (Luke). Detail increasing parameters such as the share of time the animals spend in housing, fractions of silage store and feed (Table 5.18) are national values. Data is available for GEI and VS for the years 1990-2016 and for AAP for the years 1980-2016. The livestock classification varies between the data sources. Gross energy intake (Table 5.13) is available for dairy cows, non-dairy cattle, suckler cows, bulls (age over 1 year), heifers, calves (under 1 year) and non-dairy gross energy. Data of gross energy intakes as required by the EF of cattle are presented in Table 5.15. For VS (Table 5.17), primary data is available for dairy cows, non-dairy cattle, suckler cows, bulls (age over 1 year), heifers, calves (under 1 year), swine, sow, piglets, fattening pigs, boars, weaned pigs, sheep, goats, horses, poultry, laying hens, chickens, cockerels, broiler hens, broilers, turkeys, other poultry (ducks), other animals, reindeer, fur animals, mink and fitch, fox and raccoon.

Emission factors from EMEP/EAA Guidebook 2016 are presented in Table 5.15.

Table 5.15 Default NMVOC Tier 2 emission factors for livestock (EMEP/EAA Guidebook 2016)

NFR	Animal category	EF$_{silage\_feeding}$	EF$_{house}$	EF$_{grazing}$	Unit
3B1a	Dairy cattle	2,00E-04	3,53E-05	6,90E-06	kg NMVOC kg/MJ feed
3B1b	Non-dairy cattle	2,00E-04	3,53E-05	6,90E-06	kg NMVOC kg/MJ feed
3B2	Sheep	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B3	Swine (fattening pigs	1,70E-03			kg NMVOC/kg VS excreted
3B3	Swine (sows)		7,04E-03		kg NMVOC/kg VS excreted
3B4a	Buffalo	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4d	Goats	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4e	Horses	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4f	Mules and Asses	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4gi	Laying hens	5,68E-03			kg NMVOC/kg VS excreted
3B4gii		9,15E-03			kg NMVOC/kg VS excreted
3B4giii	Turkeys		5,68E-03		kg NMVOC/kg VS excreted
3B4giv	Other poultry (ducks, geese)	5,68E-03			kg NMVOC/kg VS excreted
3B4h	Other animals (fur animals	5,68E-03			kg NMVOC/kg VS excreted
3B4h	Other animals (rabbits)	1,61E-03			kg NMVOC/kg VS excreted
3B4h	Other animals (reindeer)	1,61E-03	2,35E-05		kg NMVOC/kg VS excreted

To accommodate the emission factors to the categorization of livestock in the Finnish Normative Manure system, the following applications are made:
- Heifers: emission factor of dairy cattle applied
- Bulls: emission factor of dairy cattle applied
- Calves: emission factor of dairy cattle applied
- Weaned pig (20-50kg): emission factor of swine (fattening pigs)

Table 5.16 Gross energy intake (MJ/day) in five year intervals and the inventory year 2017

Livestock	1980	1985	1990	1995	2000	2005	2010	2015	2017
Dairy cows	249.45	257.54	263.54	276.95	300.47	322.66	340.55	353.14	361,07
Suckler cows	209.16	211.47	212.70	219.09	224.40	229.82	240.67	241.24	238,38
Bulls (age over 1 year)	125.89	129.21	131.87	136.31	140.79	156.30	165.50	165.86	167,84
Heifers	100.48	102.67	104.18	107.89	113.48	120.99	127.37	127.23	128,32
Calves (under 1 year)	67.21	68.98	70.34	72.96	76.81	82.65	88.21	89.03	89,97
Non-dairy GE	86.38	89.51	91.71	96.70	103.15	113.12	125.42	125.95	127,61

Table 5.17 Volatile solids (VS) excreted in five year intervals and the inventory year 2017 (kg/head/day)

Animal category	1980	1985	1990	1995	2000	2005	2010	2015	2017
Dairy cows	4.23	4.37	4.47	4.70	5.09	5.47	5.77	5.99	6.12
Non-dairy cattle	1.45	1.51	1.55	1.65	1.76	1.94	2.17	2.19	2.20
Suckler cows	4.17	4.22	4.24	4.37	4.48	4.58	4.80	4.81	4.75
Bulls (age over 1 year)	2.13	2.19	2.24	2.31	2.39	2.65	2.81	2.81	2.85
Heifers	1.75	1.79	1.82	1.88	1.98	2.11	2.22	2.22	2.24
Calves (under 1 year)	1.09	1.12	1.14	1.18	1.24	1.34	1.43	1.44	1.46
Swine	0.22	0.22	0.22	0.21	0.22	0.22	0.22	0.21	0.21
Sow	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Piglets	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Fattening pigs	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Boars	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Weaned pigs	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Sheep	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Goats	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Horses	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
Poultry	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Laying hens	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Chicken	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cockerels	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Broiler hens	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Broilers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Turkeys	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Other poultry (ducks)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Other animals									
Reindeer	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Fur animals	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Mink and fitch	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Fox and racoon	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

Emissions are calculated separately for silage store and feeding, housing, manure storage and field application of manure. The emissions are calculated for every animal category with annually calculated parameters (where available). In each activity, emissions are calculated for the count of one animal. The animal and year specific emissions are then multiplied by the average annual population. The corresponding equation is presented below.

$$E_{NMVOC\,i,j} = AAP_{i,j}$$
$$* \left(E_{silage_{store}} + E_{silage_{feed}} + E_{house} + E_{manure_{storage}} + E_{manure_{application}} \right.$$
$$\left. + E_{grazing} \right)_{i,j}$$

Where,

i	= Livestock category
j	= Inventory year
$AAP_{i,j}$	= Annual average population within the animal category in the given year
$E_{silage_{store}}$	= Emissions from silage store
$E_{silage_{feed}}$	= Emissions from silage feeding
E_{house}	= Emissions from housing
$E_{manure_{storage}}$	= Emissions from manure in barns and outside stores
$E_{manure_{application}}$	= Emissions from field application of manure (reported under 3Da2a)
$E_{grazing}$	= Emissions from grazing (reported under 3Da3)

Emissions from housing are estimated based on the time that the livestock spends in buildings, which is estimated annually. The estimates are retrieved from the Finnish Normative Manure System. The emission values are calculated with equations presented below.

Cattle:

$$E_{house} = MJ_i * X_{house_i} * EF_{house_i}$$

Other livestock:

$$E_{house} = VS_i * X_{house_i} * EF_{house_i}$$

Where,

i	= Livestock category
MJ_i	= Gross feed intake as (MJ/a)
VS_i	= Volatile solids excreted (kg/a)
X_{house_i}	= Annual proportion of time the livestock spends inside buildings (%)
EF_{house_i}	= Emission factor for emissions from housing

Emissions from silage store are estimated based on the time that the livestock spends in buildings (see Table 5.14b for the applied rates) and by estimating the fraction of silage feeding in the given livestock category. In order to apply the formula it is to be assumed that silage feed always occurs inside livestock buildings.

Cattle:

$$E_{silage_{store}} = MJ_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage} \right)_i$$

Other livestock:

$$E_{silage_{store}} = VS_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage} \right)_i$$

Where,

i	= Animal category
$EF_{silage_{feed}}$	= Emission factor for silage feed
$Frac_{silage}$	= Proportion of silage as feed (%)

Table 5.19 Fraction of feed as silage for all animal categories

Animal category	Fracsilage	Animal category	Fracsilage
Dairy cow	0,56	Chicken	0
Suckler cow	1	Turkey	0
Heifer >1 yr	0,7	Other poultry	0
Bull >1 yr	0,61	Horse	0,375
Calf <1 yr	0	Pony	0,375
Sow (with piglets)	0	Sheep	0,68
Boar (50- kg)	0	Goat	0,67
Fattening pig (50- kg)	0	Fox and racoon	0
Weaned pig (20-50 kg)	0	Mink and fitch	0
Laying hen breeder (female)	0	Reindeer	0
Cockerel (laying hen breeder, male)	0	Broiler breeder hen	0
Broiler	0	Broiler breeder, male	0

Emissions from silage store are estimated as the share of stored silage in relation to silage in the feeding table by introducing an estimate of the fraction of the stored silage to equations *4* and *5*.

Cattle:

$$E_{silage_{store}} = MJ_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage} * Frac_{silage_{store}}\right)_i$$

Other livestock:

$$E_{silage_{store}} = VS_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage} * Frac_{silage_{store}}\right)_i$$

Where,
i = Animal category
$Frac_{silage_{store}}$ = The relative share of stored silage in relation to silage in feeding table (%)

The guidebook default for $Frac_{silage_{store}}$ of 0.25 is used for all species and all years. Emission factors of silage feeding, however, are not cross-applied between the species except for categories with close resemblance to each other. The model suggests emissions from silage store to occur on all cattle, horses, sheep and goats.

Manure storage

The proportion of emissions from storage is assumed to possess the same ratio as with ammonia. The equation only factorizes NMVOC emissions from housing with the storage/building-ratio of ammonia emissions. Ammonia emissions are calculated in the Finnish Normative Manure System.

$$E_{manure_{storage}} = E_{NMVOC_{house}} * \left(\frac{E_{NH3_{storage}}}{E_{NH3_{building}}}\right)_i$$

Where,
i = Livestock category
$E_{NMVOC_{house}}$ = NMVOC emissions from housing
$E_{NH3_{storage}}$ = Ammonia emissions from storage
$E_{NH3_{building}}$ = Ammonia emissions from housing

Data on manure management systems

The distribution of manure management systems has been estimated by using different data sources. Information on manure management is collected by Luke but not at the detailed level needed for emissions inventory purposes. Use of manure management systems is estimated based on data from the Information Centre of the Ministry of Agriculture and Forestry, the results of a questionnaire sent to Regional Employment and Economic Development Centres and to Regional Environment Centres, and through expert estimates (Sipilä, I. and Kapuinen, P. MTT) as described in Grönroos et al., (2009). Due to the low response rate on the questionnaire (only 8 questionnaires were received back), the distribution of different manure management systems is quite uncertain. A new questionnaire (Grönroos J & Luostarinen S, Suomen lantojen käsittely

(*Manure management in Finland*, Manuscript.) has been made in 2013 to 11 120 farms, stables or fur farms, with a response rate of about 23 % answered. Based on this study, activity data of shares of manure management systems for years 1990-2005 stayed the same but from 2006 onwards the values were updated. In addition, dairy pasture parameters were updated from 2006 onwards series by updating the year 2012 management system data and interpolating the years 2006-2011. The values for 2013 and 2015 are based on the estimated trend between 2012 and 2020 where a continued increase for the share of slurry is assumed. Information about changes made to the data are presented in Grönroos 2014 (in Finnish, https://helda.helsinki.fi/handle/10138/152766).

The share of manure in dry lots (1-3% of extracted manure) is a rough estimate which will be updated when more data is available (Finland's EU GHG-NIR 2013, 2015),

Table 5.20a Animal numbers in Finland for cattle and swine (x 1 000 heads).

Year	Dairy cow	Suckler cow	Bull >1 yr	Calf <1 yr	Heifer >1 yr	Boar (50- kg)	Fattening pig (50- kg)	Sow (with piglets)	Veaned pig (20-50 kg)
1980	720	8	109	676	233	6	447	182	320
1981	701	9	114	690	253	6	465	190	333
1982	689	8	125	652	244	6	467	191	335
1983	663	9	120	640	250	6	457	186	327
1984	660	8	126	631	234	6	430	176	308
1985	628	9	125	631	215	5	404	165	289
1986	607	9	131	602	218	6	413	169	296
1987	589	9	125	558	217	6	420	172	301
1988	551	10	130	538	215	6	409	167	293
1989	507	9	134	490	206	5	405	165	290
1990	490	14	149	488	219	6	476	179	283
1991	446	21	144	486	214	6	464	174	276
1992	428	28	143	463	211	6	448	168	266
1993	426	33	139	437	217	5	439	165	261
1994	417	33	144	425	215	6	448	168	266
1995	399	29	109	422	189	7	491	161	277
1996	392	31	115	407	201	7	484	180	279
1997	391	32	121	402	197	7	512	185	332
1998	383	31	115	398	190	8	458	187	323
1999	372	30	118	379	188	6	469	180	269
2000	364	28	115	365	185	6	441	184	262
2001	355	27	111	362	182	5	426	164	264
2002	348	28	115	354	180	5	441	172	268
2003	334	28	115	344	179	5	483	178	269
2004	324	31	110	330	173	5	480	175	264
2005	319	35	108	329	169	4	500	177	280
2006	309	39	112	318	171	4	498	171	296
2007	296	43	110	311	166	4	525	177	329
2008	289	48	109	305	165	4	533	167	312
2009	290	52	110	304	163	4	535	156	303
2010	289	55	114	303	164	3	526	146	304

2011	286	57	111	299	162	3	531	134	288
2012	284	58	109	303	160	2	534	130	277
2013	283	57	110	300	162	2	534	122	273
2014	285	58	110	303	158	2	507	118	269
2015	285	59	109	307	155	2	501	116	275
2016	282	59	108	310	150	2	489	108	256
2017	275	60	111	297	150	1	447	99	249

Table 5.20b Animal numbers in Finland for poultry, sheep and goat (x 1 000 heads).

Year	Broiler breeder hen	Broiler	Chicken	Cockerel (laying hen breeder, male)	Laying hen breeder (female)	Other poultry	Turkey	Goat	Sheep
1980		1867	2435	50	6041	20	60	6	106
1981		1918	1707	50	5200	20	60	6	103
1982		1970	1622	50	5292	20	60	6	104
1983		2197	2169	50	5440	20	60	6	104
1984		2423	1932	50	6025	20	60	6	110
1985		2654	1547	50	5922	20	60	6	112
1986		2884	1505	50	5532	20	60	6	116
1987		3319	1449	50	5342	20	60	6	126
1988		3754	1441	50	5238	20	60	6	119
1989		3374	1415	50	4923	20	60	6	108
1990	62	2993	1633	50	4845	21	60	6	103
1991	97	3250	1304	45	4138	32	64	5	107
1992	133	3506	1598	40	3969	43	68	5	108
1993	168	3763	1522	35	4025	54	72	5	120
1994	203	4020	1422	30	4090	65	76	6	121
1995	240	4276	1482	25	4179	75	80	6	159
1996	279	4052	1246	25	4184	54	96	7	150
1997	299	4911	1288	32	4152	33	112	8	150
1998	347	5507	1185	30	3802	35	145	8	128
1999	382	5998	1025	17	3361	39	210	8	107
2000	364	7918	914	18	3110	32	215	9	100
2001	394	5412	1043	12	3202	35	455	7	96
2002	402	5766	772	9	3213	41	531	7	96
2003	346	6050	931	10	3016	40	603	7	98
2004	287	5573	912	10	3069	18	535	7	109
2005	457	5472	954	12	3128	20	495	7	90
2006	405	5366	844	13	3103	15	493	7	117
2007	351	5074	764	13	3134	24	431	6	119
2008	339	5675	865	19	3190	19	415	6	122
2009	329	4918	859	15	2926	16	306	6	118
2010	433	4616	838	14	3394	12	280	5	126
2011	421	5421	745	22	3304	14	308	5	129

2012	471	6038	743	27	3173	14	295	5	130
2013	520	6861	858	22	3432	13	274	5	136
2014	544	7341	714	25	3645	15	292	4	138
2015	548	6840	662	26	3501	23	247	5	155
2016	523	8175	748	26	3662	17	260	5	157
2017	473	8047	509	22	3746	47	292	5	156

Table 5.20c Animal numbers in Finland for other animals (x 1 000 heads).

Year	Fox and racoon	Mink and fitch	Reindeer	Horse	Pony
1980	1751	4207	186	30	1
1981	1894	4200	178	31	2
1982	2532	4379	185	31	2
1983	2546	4448	204	32	2
1984	2289	4686	223	33	3
1985	3117	5036	221	34	3
1986	3380	3982	230	35	4
1987	3175	3368	229	31	4
1988	2917	3520	227	34	5
1989	1995	3162	256	36	5
1990	1478	1805	239	39	6
1991	1092	1505	260	42	6
1992	1272	1576	232	43	6
1993	1221	1659	215	43	6
1994	1645	1639	214	42	6
1995	1804	1945	208	44	6
1996	2344	1801	213	46	6
1997	2493	1828	203	48	7
1998	2322	1646	196	49	7
1999	1972	1733	195	50	7
2000	1863	1498	203	51	7
2001	2044	1399	186	52	7
2002	2003	1408	200	52	7
2003	2205	1379	197	53	7
2004	2175	1355	201	54	7
2005	2320	1466	207	56	8
2006	2025	1422	198	58	8
2007	1713	1768	193	60	9
2008	1440	1259	195	61	9
2009	2116	1327	193	63	9
2010	1898	1576	194	65	10
2011	1784	1576	196	65	10
2012	1974	1402	192	65	10
2013	1816	1218	192	65	10
2014	2028	1170	187	64	10
2015	2084	1027	191	64	10

| 2016 | 2084 | 1027 | 191 | 64 | 10 |
| 2017 | 2084 | 1027 | 193 | 64 | 10 |

Uncertainty and time series' consistency

The time series is consistent. The results of the uncertainty analysis are provided in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checks related to the assessment of magnitude and trends have been carried out. At present, no verification has been carried out for the specific source-sector emissions. Cross-checking of data and functions of the model are carried out as the same model is used both by SYKE for air pollutant emissions inventories and by Luke for greenhouse gas emissions inventories.

Source-specific recalculations including changes made in response to the review Process

2009
- The agriculture emissions calculation model was used for the first time in the ammonia emissions inventory in the submission in 2009.

2011
- The allocation of boars was changed from NFR 4B13 to 4B8.
- NH3 and particle emissions were recalculated and reported in NFR format.

2013
- The time series 1990-2013 was recalculated and reported in NFR14 format.

2014
- Revision of ammonia emission factors and disaggregation of activity data in cooperation with the Natural Resources Institute Finland.

2015
- Particulate matter emission factors for manure management revised according to Guidebook 2013 for the whole time series. Also data on grazing times, manure handling systems and indoor/outdoor times were updated according to domestic studies.

2017
- Particle emissions from heifers were inserted in the time series as they were missing due to an error from inventory submissions in 2010-2014.

2016-2017
- The Finnish Agriculture Emissions Calculation Model was completed with NMVOC emissions according to the method presented in the 2016 Guidebook. (Munther et al., 2017)
- The calculation of NH3 and NOx emissions was revised (Grönroos et al, 2017)

2019
- Particulate matter added for goats, sheep, fur animals and reindeer
- Emission factors of particulate matter updated based on Guidebook 2016
- The implied emission factors for NH3 have changed from the previous reporting because of the correction of the error in emission calculation of deep litter manure system. The emissions (NH3, NO, N2O) from spreading of 80% of the manure managed as deep litter were missing because of the error in calculation sheets.of all other animals than broilers.

Source-specific planned improvements

None.

5.3 Agricultural Soils (NFR 3D)

Figure 5.14 K. Inha (1899)

Source category description

Changes in chapter	
Update of text	March 2019 KS, JMP, JG, JM

The category covers emission sources presented in Table 5.21

Table 5.21 Emission sources and emissions reported under NFR 3D

NFR		Emissions
3Da1	Inorganic N-fertilizers	NOx, , NH3
3Da2a	Animal manure applied to soils	NOx, NMVOC, NH3 (calculated in 3B)
3Da2b	Sewage sludge applied to soils	NH3, NOx
3Da2c	Other organic fertilisers applied to soils	NA
3Da3	Urine and dung deposited by grazing animals	NOx, NMVOC, NH3(calculated in 3B)
3Da4	Crop residues applied to soils	NA
3Db	Indirect emissions from managed soils	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP, PM10, PM2.5
3Dd	Off-farm storage, handling and transport of bulk	NA
3De	Cultivated crops	NMVOC
3Df	Use of pesticides	HCB
3F	Field burning of agricultural residues	NOx, NMVOC, Sox, CO, NH3, particles heavy metals, PCDD/F, PAH-4
3I	Agriculture other	NO

Synthetic N-fertilizers (NFR 3D1a)

Source category description

Nitrogen oxides and ammonia emissions from the use of synthetic nitrogen fertilizers are included under this category.

Emission trend

The emission trend fluctuates according to the use of fertilizers (Figure 5.15).
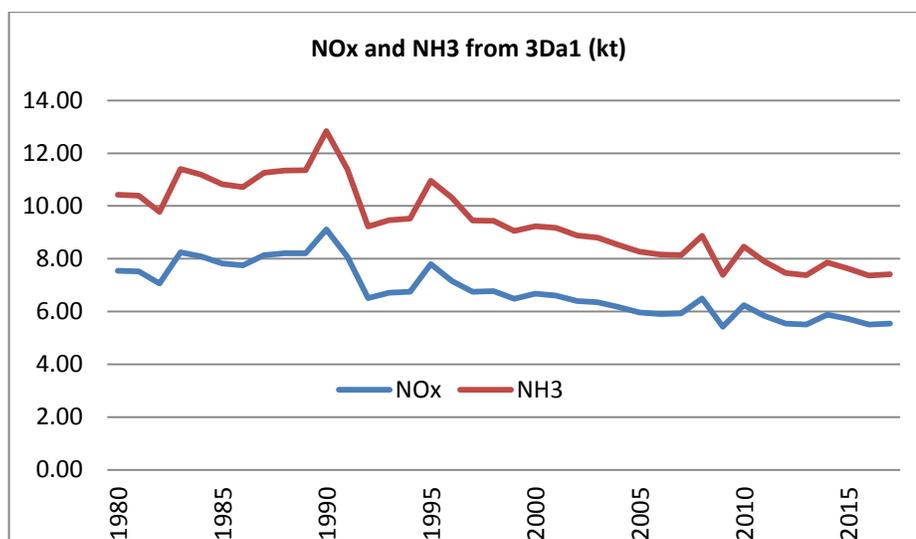
Figure 5.15 NOx and NH3 emissions from the use of synthetic N-fertilizers

Methodological issues

Ammonia emissions

Calculation of NH_3 emissions from application of nitrogen fertilizers is carried out in the agriculture emissions calculation model (Grönroos et al.. 2017). The calculation is consistent with the EMEP/EEA Guidebook 2016.

Ammonia emissions from the use of mineral N-fertilisers were calculated separately for different fertiliser types using the emission factors presented in the EMEP/EEA Emission Inventory Guidebook (EMEP/EEA 2016b, Table 3-2). Due to the low soil pH and low average annual temperature in Finland, the 'normal pH' emission factors for cool climate were applied. The total amount of nitrogen sold annually in Finland (Table 5.22) was divided over fertiliser types using the information obtained from Yara Finland Ltd (Toimela 2016) and Natural Resources Institute Finland (Mattila 2016; Tables 5.23 and 5.24). EMEP/EEA emission factors presented in Table 5.23 are

based on the emissions from surface applied fertilisers. In Finland, however, placement fertilisation is typically used for cereals. According to the EMEP/EEA (2016b, A1.2.2), fertiliser-N that is immediately incorporated into the soil will not be a source of ammonia as the NH_4^+ ions are absorbed onto soil colloids or nitrified. Thus, N-fertilisers used in Finland were divided between fertilisers spread using placement fertilisation and fertilisers applied on soil surface (typically grassland).

Table 5.22. Use of mineral N-fertilizers as N (tonnes) 1980-2017

Year	Use of N-fertlizer (t)	Year	Use of N-fertlizer (t)	Year	Use of N-fertlizer (t)
1980	189 098	1993	168 199	2006	148 161
1981	188 457	1994	169 138	2007	148 784
1982	177 234	1995	195 460	2008	162 905
1983	206 665	1996	179 529	2009	136 009
1984	202 814	1997	169 345	2010	156 523
1985	196 242	1998	169 928	2011	146 189
1986	194 304	1999	162 700	2012	138 900
1987	204 140	2000	167 276	2013	138 136
1988	205 674	2001	165 621	2014	147 373
1989	205 862	2002	160 403	2015	143 479
1990	228 470	2003	159 288	2016	138 128
1991	202 462	2004	154 708	2017	138 948
1992	163 229	2005	149 562		

Table 5.23. Distribution of mineral N-fertilisers used in Finland by fertiliser type (%), distribution of each fertiliser type by application method (placement fertilisation or spread on soil surface, %), and ammonia emission factors (EFs for normal pH, cool climate) for different fertiliser types applied.

Spread as:	% of applied fertiliser-N	Spread using placement fertilisation (%)	Spread on soil surface (%)	EF for fertiliser-N spread on soil surface (kg NH_3 kg^{-1} N)
Ammonium nitrate	0.0 %	65	35	0.015
Anhydrous ammonia	0.0 %	65	35	0.019
Ammonium phosphates	0.1 %	65	35	0.05
Ammonium sulphate	0.0 %	65	35	0.09
Calcium ammonium nitrate	30.5 %	65	35	0.008
Calcium nitrate	0.1 %	65	35	0.01
Ammonium solutions (AN)	0.0 %	65	35	0.015
Ammonium solutions (Urea AN)	0.0 %	65	35	0.098
Urea ammonium sulphate	0.0 %	65	35	0.098
Urea	1.2 %	65	35	0.155
Other NK and NPK	68.1 %	65	35	0.05

Table 5.24 Distribution of mineral N-fertilisers used in Finland by fertiliser type. The share of each fertiliser depends on the year (Source: Yara Finland and import data) (Finland's NIR 15.3.2018)

	% of applied N					
Fertiliser type	**1990**	**1995**	**2000**	**2005**	**2010**	**2016**
Ammonium sulphate	0.004	0	0	0	0.2	0
Ammonium nitrate	0	0	0	0	0	0
Calcium ammonium nitrate	10.8	9.3	15.3	15.2	23.8	30.5
Anhydrous ammonia	0	0	0	0	0	0
Urea	1.3	0.1	0.2	0.4	0.5	1.2
Nitrogen solutions	0.003	0	0	0.02	0.02	0
Ammonium phosphates	0.1	0.1	0.1	0.2	0.2	0.1
Other NK and NPK	87.5	90.3	84.3	84.2	75.3	68.1
Nitrate only	0.3	0.09	0.08	0.06	0.06	0.07

Nitrogen dioxide emissions

Nitric oxide emissions expressed as nitrogen dioxide (NO_2) were included to the inventory for first time in the 2017 submission for the whole time series (1990-2016). The calculation is carried out in the Agriculture Emissions Calculation Model (Grönroos et al., 2017). The model is described in more detail above (ammonia emissions), nitric oxide emissions are calculated in the model as part of other nitrogen emissions. For nitrogen dioxide, the emission factor of 0.04 kg NO_2 kg^{-1} fertiliser-N applied (EMEP/EEA 2016b) was used.

The emission factor for NO_2 emissions from NFR 3Da1 was updated to the 2018 submission. In the previous submission (2017), the emission factor of 0.04 was assumed to mean NO emissions, and the result was further multiplied by 46/30 to convert NO emissions to NO_2 emissions, resulting too high emission values for NO_2.

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2018
- The emission factor for NOx emissions from NFR 3Da1 was updated to the 2018 submission

Source-specific planned improvements

None.

Animal manure applied to soils (NFR 3Da2a)

Source category description

Nitrogen oxides, NMVOC and ammonia emissions due to application of manure to soils are included under this category.

Emission trend

The emissions fluctuate according to the amount of manure applied annually (Figure 5.15)
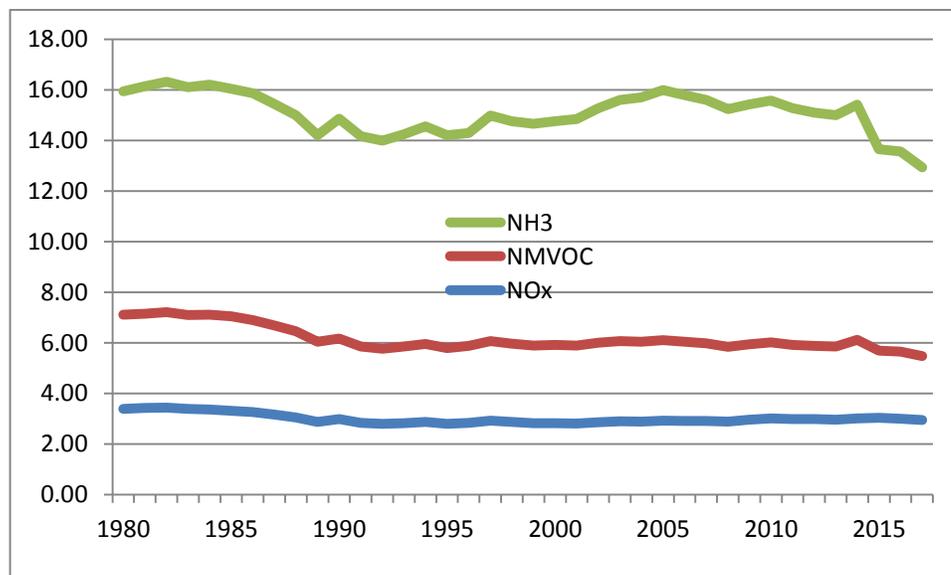

Figure 5.15 NOx, NMVOC and NH3 emissions from manure application to soils

Methodological issues

Ammonia emissions

For the detailed description see Grönroos et al 2017 (in the CDR folder)

Nitrogen dioxide emissions

The calculation is carried out in the Agriculture Emissions Calculation Model (Grönroos et al., 2017). For nitrogen dioxide, the emission factor of 0.04 kg NO_2 kg^{-1} manure-N applied (EMEP/EEA 2016b) was used.

The emission factor for NO_2 emissions from NFR 3Da1 was updated to the 2018 submission. In the previous submission (2017), the emission factor of 0.04 was assumed to mean NO emissions, and

the result was further multiplied by 46/30 to convert NO emissions to NO_2 emissions, resulting too high emission values for NO_2.

NMVOC

Calculation of NMVOC emissions from field application of manure follows the same principle than emissions from manure storage reported under NFR 3 B. The method is based on EMEP/EEA Emission Inventory Guidebook 2016.

$$E_{manure_{application}} = E_{NMVOC_{house}} * \left(\frac{E_{NH3_{application}}}{E_{NH3_{building}}}\right)_i$$

Where,

i = Animal category
$E_{NMVOC_{house}}$ = NMVOC emissions from housing
$E_{NH3_{application}}$ = Ammonia emissions from application
$E_{NH3_{building}}$ = Ammonia emissions from housing

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2017
- Nitric oxide emissions expressed as nitrogen dioxide (NO_2) were included to the inventory for first time for the whole time series

Source-specific planned improvements

None.

Sewage sludge applied to soils (NFR 3Da2b)

Source category description

The category includes nitrogen oxides and ammonia emissions to soils from the application of sewage sludge.

Emission trend

The emission trend is impacted by the amount of sludge which started to decrease since 1998 due to Finland's joining the EU earlier in 1995. As late as in the beginning of the 1990's sludge storages were too small and sludge spreading was common even in the winter time. After Finland joined the EU, the amounts of sludge spread have decreased significantly. (Figure 5.16)
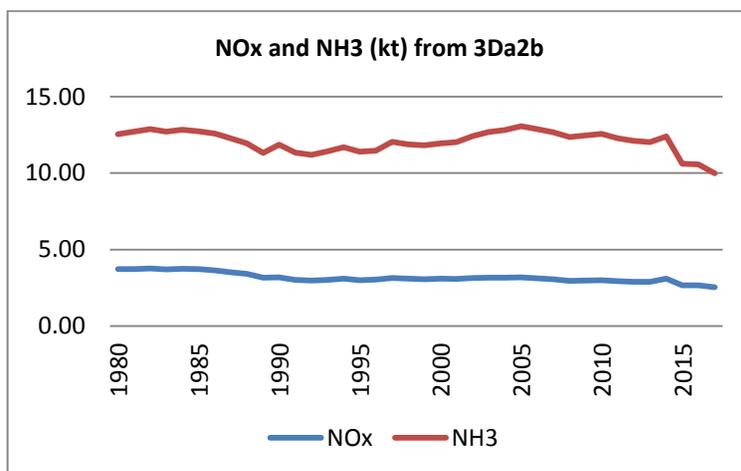
Figure 5.16. Sewage sludge applied to soils.

Methodology

Ammonia

Ammonia emissions are calculated using emissions factor from the Guidebook 2016. N input from sewage sludge used in agriculture (Finland's NIR 2019) is used as activity data. It is assumed that 15 % of total nitrogen is in the form of ammonium nitrogen and that 15 % of that ammonium nitrogen evaporates during the spreading on the fields.

NOx emissions

NOx emissions from 3Da2b Sewage Sludge Applied to Soils were included in the 2018 submission using emission factors from the 2016 EMEP/EEA Guidebook and amounts of N inputs from sewage sludge to soils from 1990-2017 (Table 5.26). It is assumed that 15 % of total nitrogen is in the form of ammonium nitrogen and that 15 % of that ammonium nitrogen evaporates during the spreading on the fields.

Annual nitrogen input from sewage sludge is presented in Table 4.25 (Finland's NIR 2019)

Table 5.25 N input from sewage sludge 1990-2017 (Mg N/year)

Year	N input from sewage sludge (Mg N/year)	Year	N input from sewage sludge (Mg N/year)	Year	N input from sewage sludge (Mg N/year)
1990	2 202	2000	513	2010	338
1991	1 749	2001	725	2011	148
1992	1 532	2002	616	2012	245
1993	1 404	2003	754	2013	223
1994	2 063	2004	441	2014	81
1995	1 316	2005	143	2015	81*
1996	1 548	2006	156	2016	81*
1997	1 696	2007	147	2017	81*
1998	575	2008	257		
1999	644	2009	266		

- no data available for 2015-2017, therefore 2014 value has been used instead

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2013
- Ammonia emissions from sewage sludge application were included in the inventory

2018
- NOx emissions were included in the inventory due to the recommendation of the NECD 2017
  review.

Source-specific planned improvements

None.

Other organic fertilizers applied to soils (NFR 3Da2c)

Changes in chapter	
Update of text	May 2018 JMP, KS

Source category description

Emissions from the application of other organic fertilizers applied to soils is not occurring in Finland (Grönroos, J., 2017).

Source-specific recalculations including changes made in response to the review process

2018
- The notation key was changed to NO

Urine and dung deposited by grazing animals (NFR 3Da3)

Changes in chapter	
Update of text	Feb 2019 JG, JM, KS

Source category description

This source category includes emissions originating from urine and dung deposited by grazing livestock to fields during grazing.

Emission trend

Emission trend is affected by changes in animal numbers, N-excretion rates, percentage of grazing animals and length of the grazing period. Since the beginning of 1980's, numbers and grazing of other cattle than suckler cows have decreased, resulting decrease in total emissions. However, increase in numbers of horses, ponies and suckler cows has smoothened the decreasing trend in emissions.
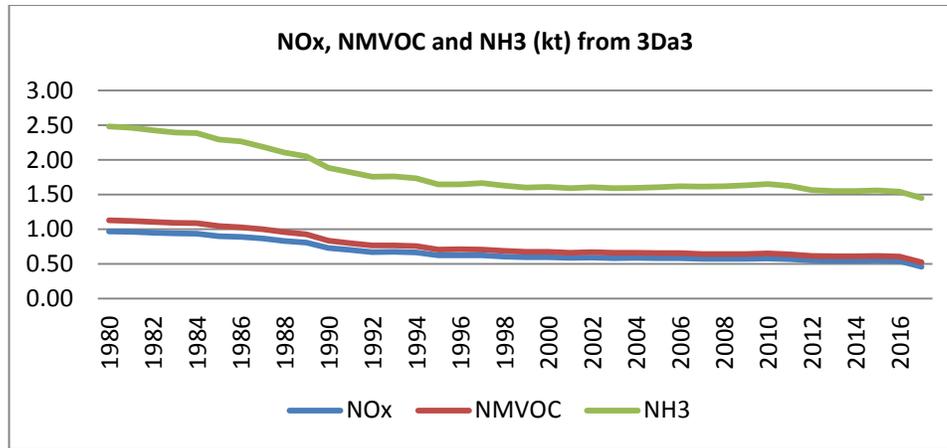
Figure 5.17 NOx, NMVOC and NH3 emissions from 3Da3

Methodology

Ammonia emissions

For the detailed description, see Grönroos et al 2017 (in the CDR folder)

Nitrogen dioxide emissions

The calculation is carried out in the Agriculture Emissions Calculation Model (Grönroos et al., 2017). For nitrogen dioxide, the emission factor of 0.04 kg NO_2 kg^{-1} manure N excreted (EMEP/EEA 2016b) was used.

The emission factor for NO_2 emissions from NFR 3Da1 was updated to the 2018 submission. In the previous submission (2017), the emission factor of 0.04 was assumed to mean NO emissions, and the result was further multiplied by 46/30 to convert NO emissions to NO_2 emissions, resulting too high emission values for NO_2.

NMVOC

Emissions from outdoors grazing of animals are calculated by gross feed intake (cattle) and volatile solids (other livestock) with an estimate of the time spent outdoors. The time animals spend indoors is estimated annually. The estimates are retrieved from the Finnish Normative Manure System. The emission factors in Table 5.26 are from Guidebook 2016.

Cattle:
$$E_{graz} = MJ_i * (1 - X_{house_i}) * EF_{graz_i}$$

Other livestock:
$$E_{graz} = VS_i * (1 - X_{house_i}) * EF_{graz_i}$$

where,
i = Animal category
MJ_i = Gross feed intake as (MJ/a)
VS_i = Volatile solids excreted (kg/a)
EF_{graz_i} = Emission factor for grazing presented in Table 5.27.
X_{house_i} = annual proportion of time the animal spends inside a livestock building (%)

Table 5.26 NMVOC emission factors for grazing animals (Source Guidebook 2016)

NFR	Livestock	EF$_{grazing}$	Unit
3B1a	Dairy cattle	6,90E-06	kg NMVOC kg/MJ feed intake
3B1b	Non-dairy cattle	6,90E-06	kg NMVOC kg/MJ feed intake
3B2	Sheep	2,35E-05	kg NMVOC/kg VS excreted
3B4a	Buffalo	2,35E-05	kg NMVOC/kg VS excreted
3B4d	Goats	2,35E-05	kg NMVOC/kg VS excreted
3B4e	Horses	2,35E-05	kg NMVOC/kg VS excreted
3B4f	Mules and Asses	2,35E-05	kg NMVOC/kg VS excreted
3B4h	Other animals (reindeer)	2,35E-05	kg NMVOC/kg VS excreted

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2017
- Nitric oxide emissions expressed as nitrogen dioxide (NO_2) were included to the inventory for first time in the 2017 submission for the whole time series (1990-2016).

2018
- NFR 3Da3: The emission factor for NOx was changed due to the change in the 2016 Guidebook. The emissions decreased by 40%.

Source-specific planned improvements

None.

Crop residues applied to soils (NFR 3Da4)

Changes in chapter	
Update of text	March 2019 JMP, KS

Emissions from crop residues applied to soils are reported as NA, because no methodology is presented in Guidebook 2016.

Indirect emissions from managed soils (NFR 3Db)

Changes in chapter	
Update of text	January 2017 JMP, KS

Indirect emissions from managed soils are reported as NA, because no methodology is presented in Guidebook 2016.

Farm-level agricultural operations including storage, handling and transport of agricultural products (NFR 3Dc)

Changes in chapter	
Update of text	February 2019 JM KS

Source category description

Particle emissions from cultivation, harvesting, cleaning and drying of crops are included under this category.

Emission trend

The activity data figures fluctuate annually mostly due to market demands. The count of producers has been steadily declining since the 1990's and simultaneously the land area per producer has been increasing. Farming subsidy policies, which in the early 90's were reshaped upon joining the European Union, is also a notable factor influencing the composition of Finnish agriculture in general. However, these factors do not present notable trends in emissions throughout the time series. A minor decline can be observed in total TSP emissions, despite the total land area for cultivated crops remaining constant (Figure 5.18) This is due to a slight shift from most common crops towards more specialized crops for which there is no emission factor for harvesting, cleaning or drying.
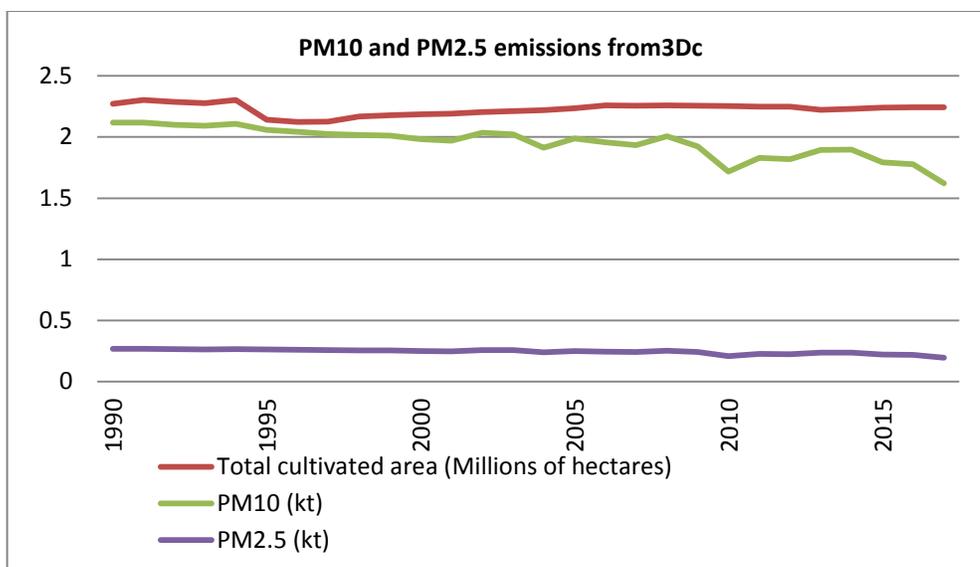
Figure 5.18 Total cultivated area and small particle emissions

Methodological issues

Activity data

Information on the use of arable land and harvested areas are provided by Natural Institute Resources Finland. For harvesting, data is available only from the year 2000 onwards. The figures used in calculation for 1990's are trend-projected values. Reliable statistics of cleaning and drying of crops does not exist and harvested areas are applied instead. This leads to a possible over-estimate on emission values for cleaning and drying, as it can be safely assumed that not all of the harvested crops go through these processes. The activity data used in calculation is presented in Table 5.27 (Natural Resources Institute Finland)

Table 5.27a Use of arable land area as thousands of hectares (Natural Resources Institute Finland)

Year	Wheat	Rye	Barley	Oats	Mixed grain	Other grains	Peas	Potatoes	Sugar beet	Turnip rape and rape	Hay	Silage	Pasture	Other grassland	Other crops	Fallow
1990	191	83	503	461	14	0	3	37	31	66	291	224	129	39	19	183
1991	118	10	541	343	12	0	11	36	32	61	232	234	120	37	21	494
1992	88	11	473	335	13	0	16	35	32	73	243	247	130	42	21	529
1993	99	23	459	332	13	0	13	36	33	69	255	261	125	46	20	494
1994	89	9	506	334	10	0	6	37	34	67	258	268	123	36	21	505
1995	101	21	516	329	11	1	5	36	35	85	287	301	127	40	25	223

1996	113	35	543	374	14	1	6	35	35	62	244	302	118	38	24	179
1997	125	23	583	369	16	2	6	33	35	61	220	314	114	39	25	162
1998	137	36	578	387	16	3	5	33	33	65	198	339	112	34	26	167
1999	118	12	581	404	18	1	5	32	35	63	175	350	114	33	25	211
2000	150	45	559	400	17	3	5	32	32	53	160	376	118	33	24	181
2001	145	29	547	423	16	1	5	30	31	73	158	381	94	32	25	202
2002	175	31	523	451	16	1	5	30	31	68	118	397	95	28	27	211
2003	192	31	531	426	16	1	4	29	29	75	101	399	102	27	30	220
2004	236	31	565	372	17	1	4	29	31	83	93	415	87	26	35	196
2005	215	14	595	346	16	1	4	29	31	77	107	398	92	24	45	241
2006	192	22	564	354	19	1	4	28	24	108	126	386	88	26	64	253
2007	204	32	550	362	20	1	4	28	16	90	103	438	90	23	64	232
2008	220	24	613	373	21	1	3	27	14	65	103	452	81	21	55	189
2009	218	16	601	343	23	2	4	26	15	81	86	450	79	25	57	230
2010	214	25	448	296	26	3	6	25	15	158	106	452	77	24	71	307
2011	257	27	465	324	28	3	5	25	14	92	103	472	75	17	67	276
2012	242	21	503	353	32	2	5	23	12	69	95	471	73	20	59	267
2013	231	12	533	367	33	2	4	22	12	53	93	466	72	19	50	254
2014	272	24	532	326	37	2	6	22	14	44	94	472	71	16	53	247
2015	249	32	513	307	36	3	12	22	13	57	86	492	58	16	75	271
2016	223	27	486	332	40	3	12	22	12	62	94	512	58	24	79	261
2017	219	32	437	337	43	3	11	22	12	65	87	552	57	21	90	254

Table 5.27b Harvested area as thousands of hectares (Natural Resources Institute Finland)

Year	Wheat	Rye	Barley	Oats	Mixed grain	Peas	Potatoes	Sugar beet	Turnip rape and rape	Hay	Silage
1990	119	42	589	480	14	5	35	44	55	162	331
1991	124	40	588	474	14	4	35	44	56	160	333
1992	128	39	581	467	15	5	34	43	59	157	335
1993	133	39	578	461	15	4	34	42	61	155	339
1994	139	38	587	458	15	4	34	41	56	150	344
1995	142	36	590	450	15	4	33	39	59	146	348
1996	148	35	588	441	15	4	33	38	66	143	354
1997	154	35	581	428	15	4	33	36	71	139	361
1998	157	33	573	420	14	4	32	35	75	136	368
1999	163	31	569	414	16	4	31	33	77	133	373
2000	149	45	559	400	17	5	32	32	53	158	372
2001	143	29	543	416	16	5	30	31	72	158	381
2002	174	30	522	451	16	5	30	31	66	118	397
2003	191	31	530	425	16	4	29	29	75	101	399

2004	225	27	532	326	16	3	27	30	68	91	412
2005	215	14	594	345	16	4	29	31	77	107	398
2006	192	22	564	353	19	4	28	24	107	125	384
2007	203	32	533	347	15	4	27	16	90	102	438
2008	216	24	586	355	13	3	26	14	64	102	451
2009	216	16	562	322	15	4	26	15	81	86	450
2010	211	25	417	278	19	6	25	15	158	106	452
2011	253	27	432	308	19	5	24	14	91	103	472
2012	227	21	451	314	21	4	21	12	57	95	471
2013	228	12	494	344	21	4	22	12	53	93	465
2014	267	24	497	305	24	6	22	14	43	94	472
2015	242	31	452	281	11	12	22	12	55	86	492
2016	215	26	436	305	14	10	22	12	60	94	511
2017	194	29	358	270	10	4	21	12	55	87	552

* Figures in grey represents projected data.

Particles

The emission factors are from EMEP/EEA Emission Inventory Guidebook 2016. For TSP emissions same emission factor as for PM10 emissions is used. The emission factor of cultivation of "other arable" is applied to all cultivated species with available statistics. This leads to a minor increase in total particle emissions as opposed to the previous submissions. The wet climate emission factors of the Guidebook 2016 are applied to local crops as presented in Table 5.27 below.

Table 5.27a TSP emission factor for farm-level agricultural operations: cultivation, harvesting, cleaning and drying of crops (Applied to Finnish conditions from Guidebook 2016)

Species	TSP *			
	Cultivation	Harvesting	Cleaning	Drying
Wheat	0,250	0,490	0,190	0,560
Rye	0,250	0,370	0,160	0,370
Barley	0,250	0,410	0,160	0,430
Oats	0,250	0,620	0,250	0,660
Mixed grain	0,250	NC	NC	NC
Other grains	0,250	NC	NC	NC
Peas	0,250	NC	NC	NC
Potatoes	0,250	NC	NC	NC
Sugar beet	0,250	NC	NC	NC
Turnip rape and rape	0,250	NC	NC	NC
Hay	0,250	0,250	0,000	0,000
Silage	0,250	NC	NC	NC
Pasture	0,250	NC	NC	NC
Other grassland	0,250	NC	NC	NC
Other crops	0,250	NC	NC	NC
Fallow	0,250	NC	NC	NC

Table 5.27b PM10 emission factor for farm-level agricultural operations: cultivation, harvesting, cleaning and drying of crops (Applied to Finnish conditions from Guidebook 2016)

Species	PM10			
	Cultivation	Harvesting	Cleaning	Drying
Wheat	0,250	0,490	0,190	0,560
Rye	0,250	0,370	0,160	0,370
Barley	0,250	0,410	0,160	0,430
Oats	0,250	0,620	0,250	0,660
Mixed grain	0,250	NC	NC	NC
Other grains	0,250	NC	NC	NC
Peas	0,250	NC	NC	NC
Potatoes	0,250	NC	NC	NC
Sugar beet	0,250	NC	NC	NC
Turnip rape and rape	0,250	NC	NC	NC
Hay	0,250	0,250	0,000	0,000
Silage	0,250	NC	NC	NC
Pasture	0,250	NC	NC	NC
Other grassland	0,250	NC	NC	NC
Other crops	0,250	NC	NC	NC
Fallow	0,250	NC	NC	NC

Table 5.27c PM2.5 emission factor for farm-level agricultural operations: cultivation, harvesting, cleaning and drying of crops (Applied to Finnish conditions from Guidebook 2016)

Species	PM2.5			
	Cultivation	Harvesting	Cleaning	Drying
Wheat	0,015	0,020	0,009	0,168
Rye	0,015	0,015	0,008	0,111
Barley	0,015	0,016	0,008	0,129
Oats	0,015	0,025	0,013	0,198
Mixed grain	0,015	NC	NC	NC
Other grains	0,015	NC	NC	NC
Peas	0,015	NC	NC	NC
Potatoes	0,015	NC	NC	NC
Sugar beet	0,015	NC	NC	NC
Turnip rape and rape	0,015	NC	NC	NC
Hay	0,015	0,010	0,000	0,000
Silage	0,015	NC	NC	NC
Pasture	0,015	NC	NC	NC
Other grassland	0,015	NC	NC	NC

Other crops	0,015	NC	NC	NC
Fallow	0,015	NC	NC	NC

$$E_i = \sum \left(\left(\mathbf{EF}_{j,\text{cultivation}} * \mathbf{A}_{j,\text{cultivation}} \right) + \mathbf{A}_{j,\text{harvesting}} \left(\mathbf{EF}_{j,\text{harvesting}} + \mathbf{EF}_{j,\text{cleaning}} + \mathbf{EF}_{j,\text{drying}} \right) \right)$$

Where,

i	= Inventory year
j	= Crops species
EF	= Emission factor (cultivation, harvesting, cleaning or drying) as kg/ha
A	= Land area as hectares (cultivation or harvesting)

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2018
- Particle emission factors (as well as activity data) were revised from the TNO emission factors used earlier to those presented in the EMEP/EEA Emission Inventory Guidebook 2016 due to the recommendation of the 2017 NECD review. The revision increased the emissions to be 10-fold compared to the earlier estimates.

2019
- Calculation of new species for which statistical data is available. Considered as "other arable" and the emissions were recalculated with Tier 2 methodology of EMEP/EEA Guidebook 2016.

Source-specific planned improvements

None.

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Off farm storage, handling and transport of bulk agricultural products (NFR 3Dd)

Changes in chapter	
Update of text	January 2017 JMP, KS

Emissions from off-farm storage, handling and transport of bulk agricultural products are reported as NA, because no methodology is presented in Guidebook 2016.

Cultivated crops (NFR 3De)

Changes in chapter	
Update of text	Feb 2019 JM, KS

Source category description

This chapter describes the calculation of NMVOC from cultivated crops, grasslands and fallows that serve agricultural purposes. Activity data is provided by Natural Resources Institute Finland (LUKE).

Emission trend

The activity data figures fluctuate annually mostly due to market demands and production rates of specific crops. NMVOC emissions follow this trend.
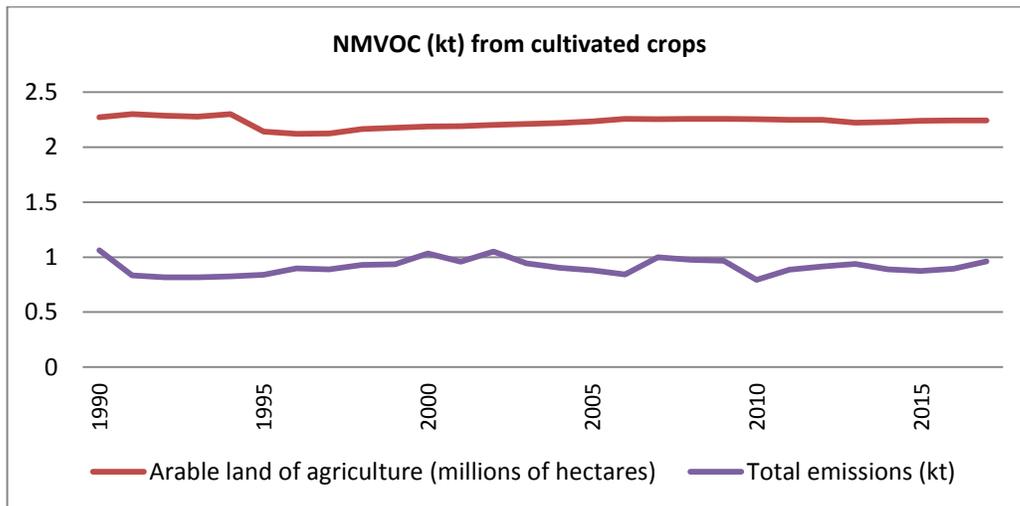
Figure 5.19 NMVOC emissions from cultivated crops

Methodological issues

The emissions of cultivated crops are calculated according to the guidance of EMEP/EAA Guidebook 2016. The model is constructed to calculate by Tier 1 and Tier 2 methods with a possibility to extend calculation into Tier 3.

NMVOC

NMVOC emissions from cultivated crops such as cereals, grasslands and silage are included in the inventory. Table 5.28 presents total cultivated land area for the years 1990-2017. Table 5.29 presents cultivated land areas by species included in the inventory. The total cultivated land area for 2017 was 2242 hectares.

Table 5.28 Total cultivated land area per species (thousands of hectares)

Year	Total Cultivated Area (kha)	Year	Total Cultivated Area (kha)
1 990	2 271	2 004	2 219
1 991	2 302	2 005	2 235
1 992	2 287	2 006	2 259
1 993	2 278	2 007	2 255
1 994	2 302	2 008	2 257
1 995	2 141	2 009	2 257
1 996	2 122	2 010	2 253
1 997	2 125	2 011	2 249
1 998	2 166	2 012	2 248
1 999	2 177	2 013	2 223
2 000	2 187	2 014	2 230
2 001	2 192	2 015	2 241
2 002	2 204	2 016	2243
2003	xxxx	2 017	2242

Table 5.29 Total cultivated land area per species in 2017 (thousands of hectares)

Species	Cultivated area	SNAP
Wheat	219	100102
Rye	32	100102
Barley	437	100102
Oats	337	100102
Mixed grain	43	100102
Other grains	3	100102
Peas	11	100102
Potatoes	22	100102
Sugar beet	12	100102
Turnip rape and rape	65	100102
Hay	87	100105
Silage	552	100105
Pasture	57	100105
Other grassland	21	100105

Other crops	90	100104
Fallow	254	100101
Total	**2242**	

The methodology for the calculation is based on EMEP/EEA Guidebook 2016 Tier 2 method, which reproduces the calculation of Tier 1 emission factor of by substituting the estimation of NMVOC Tier1 emission factor in kg ha-1 a-1 with national data. The recalculation is done for each year independently taking into account the annual relative changes within crop distribution and mean dry matter.

Default emission factor for Tier 1 calculation is 0.86 kg of NMVOC per hectare. The Tier 2 emission factor is calculated annually with the equation presented below.

$$EF_i = \sum \left(E_{j,\text{NMVOC}} * 24 * 365 * Frac_{emit,j} \right) * m_{dm_j} * Frac_{i,j}$$

Where,

i	= Inventory year
j	= Crops species
$E_{j,\text{NMVOC}}$	= Hourly emission flux of NMVOC per species (kg/dm³/h)
$Frac_{emit}$	= Fraction of the year during which the species is emitting
m_{dm}	= Mean dry matter of crop (kg/ha/a)
$Frac_{i,j}$	= Fraction of species j in relation to the total of cultivated areas and fallows for the year i

The Guidebook presents default values for calculation of the EF (Table 5.30). These defaults are used whenever national data is not available, and replaced if more detailed information is available.

Table 5.30 Default values for emission factor calculation

Species (i)	Ej,NMVOC	Fracemit	mdm,	Fracij
Wheat	2.60E-8	0,3	4700	0.35
Rye	1.41E-7	0.3	2800	0.05
Rape	2.02E-7	0.3	2500	0.1
Grass (15 C)	1.03E-8	0.5	9000	0.25
Grass (25 C)	4.67E-8	0.5	9000	0.25

Mean dry matter is derived from national statistics of species-specific yields per hectare by estimating their share of dry matter. Yield mean dry matter content remains constant throughout all years. Statistical data for yield per hectare is available for 2000-2016. The values for the year 2016 are presented in Table 5.31

Table 5.31 Yields per hectare and dry matter of 2017 in Finland

Species	Yield per hectare (kg/ha)	Yield mean dry matter content (kg/kg)	Mean dry matter mdm (kg/ha)
Wheat	4130	0.86	3551.8
Rye	3920	0.86	3371.2
Barley	4070	0.86	3500.2
Oats	3760	0.86	3233.6
Mixed grain	2850	0.86	2451.0

Other grains	2850	0.86	2451.0
Peas	2180	0.86	1874.8
Potatoes	28860	0.22	6349.2
Sugar beet	36550	0.23	8406.5
Turnip rape and rape	1650	0.92	1518.0
Hay	3390	0.86	2915.4
Silage	12290	0.25	3072.5
Pasture	12290	0.2	2458.0
Other grassland	12290	0.2	2458.0
Other crops	9000	0.22	1980.0
Fallows	6145	0.21	1290.5

The total cultivated area as thousands of hectares for all species accompanied with the calculated crop distribution (from the total of 2 241 000 hectares including fallows and other grasslands) are presented in Table 5.32. Emission factors are presented in Table 5.33.

Table 5.32 Weighed emission factor and crop distribution of the year 2017, and NMVOC flux per for the main cultivated species.

Species	Cultivated area (1 000 ha)	Crop distribution (%)	NMVOC (kg/dm/a)	Weighted EF (kg NMVOC / ha / a)
Wheat	219	9.7 %	6.82E-05	2.36E-02
Rye	32	1.4 %	3.70E-04	1.77E-02
Barley	437	19.5 %	6.82E-05	4.65E-02
Oats	337	15.0 %	5.30E-04	2.58E-01
Mixed grain	43	1.9 %	6.82E-05	3.20E-03
Other grains	3	0.2 %	6.82E-05	2.53E-04
Peas	11	0.5 %	6.82E-05	6.39E-04
Potatoes	22	1.0 %	6.82E-05	4.27E-03
Sugar beet	12	0.5 %	6.82E-05	3.04E-03
Turnip rape and	65	2.9 %	5.30E-04	2.34E-02
Hay	87	3.9 %	4.51E-05	5.08E-03
Silage	552	24.6 %	4.51E-05	3.41E-02
Pasture	57	2.6 %	4.51E-05	2.83E-03
Other grassland	21	0.9 %	4.51E-05	1.04E-03
Other crops	90	4.0 %	4.51E-05	3.58E-03
Fallows	254	11.3 %	4.51E-05	6.59E-03

Table 5.33 Finnish NMVOC emission factors of cultivated crops in 5-year intervals and the inventory year 2017.

Year	1980	1985	1990	1995	2000	2005	2010	2015	2017
Total Cultivated Area	2372	2276	2271	2141	2186	2234	2253	2240	2242
Emission Factor	0.482	0.470	0.513	0.431	0.477	0.399	0.358	0.396	0.434

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2018
Open and stubble fallows were removed from the total cultivated area as these are not expected to be sources of NMVOC emissions.

Source-specific planned improvements
None.

Use of pesticides (NFR 3Df)

Changes in chapter	
Update of text	March 2019 KS & JMP

Source category description

HCB emissions from the use of pesticides resulting from HCB residues in chlorine containing pesticides are included under this category.

Emission trend

The emission trend (Figure 5.20) is sharply declining in the early 1990's due to decreased use of chlorine containing pesticides. A new herbicide containing clopyralid was put on the market in Finland in 2010.
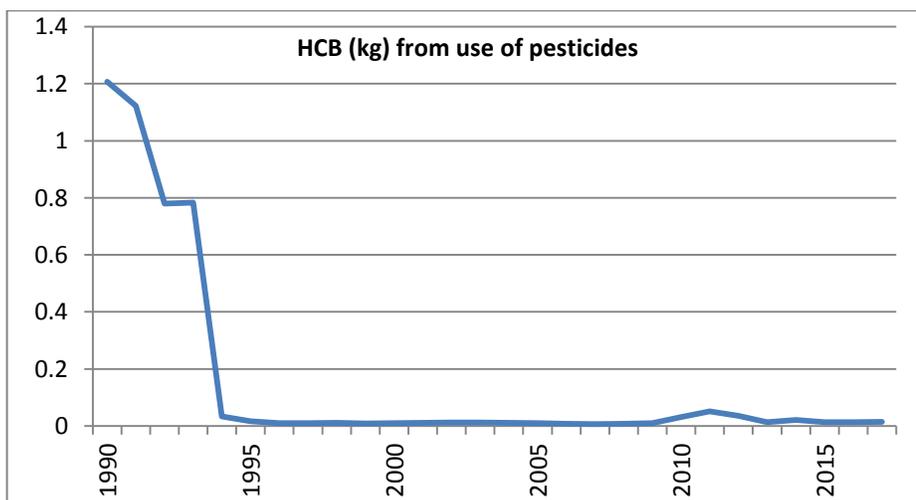

Figure 5.20 HCB from the use of pesticides

Methodological issues

NH3

In the Guidebook 2016 version calculation of ammonia emissions from ammonia treated straw is presented. In Finland straw is neither treated with ammonia nor urea, therefore NH3 emissions from this category are reported as NA.

HCB emissions

During the manufacture of chlorine containing pesticides HCB may be formed as a by-product and part of this may be left in the product as an impurity (Jones. 2005). Pesticides where HCB can exist as impurity include Lindane, Dacthal (DCPA), Pentachlorophenol, Atrazine, Simazine. Picloram, Pentachloronitrobenzene (PCNB, quintozene), Chlorothalonil, Endosulfan and Clopyralid (Jones, 2005; Environment Canada. 2006).

It is assumed that all HCB residues in the pesticides are emitted to the air, which might be considered as an overestimation.

The HCB impurity concentrations in certain pesticides have been used as emission factors (Table 4.34) and the sales of the effective substance (Evira Finnish Food Safety Authority, 2019) in pesticides as activity data. Sales information provided by Evira has been claimed confidential since the year 2009 and cannot therefore be published.

Lindane, Dacthal, PCNB and Picloram have not been used in Finland during the period 1990-2017. A new herbicide containing clopyralid was put on the market in Finland in 2010.

Table 5.34 Pesticides containing HCB (Environment Canada. 2006).

Selected Pesticide Active Ingredient	Pesticide type	Concentration of HCB impurity in the pesticide (ppm or mg/kg)
Atrazine	Herbicide	1 ppm
Chlorothalonil	Fungiside	10 ppm
Clopyralid	Herbicide	2.5 ppm
Dacthal (Chlorthan Methyl. DCPA)	Herbicide	40 ppm
Endosulfan	Insecticide	0.1 ppm
Lindane	Insecticide	1 ppm
Pentachloronitrobenzene (PCNB =	Fungiside	500 ppm
Picloram	Herbicide	8 ppm
Simazine	Herbicide	1 ppm

The emission factor for HCB emissions (0.5) from fungicides presented in Guidebook 2016 was considered to be inaccurate compared to the emission factors currently in use in the inventory (presented above) as they are available for each active ingredients.

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2010 emissions. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

None.

Source-specific planned improvements

None.

5.4 Field burning of agricultural wastes (NFR 3F)

Changes in chapter	
Update of text	Feb 2019 JMP, KS, JM

Source category description

Field burning of crop residues is a source of NH_3, NO_x, CO, SO_x, NMVOC, particle (TSP, PM_{10}, $PM_{2.5}$, BC) and heavy metal emissions. Also PCDD/F and PAH emissions are included in the inventory.

Emission trend

The emission trends follow the trends in the activity data for all pollutants (Figure 5.21).
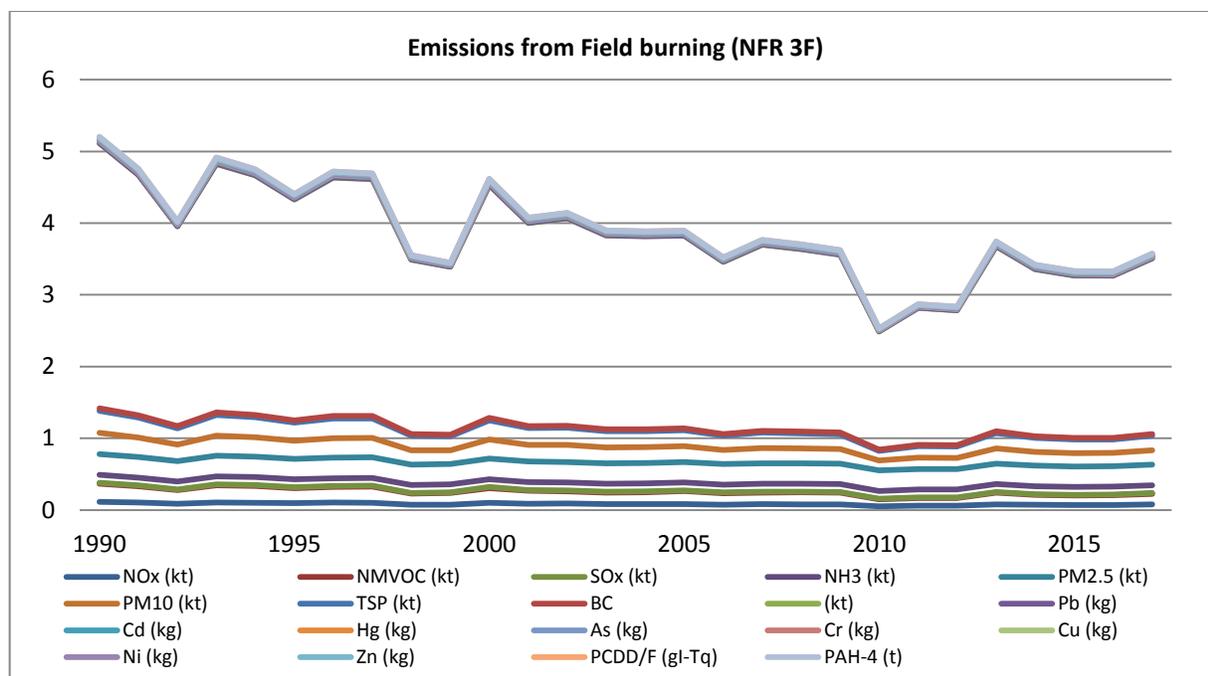
Figure 5.21 Emissions from field burning

Methodological issues

The calculation follows the methodology presented in EMEP/EEA Guidebook 2016.

Activity data

In Finland, burning of agricultural residues occurs only at small scale and it is becoming increasingly rare. Straw is assumed to be the most important agricultural residue burned.

According to the Decree 189/2009 of the Ministry of Agriculture and Forestry field burning of crop residues has to be avoided and is allowed only if it is necessary in order to succeed in sowing or to prevent weeds or pests. According to several agricultural experts residue burning on fields occurs only in small scale in Finland and is becoming increasingly rare. The machinery is usually able to manage the excess straw left on fields after harvesting. Cereal (especially rye) straw is the most important crop residue that may be burned on fields. Straw is mainly left on field but a minor part is used for feed or as litter in animal shelters or burning in boilers.

The annual crop yields for cereals and other crops are based on data from the Yearbook of Agricultural Statistics and the areas for cultivated cereals were also obtained from TIKE (the Information Centre of the Ministry of Agriculture and Forestry). The share of burned residue from total cereal residue on the fields for the years 1990-2013 was re-evaluated and simplified. The situation of residue burning for years 2013 (0.9%) and 2012 (0.7%) is rather accurately known as TIKE made an inquiry to the farmers.

The situation in the beginning of the 1990's is, however, still highly uncertain. Most likely, burning has been more common than nowadays and an expert opinion (Ansalehto, 2007) supports this. Therefore, field burning in the year 1990 was estimated to be twice as much as the average of years 2012 and 2013 and was assumed to rise linearly from year 2012 backwards.

Estimates for the burned fraction of cereal are presented in Table 5.35 and emission factors from Guidebook 2016. From 2014-2017 the fraction burned has been 0.008. Emission factors for wheat are used also for rye and oats.

Table 5.35a Estimates of the burned fraction. Fraction of total residue burned is calculated by dividing the burned straw with total residue of all crops (as dry matter) (Finland's NIR 2018 Table 5.5-2)

Year	Frac of residue burned, cereals	Frac of residue burned, total residue
1990	0.016	0.008
1995	0.014	0.007
2000	0.012	0.007
2005	0.010	0.005
2006	0.009	0.006
2007	0.009	0.005
2008	0.009	0.006
2009	0.008	0.005
2010	0.008	0.004
2011	0.007	0.004
2012*	0.007	0.004
2013*	0.009	0.005
2014	0.008	0.005
2015	0.008	0.005

*an estimate based on TIKE inquiry

Table 5.35b Activity data for total burned biomass (kt dm)

Year	Wheat	Barley	Oats	Rye	Total	Year	Wheat	Barley	Oats	Rye	Total
1990	5.98	20.56	17.82	1.16	45.52	2010	6.25	7.84	6.22	0.63	20.94
1991	6.26	18.36	15.78	1.04	41.44	2011	7.97	8.44	7.51	0.69	24.61
1992	3.90	15.49	14.03	0.91	34.34	2012	7.19	8.57	7.79	0.54	24.09
1993	5.93	19.48	16.30	0.96	42.66	2013	8.66	12.90	10.64	0.28	32.47
1994	6.05	19.00	15.03	0.91	40.98	2014	9.67	11.08	8.23	0.68	29.66
1995	5.76	17.15	14.09	0.94	37.95	2015	9.65	10.22	8.42	0.76	29.06
1996	6.79	17.55	15.74	1.39	41.46	2016	9.05	10.74	8.22	0.74	28.75
1997	6.72	18.25	15.06	0.73	40.76	2017	9.54	11.88	8.76	0.85	31.03
1998	5.69	12.26	11.79	0.86	30.59						
1999	3.43	13.53	11.30	0.35	28.61						
2000	7.10	16.56	15.59	1.53	40.77						
2001	6.22	14.48	13.93	0.88	35.51						
2002	6.90	13.51	15.50	0.96	36.87						
2003	7.94	12.72	12.84	0.93	34.42						
2004	9.16	13.13	10.87	0.87	34.04						
2005	8.62	14.53	9.82	0.38	33.35						

2006	7.05	13.07	9.04	0.57	29.73						
2007	7.90	13.14	10.64	0.94	32.62						
2008	7.52	13.40	10.17	0.63	31.71						
2009	8.03	13.33	9.02	0.41	30.78						

Emission factors

The emission factors used are from the EMEP/EEA Guidebook 2016. For wheat and barley Tier 2 EF is used. For oats and rye the emission factor of wheat is used. For PCDD/F Tier 1 EF is used for all species

Table 5.36 Emission factors used for field burning of agricultural residues.

Pollutant	**Wheat**	**Barley**	**Oats**	**Rye**	**Unit**
NOx	0.0023	0.0027	0.0023	0.0023	kg kg-1 dm
CO	0.0667	0.0987	0.0667	0.0667	kg kg-1 dm
NMVOC	0.0005	0.0117	0.0005	0.0005	kg kg-1 dm
SOx	0.0005	0.0001	0.0005	0.0005	kg kg-1 dm
NH3	0.0024	0.0024	0.0024	0.0024	kg kg-1 dm
TSP	0.0058	0.0078	0.0058	0.0058	kg kg-1 dm
PM10	0.0057	0.0077	0.0057	0.0057	kg kg-1 dm
PM2.5	0.0054	0.0074	0.0054	0.0054	kg kg-1 dm
BC	500	1200	500	500	mg kg-1 dm
Pb	0.11	0.0036	0.11	0.11	mg kg-1 dm
Cd	0.88	0.24	0.88	0.88	mg kg-1 dm
Hg	0.14	0.096	0.14	0.14	mg kg-1 dm
As	0.0064	NA	0.0064	0.0064	mg kg-1 dm
Cr	0.08	0.14	0.08	0.08	mg kg-1 dm
Cu	0.073	0.0036	0.073	0.073	mg kg-1 dm
Ni	0.052	0.011	0.052	0.052	mg kg-1 dm
Se	0.02	0.039	0.02	0.02	mg kg-1 dm
Zn	0.56	0.49	0.56	0.56	mg kg-1 dm
Benzo(a)pyrene	67.7	98.8	67.7	67.7	mg kg-1 dm
Benzo(b)fluoranthene	189.1	307.4	189.1	189.1	mg kg-1 dm
Benzo(k)fluoranthene	80.7	77	80.7	80.7	mg kg-1 dm
Indeno(1.2.3-cd)pyrene	57.9	38.2	57.9	57.9	mg kg-1 dm
PCDD/F	0.5	0.5	0.5	0.5	mg kg-1 dm

* For wheat and barley. Tier 2 EF is used. (EMEP/EEA Guidebook 2016)

* For PCDD/F Tier 1 EF is used for all species

$$E_i = \sum (\text{EF}_{\text{pollutant.}} * \text{AR})_j$$

Where.
i	= Inventory year
j	= Crops species
EF	= Emission factor for pollutant (kg/kg dm)
AR	= Activity rate (AR). mass of residue burnt (kg dry matter)

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2010 emissions. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2009
- Emissions from cereal straw (wheat. barley. oats. rye) burning were included

2014
- The activity data for field burning was revised due to new information from inquiries in 2012 and 2013 for the whole time series and thus NH3 emissions have also changed.

2015
- Calculation of emissions from field burning of agricultural waste was revised according to new emission factors presented in Guidebook 2013

2016
- Calculation of emissions from field burning of agricultural waste was revised for the 2016 submission due to update of emission factors according to Guidebook 2016 and new studies that improved the activity data.

2017
- Calculation of heavy metal and PCDD/F emissions from field burning of agricultural waste was revised for the 2017 submission due to inclusion of emission factors from Guidebook 2016.
2019
- In response to a question raised during the review, activity data (kg dm burning for specific crop types) has been included in the IIR.

Source-specific planned improvements

None.

4.4 Agriculture other (NFR 3 I)

Not occurring in Finland.