Latvijas Republikas Zemkopības ministrija
Latvijas Lauksaimniecības universitāte

Pētījuma „SILTUMNĪCEFEKTA GĀZU EMISIJU APRĒĶINU VEIKŠANA LAUKSAIMNIECĪBAS SEKTORĀ PAR 2012.GADU”

Atskaite

Jelgava
2014.gada marts

Pasūtītājs:
Zemkopības ministrija

Izpildītājs
Latvijas Lauksaimniecības universitāte

Līgums Nr. Nr.2014/27
„Siltumnīcefekta gāzu emisiju aprēķinu veikšana lauksaimniecības sektorā par 2012.gadu"

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Latvia's National Inventory Report (NIR) under the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol and Regulation (EU) No 525/2013 of the European Parliament and of the Council

Chapter **AGRICULTURE**

Contents

AGRICULTURE (CRF 4) **5**

1.1 OVERVIEW OF SECTOR 5

Overview of greenhouse gas emissions *5*

Sources of information and activity data *7*

1.2 ENTERIC FERMENTATION (CRF 4.A) 9

Source category description *9*

Methodological issues *10*

Source-specific QA/QC and verification *14*

Source-specific recalculations *14*

Source-specific planned improvements *14*

1.3 MANURE MANAGEMENT (CRF 4.B) 14

Source category description *14*

Methodological issues *16*

Source-specific QA/QC and verification *23*

Source-specific recalculations *23*

Source-specific planned improvements *23*

1.4 AGRICULTURAL SOILS (CRF 4.D) 23

Source category description *23*

Methodological issues *24*

Uncertainties and time series consistency *29*

Source-specific QA/QC and verification *29*

Source-specific recalculations *29*

Source-specific planned improvements *29*

1.5 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 4.F) 30

AGRICULTURE (CRF 4)

1.1 OVERVIEW OF SECTOR

Overview of greenhouse gas emissions

The emissions of greenhouse gases (GHG) from agriculture sector in Latvia include:
1) emissions of CH_4 (methane) from enteric fermentation of domestic livestock and manure management;
2) emissions of N_2O (nitrous oxide) from manure management and agricultural soils. Emissions from agricultural soils include direct N_2O emissions (application of synthetic N-fertilizer, animal manure application to soils, biological nitrogen fixation of N-fixing crops, crop residues and cultivation of organic soils) and indirect N_2O emissions (atmospherics deposition and nitrogen leaching and run-off).

Rice cultivation (4 C) and savannas (4 E) are not typical for Latvia; therefore these categories are reported as "NO" in CRF tables. Legislative measures and agricultural residue management practices prohibit field burning of agricultural residues in Latvia. This is explained by Latvian Administrative Violations Code Section 179 Violation of Fire Safety Regulations[1], therefore notation key "NO" is used in CRF tables under category 4 F. The calculation of emissions is based on *Revised 1996 IPCC Guidelines* and *IPCC GPG Guidelines 2000* methodology. Detailed information about methods is described under each subcategory.

In 2012, agriculture sector contributed 2420.30 Gg CO_2 eq. (equivalents) which was approximately 20% of total national emissions and it was the second largest source of GHG emissions in Latvia. Nitrous oxide emissions contributed 67% (1636.16 Gg CO_2 eq.), but CH_4 emissions contributed remaining 32% (784.14 Gg CO_2 eq.) of total GHG emissions from agricultural sector. 87% of total methane emissions from agriculture sector resulted from enteric fermentation and 13% from manure management. The major portion (almost 92%) of agriculture sector total nitrous oxide emissions resulted from direct-indirect emissions; only 8% of total nitrous oxide emissions were contributed from manure management. The share of GHG emissions by subcategories in agriculture sector in 2012 is presented in Figure 0.1.

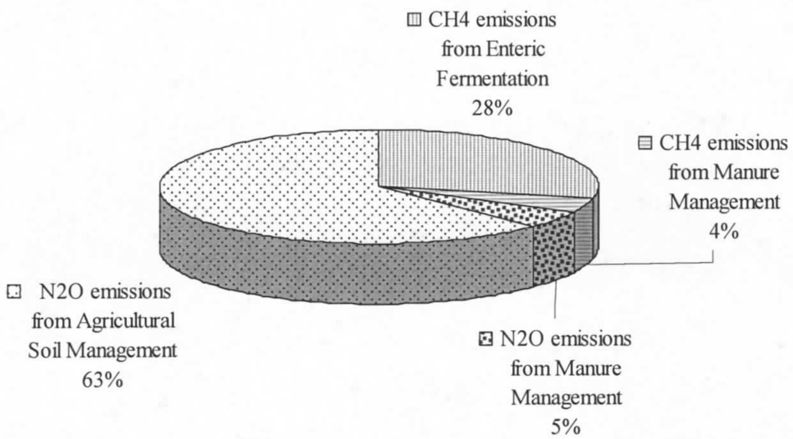

Figure 0.1 The share of GHG emissions by subcategories in agriculture sector, 2012 (%)

[1] Available at http://www.likumi.lv/doc.php?id=89648

GHG emissions increased in 2012 by 4.3%, if to compare with 2011. However, the annual emissions have reduced approximately by 60% since 1990 due to decreases in the number of livestock, nitrogen fertilization and etc. (Table 0.1, Figure 0.2).

Table 0.1 Greenhouse gas emissions (Gg CO_2 eq.) in the agricultural sector, 1990–2012

Year	CH_4	N_2O	Total
1990	2351.75	3580.79	5932.54
1991	2242.05	3321.16	5563.21
1992	1827.80	2544.32	4372.12
1993	1136.94	1771.94	2908.88
1994	972.74	1536.81	2509.55
1995	955.21	1356.31	2311.52
1996	904.14	1338.59	2242.73
1997	887.91	1343.79	2231.70
1998	822.26	1294.00	2116.25
1999	715.23	1215.88	1931.11
2000	717.98	1239.12	1957.11
2001	758.31	1343.12	2101.43
2002	754.26	1311.30	2065.56
2003	752.70	1384.17	2136.88
2004	728.89	1354.70	2083.59
2005	752.63	1423.25	2175.88
2006	750.16	1419.90	2170.06
2007	783..53	1477.94	2261.47
2008	756.80	1468.53	2225.32
2009	752.37	1504.75	2257.11
2010	759.92	1567.45	2327.37
2011	761.67	1559.53	2321.21
2012	784.14	1636.16	2420.30

Some inter-annual variation between the years can be noticed from the time series mainly caused by fluctuation in activity data between the years because of changes in animal numbers, which is significantly affected by economical situation in country as well as agricultural policy. Methane and nitrous oxide emissions from manure management are affected by the fluctuation in animal numbers and the proportion of manure managed in different manure management systems which vary depending on animal species. Nitrous oxide emissions from agricultural soils generally are affected by the cultivation of organic soils; amount of synthetic fertilizers sold annually, animal numbers and crop yields of cultivated crops, which have large variation between the years.

The major part of emissions from agriculture in Latvia originates from agricultural soils. The share of these emissions during 1990-2012 increased from 50 to 62%. Second the most important source of emissions is enteric fermentation. The share of enteric fermentation emissions from1990 to 2012 decreased to 28%, however in the beginning of 90`s the share of enteric fermentation emissions was close to 40%. Less significant part of total agriculture emissions is relevant to manure management. The share of these emissions in the beginning of 90`s was around 14% and they decrease to 9% in 2012 (Figure 0.2).

Emissions from agriculture noticeably decreased in the beginning of 90`s after Soviet system and large state, or collective farms collapsis. However, in recent years there is possible to observe a slight increase of sown area, consumption of synthetics N-fertilizers and non-dairy, sheep and poultry numbers. State efforts to improve animal waste management systems (AWMS) and expansion of anaerobic digester production as AWMS in the largest farms is main reason that reduces the increase of emissions from manure management in the last years.

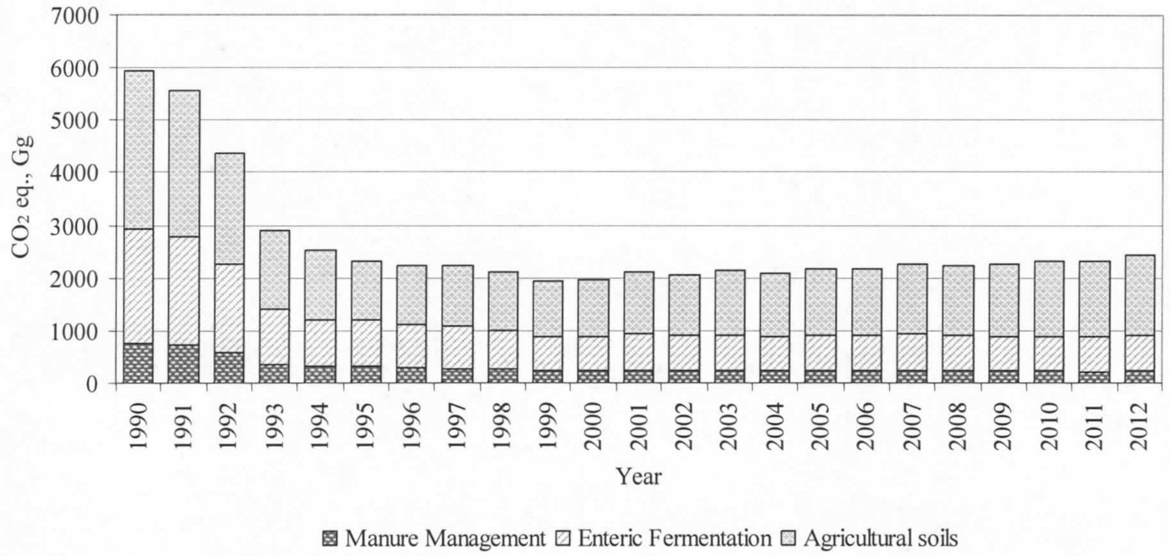

Figure 0.2 Trends of emissions by category within the sector, 1990-2012 (Gg, CO_2 eq.)

Sources of information and activity data

Numbers of cattle, sheep, goats, horses, swine and poultry population, as well as data on milk production and fat content in milk are obtained from the CSB (Central Statistical Bureau) of Latvia Database and statistical yearbooks[2]. Similarly like numbers of domestic livestock, also statistical information about amounts of nitrogen (N) synthetic fertilizers application and crop production is obtained from CSB database. The distribution of different manure management systems is adopted from national studies in two periods:

1) 1990-1999 according to research made by Latvian State Institute of Agrarian Economics (LSIAE, 2005);

2) 2000-2012 according to research activities provided by Latvia University of Agriculture[3]. Numbers of cultivated Histosols area are provided by Latvian State Forest Research Institute "Silava".

Statistical information about livestock numbers in Latvia is included in Table 0.2.

Table 0.2 Number of livestock (thousand heads), 1990–2012

Year	Dairy cattle	Non - Dairy cattle	Sheep	Goats	Horses	Swine	Poultry
1990	535.1	904.2	164.6	5.4	30.9	1401.1	10321.1
1991	531.4	851.5	183.7	6.1	30.0	1246.5	10395.1
1992	481.7	662.6	164.7	6.4	28.4	866.5	5438.3
1993	351.0	326.9	114.0	6.3	26.2	481.8	4123.7
1994	311.9	238.9	86.3	7.4	26.8	500.7	3699.6
1995	291.9	245.2	72.2	8.9	27.2	552.8	4198.3
1996	274.6	234.8	55.5	8.4	25.8	459.6	3790.7
1997	262.8	214.1	40.7	8.9	23.3	429.9	3550.7
1998	242.1	192.3	29.4	10.5	22.0	421.1	3208.8
1999	205.6	172.8	27.0	8.1	19.0	404.9	3236.9
2000	204.5	162.2	28.6	10.4	19.9	393.5	3104.6

[2] AGRICULTURE IN LATVIA. Collection of Statistical Data. Rīga: 2013. 62 pp

[3] Rivža P. u.c. Lauksaimniecības rādītāju prognoze 2015. un 2020. gadam. Latvijas Republikas Zemkopības ministrija. Latvijas Lauksaimniecības universitāte. 2011

Year	Dairy cattle	Non - Dairy cattle	Sheep	Goats	Horses	Swine	Poultry
2001	209.1	175.6	29.0	11.5	19.6	428.7	3621.2
2002	204.6	183.5	31.5	13.2	18.5	453.2	3882.0
2003	186.3	193.3	39.2	15.0	15.4	444.4	4002.6
2004	186.2	184.9	38.6	14.7	15.5	435.7	4049.5
2005	185.2	200.0	41.6	14.9	13.6	427.9	4092.3
2006	182.4	194.7	41.3	14.3	14.0	416.8	4488.1
2007	180.4	218.3	53.9	13.0	13.0	414.4	4756.8
2008	170.4	209.8	67.1	12.9	13.1	383.7	4620.5
2009	165.5	212.7	70.7	13.2	12.6	376.5	4828.9
2010	164.1	215.4	76.8	13.5	12.0	389.7	4948.7
2011	164.1	216.5	79.7	13.4	11.5	375.0	4417.9
2012	164.6	228.5	83.6	13.3	10.9	355.2	4910.9

Latvian livestock industry has been influenced by historical events and the changing world economic situation. Particularly significant changes in the livestock industry began in 1992 after the restoration of Latvian independence when most of big farms went into liquidation. Since the Soviet Union had a planned economy, most of the output of livestock products was carried out in other Soviet republics. Russian crisis almost stopped the export of livestock products. Reorientation of livestock product export to Western markets was more difficult in terms of market saturation and because the Latvian products are not necessarily in their requirements. All the above conditions affect the Latvian farmers and they were forced to reduce the milk, meat and egg production levels. Consequently, livestock numbers declined most rapidly in 1990-1994 in all sectors, except for goat farming. In the case of stud-farms - all the above-mentioned social and economic changes lead to eliminating of stud-farms, the horses were sold, only the strongest stud-farms continued to work. Starting with 2002 the number of animals has stabilized, but with 2004, according to Latvian accession to the European Union, the increase in the number of animals is characteristic for beef cattle, sheep, goat and poultry industries. The livestock sector has contributed to the development of European Union agricultural subsidies and public sectors.

Statistical information about crop production in Latvia is included in Table 0.3.

Table 0.3 Crop production (thousand t) statistics for calculation of nitrous oxide emissions1990–2012

Year	Wheat	Barley	Triticale	Maize for silage and forage	Oats	Rye	Crops for green feed and silage	Rape	Mixed cereals and pulses	Buck-wheat	Potatoes	Sugar beet	Feedbeet	Vegetable	Peas and beans
1990	371.8	697	-	967.3	176.1	323.6	952.8	3.7	30.7	0.0	1016.1	439.1	1388.4	169.4	22.7
1991	190.2	764.9	7.4	785	177.2	145.8	894.1	0.9	29.3	0.0	944	377.9	1211.8	209.2	20.7
1992	432.4	433.5	8.6	317.5	60.0	295.0	442	1.4	13.3	0.0	1167.4	462.6	901.5	250.8	8.6
1993	338.3	455.5	13.6	137.6	73.7	340.7	341.6	2.5	8.8	0.1	1271.7	298	859	284.8	4.3
1994	199.4	481.1	5.6	26.5	88.9	113.4	206.6	1.8	7.6	0.1	1044.9	228.2	687.2	233.2	4.5
1995	243.7	284	4.9	13.0	73.2	71.3	164.8	0.9	11.9	0.0	863.7	250	432.7	223.7	4.7
1996	357.5	371.5	3.4	11.9	101.4	112.9	151.3	1.3	14.0	0.1	1081.9	257.8	399.1	179.5	7.8
1997	394.6	359.8	7.5	10.4	116.5	133.5	154.3	0.5	22.5	0.8	946.2	387.5	404	162.5	8.3
1998	385.3	321.7	12.6	13.3	103.6	104.8	164.3	1.6	29.3	1.6	694.1	597	347	119.6	11.3
1999	351.9	232.6	11.9	15.7	66.1	88.7	128.0	11.7	16.2	2.2	795.5	451.5	235.1	130.1	3.6
2000	427.4	261.1	13.5	24.1	79.6	110.7	137.6	10.0	25.4	5.9	747.1	407.7	222.3	105.8	3.9
2001	451.7	231.1	28.9	25.1	82.4	107.2	98.0	13.0	16.9	9.8	615.3	491.2	203.0	159.3	4.0
2002	519.5	262.4	40.9	25.7	79.7	101.5	98.4	32.7	16.2	8.3	768.4	622.3	153.7	148.2	4.2
2003	468.4	246.6	33.0	44.3	78.3	87.6	140.3	37.4	13.1	5.4	739.0	532.4	158.5	217.5	5.0
2004	499.9	283.5	42.1	52.8	107.4	96.8	148.5	103.6	22.9	6.9	628.4	505.6	130.1	180.8	4.5
2005	676.5	365.8	31.8	58.0	122.0	87.2	112.1	145.7	21.1	9.9	658.2	519.9	88.3	172.2	3.5
2006	598.3	307.0	22.2	63.8	91.6	116.8	110.7	120.6	15.9	6.9	550.9	473.9	61.4	174.4	1.4
2007	807.3	350.5	37.9	122.6	130.2	181.1	148.6	196.9	17.1	11.1	642.1	11.0	53.2	155.9	2.6
2008	989.6	307.1	35.2	125.3	141.5	194.9	109.9	198.5	14.0	7.1	673.4	-	22.4	143.2	2.9

Year	Wheat	Barley	Triticale	Maize for silage and forage	Oats	Rye	Crops for green feed and silage	Rape	Mixed cereals and pulses	Buck-wheat	Potatoes	Sugar beet	Feedbeet	Vegetable	Peas and beans
2009	1036.4	265.4	33.3	226.6	141.4	162.2	90.7	204.7	19.6	4.8	525.4	-	17.6	182.5	5.2
2010	989.3	228.5	26.4	209.0	100.6	70.2	82.6	226.3	15.0	5.5	484.3	-	20.4	151.0	5.4
2011	939.5	236.7	21.4	345.6	120.9	64.0	84.0	219.1	19.9	9.6	498.6	-	14.8	168.2	8.4
2012	1539.8	248.6	48.8	553.7	137	124.2	167.7	303.5	18.1	8	538.9		17.4	161.4	11.1

Statistical surveys are the source of data on crop production in commercial companies, private farms and individual merchants. Fluctuations in activity data is observed due to economical situation in the country. Since 2007, two sugar companies stopped their activity therefore no data presented further.

Agricultural statistics data fully comply with criteria determined by the EU and precision requirements determined in the legislative acts. The Project Documentation System (ADS) is established at CSB. It is quality metadata system for internal and external users. There are methodological descriptions of all statistical surveys and calculation. Annual samples are made up as stratified simple samples. Holdings are selected by economic size (standard output - SO) and type of farming. Standard output is standard indicator characterizing the economic activity of agricultural holding, i.e., value acquired from one hectare of agricultural crops or one livestock head (unit), estimated at prices of corresponding region and expressed in EUR. Total standard output characterise the economic size of the holding in monetary terms. Farms with SO >= 50000 EUR are included for 100% statistical surveys; farms with 2000 EUR<SO < 50000 EUR are selected by economic size and type of farming. Sample size for annual sample (Crop and Animal survey) includes 5.1 thousand holdings. Small holdings with SO < 2000 EUR are not included in annual Crop and Animal surveys, but information for these holdings is estimated using expert's method. For this estimation CSB uses information from Agricultural Censuses and surveys of small farms, which are organized between Censuses. Crop and livestock statistics quality reports are available on CSB web page[4;5].

Other statistical data are included in relevant subchapters.

1.2 ENTERIC FERMENTATION (CRF 4.A)

Source category description

Methane (CH_4) is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation[6]. Ruminant livestock (cattle, sheep and goats) are primary source of methane emissions. The amount of enteric methane emitted is driven primarily by the number of animals, the type of digestive system, and the type and amount of feed consumed.

The emission source covers domestic livestock. Latvia reports emissions from cattle (including dairy cows), swine, horses, goats and sheep (Table 0.4). Emissions from poultry have not been estimated. According to *Revised 1996 Guidelines for National Greenhouse Gas Inventories* methane emissions relevant to poultry are negligible.

Table 0.4 Reported emissions under the subcategory Enteric Fermentation

CRF	Source	Emissions reported
4.A 1	Cattle Dairy / Cattle Non-Dairy Cattle	CH_4
4.A 2	Buffalo	NO

[4] http://www.csb.gov.lv/sites/default/files/quality_report_on_annual_crop_statistics_2010_0.pdf
[5] http://www.csb.gov.lv/sites/default/files/quality_report_on_livestock_and_meat_statistics_2010_0.pdf
[6] IPCC GPG, 2000

CRF	Source	Emissions reported
4.A 3	Sheep	CH_4
4.A 4	Goats	CH_4
4.A 5	Camels and Lamas	NO
4.A 6	Horses	CH_4
4.A 7	Mules and Asses	NO
4.A 8	Swine	CH_4
4.A 9	Poultry	NE

Cattle are the largest source of enteric methane emissions (96% from total methane emissions from enteric fermentation) in Latvia. In 2012, methane emissions from enteric fermentation of domestic livestock increased by 0.92 Gg, if to compare with 2011. This is caused by the increase of the number of non-dairy cattle and sheep by approximately 5%. Since 1990 generally due to evident fall of the number of cattle, emissions decreased by 68% (Table 0.5).

Table 0.5 Methane emissions from Enteric Fermentation by animal type in 1990–2012 (Gg)

Year	Dairy cattle	Non-Dairy cattle	Sheep	Goats	Horses	Swine	Total, CH_4	Total, CO_2 eq.
1990	51.14	47.18	1.32	0.03	0.56	2.10	102.32	2148.74
1991	49.50	44.43	1.47	0.03	0.54	1.87	97.84	2054.65
1992	42.80	34.58	1.32	0.03	0.51	1.30	80.54	1691.24
1993	31.00	17.06	0.91	0.03	0.47	0.72	50.19	1054.03
1994	28.13	12.47	0.69	0.04	0.48	0.75	42.56	893.80
1995	26.79	12.80	0.58	0.04	0.49	0.83	41.53	872.05
1996	25.67	12.25	0.44	0.04	0.46	0.69	39.56	830.79
1997	26.33	11.17	0.33	0.04	0.42	0.64	38.93	817.61
1998	24.62	10.03	0.24	0.05	0.40	0.63	35.97	755.34
1999	20.89	9.02	0.22	0.04	0.34	0.61	31.11	653.33
2000	20.96	8.52	0.23	0.05	0.36	0.59	30.71	644.84
2001	21.80	9.21	0.23	0.06	0.35	0.64	32.29	678.17
2002	21.11	9.63	0.25	0.07	0.33	0.68	32.07	673.47
2003	20.53	10.14	0.31	0.08	0.28	0.67	32.01	672.17
2004	19.89	9.70	0.31	0.07	0.28	0.65	30.90	648.86
2005	20.14	10.48	0.33	0.07	0.25	0.64	31.92	670.36
2006	20.10	10.18	0.33	0.07	0.24	0.63	31.55	662.54
2007	20.23	11.40	0.43	0.07	0.23	0.62	32.99	692.75
2008	19.45	10.95	0.54	0.06	0.24	0.58	31.81	667.96
2009	19.04	11.09	0.57	0.07	0.23	0.56	31.55	662.51
2010	19.05	11.21	0.61	0.07	0.22	0.58	31.73	666.43
2011	19.08	11.27	0.64	0.07	0.21	0.56	31.83	668.36
2012	19.40	11.88	0.67	0.07	0.20	0.53	32.74	687.58
Share of total % in 2012	59.24%	36.29%	2.04%	0.20%	0.60%	1.63%	100%	+3% versus 2011

Methodological issues

The Tier 1 approach relies on default emissions factors. For Tier 1, countries are required to collect data on the average number of animals for each animal group. The Tier 2 approach is more complex than Tier 1 because it draws upon country-specific information on animal and feed characteristics. The Tier 2 approach is recommended to estimate methane emissions for countries with large cattle and sheep populations.

Emissions from enteric fermentation of domestic livestock in Latvia have been calculated by using the *IPCC* Tier 1 and Tier 2 methodologies presented in the *Revised 1996 IPCC* and the *IPCC GPG 2000*. Methane emissions from enteric fermentation for horses, swine, sheep and goats have been calculated with the *IPCC* Tier 1 method by multiplying the number of the animals in each category with the *IPCC* default emission factor of the respective animal category as shown in *IPCC GPG 2000* equation 4.12:

$$Emissions\ CH_4 = EF * population / (10^6\ kg/Gg)$$

The default emission factors as for developed countries according to *Revised 1996 IPCC* (Table 4-3, page 4.10) were used to calculate methane emissions from enteric fermentation for sheep, goats, horses and swine (Table 0.6).

Table 0.6 Default methane emission factors from Enteric Fermentation

Types of animals	EF (kg/head/year)
Sheep	8
Goats	5
Horses	18
Swine	1.5

The contribution of emissions from horses, swine, sheep and goats to the total emissions from enteric fermentation is less significant, therefore default Tier 1 was applied. The Tier 2 method has been used for cattle, because emissions from cattle make the biggest part of total agricultural sector methane emissions. With the Tier 2 method methane emissions have been calculated as in the Tier 1 method mentioned above, but the emission factors for dairy cattle and non-dairy cattle has been calculated according to Equation 4.14 in the *IPCC GPG 2000*:

$$EF = (GE * Ym * 365\ days/year)/(55.65\ MJ/kg\ CH_4),$$

where:

GE = Gross energy intake (MJ/animal/day);

Ym = Methane conversion rate, fraction of gross energy in feed converted to methane (IPCC default value 0.06).

For cattle, the gross energy intake (GE) has been calculated by using the *IPCC GPG 2000* methodology by using a slightly modified version of Equation 4.11:

$$GE = \{[NEm + NEa + NE_l + NEp) / (NEma/DE)] + [(NEg) / (NEga / DE)]\} / (DE / 100)$$

where:

NEm = Net energy for maintenance, MJ/day;
NEa = Net energy for activity, MJ/day;
NE_l = Net energy for lactation, MJ/day (dairy cattle);
NEp = Net energy required for pregnancy, MJ/day (dairy cattle, corrected on 80% according to IPCC GPG 2000);
NEma/DE = ratio of net energy available in a diet for maintenance to digestible energy consumed;
NEg = Net energy for growth, MJ/day;
NEga/DE = Ratio of net energy available for growth in a diet to digestible energy consumed;
DE = Digestible energy expressed as a percentage of gross energy.

The equations for calculating *NEm* (Equation 4.1, 2000 IPCC GPG), *NEa* (Equation 4.2.a, 2000 IPCC GPG), NE_l (Equation 4.5.a, 2000 IPCC GPG), *NEp* (Equation 4.8, 2000 IPCC GPG), *NEg* (Equation 4.3.a, 2000 IPCC GPG), *NEma/DE* (Equation 4.9, 2000 IPCC GPG) *and NEga/DE* (Equation 4.10, 2000 IPCC GPG) are:

$$NEm = Cfi * (Weight)^{0.75}$$

$$NEa = [Cap * (tp / 365) + Cao * (1 - (tp / 365))] * NEm$$

$$NE_l = My / 365 * 1.47 + 0.40 * Fat)$$

$$NEp = Cp * NEm$$

$$NEg = 4.18 * \{0.0635 * [0.891 * (BV * 0.96) * (478 / (C * MW))]^{0.75} * (WG * 0.92)^{1.097}\}$$

$$NEma/DE = 1.123 - (4.092 * 10^{-3} * DE) + [1.126 * 10^{-5} * (DE)^2] - (25.4/DE)$$

$$NEga/DE = 1.164 - (5.160 * 10^{-3} * DE) + (1.308 * 10^{-5} * (DE)^2) - (37.4/DE)$$

where,

Cfi = Maintenance coefficient;
Weight = Animal weight, kg;
tp = Length of pasture season, days;
Cap = Coefficient corresponding to animal's feeding situation for pasture;
Cao = Coefficient corresponding to animal's feeding situation for stall;
My = Amount of milk produced per year, kg /cow;
Fat = Fat content in milk, %;
Cp = Pregnancy coefficient;
C = Coefficient related to growth;
BV = Live body weight of the animal, kg;
MW = Mature weight, kg;
WG = Daily weight gain, kg/day;
DE = Feed digestibility, %.

Detailed information about applied coefficients and other parameter values for calculation of cattle GE, as well as sources of information are summarized in Table 0.7.

Table 0.7 Input data for gross energy intake calculation

Parameter	Symbol	Dairy cattle	Non-Dairy cattle	Comments
Maintenance coefficient	Cfi	0.335	0.322	Table 4.4, 2000 IPCC GPG
Coefficient corresponding to animal's feeding situation (pasture)	Cap	0.17	0.17	Table 4.5, 2000 IPCC GPG
Coefficient corresponding to animal's feeding situation (stall)	Cao	0	0	Table 4.5, 2000 IPCC GPG
Pregnancy coefficient	Cp	0.1	-	Table 4.7, 2000 IPCC GPG
Growth coefficient	C	0.8	1.2	Page 4.15, 2000 IPCC GPG
Weight (kg)	Weight	550	500	National studies
Weight gain (kg/day)	WG	0.25	0.5	National studies
Mature weight (kg)	MW	550	500	National studies
Live body weight (kg)	BV	39	39	National studies
Feed Digestibility (%)	DE	60	60	Page 4.13, 2000 IPCC GPG
Pasture season length (days)	tp	145	185	National studies 1990-1999. From 2000 calculated based on AWMS
Milk yield (kg/cow/year)	My	Table 0.8	-	National studies
Milk fat (%)	fat	Table 0.8	-	National studies

The calculation of GE is strongly based on the milk production and fat content in milk. Trends about milk production and fat content in milk are presented in Table 0.8. Values of milk fat contend for 1990-1997 is based on national expert judgment; all other information comes from CSB.

Table 0.8 Average milk yield per cow (kg/head/year) and fat content (%)

Year	Average milk yield	Fat content
1990	3437	3.50
1991	3205	3.50
1992	2793	3.50
1993	2741	3.50
1994	2923	3.50
1995	3074	3.50
1996	3237	3.50
1997	3585	4.09
1998	3733	4.06
1999	3754	4.00
2000	3898	4.08
2001	4055	4.08
2002	3958	4.08
2003	4261	4.11
2004	4251	4.17
2005	4364	4.25
2006	4492	4.26
2007	4636	4.31
2008	4822	4.29
2009	4892	4.31
2010	4998	4.29
2011	5064	4.22
2012	5250	4.16

Results of calculation of GE and emission factors for dairy and non-dairy cattle from enteric fermentation are summarized in Table 0.9.

Table 0.9 Calculated average gross energy intake (MJ/head/day) and emission factors of methane emission from Enteric Fermentation (kg CH_4/head/year), 1990-2012

Year	GE for Dairy Cattle	GE for Non-Dairy Cattle	EF for Dairy Cattle	EF for Non-Dairy Cattle
1990	242.83	132.60	95.56	52.18
1991	236.69	132.60	93.14	52.18
1992	225.77	132.60	88.85	52.18
1993	224.40	132.60	88.31	52.18
1994	229.22	132.60	90.20	52.18
1995	233.22	132.60	91.78	52.18
1996	237.54	132.60	93.48	52.18
1997	254.56	132.60	100.18	52.18
1998	258.39	132.60	101.69	52.18
1999	258.16	132.60	101.60	52.18
2000	260.47	133.40	102.50	52.50
2001	264.88	133.31	104.24	52.46
2002	262.15	133.38	103.16	52.49
2003	280.06	133.35	110.21	52.48
2004	271.39	133.27	106.80	52.44
2005	276.40	133.13	108.77	52.39
2006	280.04	132.82	110.20	52.27

Year	GE for Dairy Cattle	GE for Non-Dairy Cattle	EF for Dairy Cattle	EF for Non-Dairy Cattle
2007	285.00	132.74	112.16	52.24
2008	290.00	132.60	114.12	52.18
2009	292.29	132.47	115.03	52.13
2010	294.94	132.19	116.07	52.02
2011	295.45	132.31	116.27	52.07
2012	299.43	132.14	117.84	52.00

Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures applied to the category enteric fermentation based on the IPCC GPG 2000, Table 8.1, p. 8.8-8.9. These procedures are implemented every year during the agricultural inventory. If errors or inconsistencies are found they are documented and corrected. The QC checklist is used during the inventory.

Source-specific recalculations

For 2014 submission recalculations of methane emissions from dairy cattle for period 2000-2011 are done based on ERT recommendation about different approach to calculate number of days on pasture. Same minor recalculations are done according to correction of statistical data about livestock numbers.

Source-specific planned improvements

Elaboration of methodology to expand calculations on age subgroups of non-dairy livestock.

1.3 MANURE MANAGEMENT (CRF 4.B)

Source category description

The emission sources cover management of manure from domestic livestock. Latvia reports methane (CH_4) and nitrous oxide (N_2O) emissions from cattle (including dairy cows), swine, horses, goats, sheep and poultry (Table 0.10). When organic matter in livestock manure decomposes in anaerobic environment, methanogenic bacteria produce methane. The amount of methane produced from manure depends on livestock type and diet, special feeding and digestibility of food, as well as waste management system. The nitrous oxide estimated in this section is the N_2O produced during the storage and treatment of manure before it is applied to land. Production of nitrous oxide during storage and treatment of animal wastes occur via combined nitrification-denitrification of nitrogen in animal waste.

Table 0.10 Reported emissions under the subcategory Manure Management

CRF	Source	Emissions reported
4.B 1	Dairy Cattle Non-Dairy Cattle	CH_4, N_2O
4.B 2	Buffalo	NO
4.B 3	Sheep	CH_4, N_2O
4.B 4	Goats	CH_4, N_2O
4.B 5	Camels and Lamas	NO
4.B 6	Horses	CH_4, N_2O
4.B 7	Mules and Asses	NO
4.B 8	Swine	CH_4, N_2O
4.B 9	Poultry	CH_4, N_2O
4.B 11	Anaerobic Lagoons	NO
4.B 12	Liquid Systems	N_2O
4.B 13	Solid Storage and Dry Lot	N_2O
4.B 14	Other AWMS	N_2O

Methane emissions from manure management have decreased by 51%, but nitrous oxide emissions by 78% over the time period 1990-2012 (Table 0.11,
Table **0.12**). In 2012, methane emissions from manure management of domestic livestock increased by 0.16 Gg, if to compare with 2011. Nitrous oxide emissions in 2012 increased by 0.01 Gg compared to 2011. The fluctuation of emissions is related to the variation of animal numbers, which is largely dependent on agricultural policy, as well as changes in the distribution of animal waste management systems (AWMS).

Table 0.11 Methane emissions (Gg) from Manure Management by animal type, 1990-2012

Year	Dairy cattle	Non-Dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Total, CH_4	Total, CO_2 eq.
1990	2.00	1.18	0.03	0.00	0.04	5.60	0.81	9.67	203.01
1991	1.94	1.11	0.03	0.00	0.04	4.99	0.81	8.92	187.40
1992	1.67	0.87	0.03	0.00	0.04	3.47	0.42	6.50	136.55
1993	1.21	0.43	0.02	0.00	0.04	1.93	0.32	3.95	82.90
1994	1.10	0.31	0.02	0.00	0.04	2.00	0.29	3.76	78.94
1995	1.05	0.32	0.01	0.00	0.04	2.21	0.33	3.96	83.16
1996	1.00	0.31	0.01	0.00	0.04	1.84	0.30	3.49	73.35
1997	1.03	0.28	0.01	0.00	0.03	1.72	0.28	3.35	70.30
1998	0.96	0.25	0.01	0.00	0.03	1.68	0.25	3.19	66.92
1999	0.82	0.23	0.01	0.00	0.03	1.62	0.25	2.95	61.90
2000	1.31	0.32	0.01	0.00	0.03	1.57	0.24	3.48	73.14
2001	1.42	0.36	0.01	0.00	0.03	1.72	0.28	3.82	80.18
2002	1.33	0.36	0.01	0.00	0.03	1.81	0.30	3.85	80.82
2003	1.33	0.39	0.01	0.00	0.02	1.78	0.31	3.83	80.46
2004	1.34	0.38	0.01	0.00	0.02	1.74	0.32	3.81	80.03
2005	1.42	0.43	0.01	0.00	0.02	1.71	0.32	3.92	82.27
2006	1.65	0.48	0.01	0.00	0.02	1.67	0.35	4.17	87.58
2007	1.71	0.55	0.01	0.00	0.02	1.66	0.37	4.32	90.70
2008	1.75	0.55	0.01	0.00	0.02	1.53	0.36	4.23	88.84
2009	1.78	0.58	0.01	0.00	0.02	1.51	0.38	4.28	89.86
2010	1.84	0.63	0.01	0.00	0.02	1.56	0.39	4.45	93.50
2011	1.92	0.65	0.02	0.00	0.02	1.50	0.34	4.44	93.31
2012	2.04	0.72	0.02	0.00	0.02	1.42	0.38	4.60	96.60
Share of total % in 2012	44.30%	15.70%	0.40%	0.00%	0.40%	30.9%	8.30%	100%	+3% versus 2011

Table 0.12 Nitrous oxide emissions (Gg) from Manure Management by animal type, 1990-2012*

Year	Dairy cattle	Non-Dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Total, N_2O	Total, CO_2 eq.
1990	0.68	0.75	0.02	0.00	0.02	0.25	0.12	1.84	569.75
1991	0.67	0.71	0.02	0.00	0.02	0.22	0.12	1.76	547.00
1992	0.61	0.55	0.02	0.00	0.02	0.15	0.06	1.42	438.86
1993	0.44	0.27	0.01	0.00	0.02	0.09	0.05	0.88	273.13
1994	0.39	0.20	0.01	0.00	0.02	0.09	0.04	0.75	233.88

Year	Dairy cattle	Non-Dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Total, N_2O	Total, CO_2 eq.
1995	0.37	0.20	0.01	0.00	0.02	0.10	0.05	0.75	232.02
1996	0.35	0.19	0.01	0.00	0.02	0.08	0.04	0.69	215.06
1997	0.33	0.18	0.00	0.00	0.02	0.08	0.04	0.65	201.57
1998	0.31	0.16	0.00	0.00	0.02	0.07	0.04	0.60	185.49
1999	0.26	0.14	0.00	0.00	0.01	0.07	0.04	0.53	164.55
2000	0.28	0.09	0.00	0.00	0.01	0.07	0.05	0.52	160.59
2001	0.29	0.10	0.00	0.00	0.01	0.07	0.06	0.54	166.59
2002	0.28	0.11	0.00	0.00	0.01	0.06	0.07	0.54	167.01
2003	0.26	0.11	0.00	0.00	0.01	0.06	0.07	0.51	157.93
2004	0.25	0.11	0.00	0.00	0.01	0.05	0.07	0.49	153.43
2005	0.24	0.11	0.01	0.00	0.01	0.04	0.07	0.50	153.68
2006	0.23	0.11	0.01	0.00	0.01	0.03	0.08	0.47	145.74
2007	0.22	0.12	0.01	0.00	0.01	0.03	0.08	0.48	148.76
2008	0.21	0.11	0.01	0.00	0.01	0.03	0.08	0.45	140.68
2009	0.20	0.11	0.01	0.00	0.01	0.02	0.09	0.45	138.75
2010	0.19	0.11	0.01	0.00	0.01	0.02	0.06	0.42	129.61
2011	0.19	0.11	0.01	0.00	0.01	0.02	0.05	0.39	122.13
2012	0.19	0.11	0.01	0.00	0.01	0.02	0.05	0.40	123.24
Share of total % in 2012	47.15%	28.75%	3.44%	0.96%	2.07%	4.96%	12.67%	100.00%	+1% versus 2011

*emissions from pasture not included, they are reported under 4.D Agricultural soils

Methodological issues

The *IPCC Guidelines* include two tiers to estimate methane emissions from livestock manure. The Tier 1 approach requires livestock population data by animal species/category and climate region in order to estimate emissions. The Tier 2 approach requires detailed information on animal characteristics and the manner in which manure is managed; it is encouraged to be used for countries where a particular livestock species/category represents a significant share of emissions.

The process of developing Tier 2 emission factors involves determining the mass of volatile solids excreted by the animals (VS, in kg) along with the maximum methane producing capacity for the manure (Bo, in m3/kg of VS). In addition, a methane conversion factor (MCF) that accounts for the influence of climate on methane production must be obtained for each manure management system[7].

Methane emissions from manure management for sheep, goats, horses, swine and poultry are calculated by multiplying the number of the animals in each category with the default emission factor for each category according to Equation 4.15 in the *IPCC GPG 2000:*

$$Emissions\ CH_4 = Emission\ Factor * population / (10^6\ kg/Gg)$$

Mainly default emission factors according to Revised 1996 IPCC (Tables 4-5, 4-6 pages 4.12-4.13) were used to calculate methane emissions from manure management. Emission factors as for *cool* climate region were chosen (Table 0.13).

[7] IPCC GPG 2000, p. 4.31

Table 0.13 Methane emission factors from Manure Management

Types of animals	EF (kg/head/year)
Sheep	0.19
Goats	0.12
Horses	1.4
Swine	4
Poultry	0.078

For dairy cattle and non-dairy cattle the Tier 2 approach was used for estimating methane emissions from manure management systems as dairy cattle's represent a significant share of emissions. This method requires detailed information on animal characteristics and the manner in which manure is managed.

Tier 2 emission factors (for defined livestock population, kg) were developed for period 1990-2012 (Table 0.14) according to *IPCC GPG 2000*, Equation 4.17:

$$EF = VS * 365\ days/year * Bo * 0.67\ kg/m3 * \Sigma(MCF * MS)$$

where,

VS = daily VS excreted for an animal within defined population, kg;
Bo = maximum CH_4 producing capacity for manure produced by an animal within defined population, m3/kg of VS (0.24 for dairy cattle and 0.17 for non-dairy cattle);
MCF = CH_4 conversion factor for each manure management system by climate region (Solid Storage – 0.1%, Liquid Storage – 10%, Pasture/Range/Paddock – 1%; Anaerobic Digester – 0%);
MS = fraction of animal species/category manure handled using each manure system by climate region (Table 0.15-Table 0.28).

The preferred method to obtain methane producing potential values Bo values is to use data from country-specific published sources, measured with a standardised method. For Latvia country-specific Bo measurement values are not available, therefore default values are used: 0.24 for dairy cattle and 0.17 for non-dairy cattle[8]. Default Methane conversion factor MCF values provided in the *IPCC GPD 2000* Table 4.10 are included for calculations for different manure management systems: Pasture/Range/Paddock – 1%; Solid Storage – 0.1%, Anaerobic Digester – 0%. For Liquid Storage Latvia uses MCF 10% as noted in *Revised 1996 IPCC Guidelines Reference Manual, Table 4-8*[9]. According to local expert judgement these MCF values are appropriate to manure management systems for Latvia. Evaluation of measurements of MCF for Latvia include following factors: timing of storage/application; length of storage; manure characteristics; determination of the amount of manure left in the storage facility. VS excretion rate (per day on a dry-matter weight basis, kg-dm/day) is estimated as shown in Equation 4.16 in the *IPCC GPG 2000:*

$$VS = GE * (1\ kg\text{-}dm/18.45\ MJ) * (1 - DE/100) * (1 - ASH/100)$$

where,

GE = Estimated daily average feed intake in MJ/day (Table 0.9);
DE = Digestible energy of the feed in percent (60%);
ASH = Ash content of the manure in percent (8%).

[8] Revised 1996 IPCC Guidelines (Volume 3). Reference Manual, Table B-1. p. 4.39
[9] Revised 1996 IPCC Guidelines (Volume 3). Reference Manual, Table 4-8. p. 4.25

Results of calculation of country specific emissions factors for methane emissions from manure management are included in Table 0.14.

Table 0.14 Calculated methane emission factors for Dairy and Non-Dairy cattle from Manure Management

Year	Implemented EF for Dairy-cattle	Implemented EF for Non-Dairy-cattle
1990	3.74	1.31
1991	3.64	1.31
1992	3.48	1.31
1993	3.45	1.31
1994	3.53	1.31
1995	3.59	1.31
1996	3.66	1.31
1997	3.92	1.31
1998	3.98	1.31
1999	3.97	1.31
2000	6.42	1.96
2001	6.81	2.05
2002	6.52	1.98
2003	7.11	2.01
2004	7.18	2.08
2005	7.69	2.17
2006	9.03	2.46
2007	9.49	2.53
2008	10.27	2.63
2009	10.75	2.75
2010	11.24	2.93
2011	11.68	3.00
2012	12.40	3.96

The *IPCC Guidelines* methodology were used for estimating nitrous oxide emissions (N_2O) emissions from manure management by multiplying the total amount of N excretion (from all animal species/categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems[10].

Nitrous oxide emissions (kg N_2O-N/yr) from manure management have been calculated by using IPCC GPG 2000 methodology equation 4.18:

$$Emissions\ N_2O\text{-}N = \Sigma_{(S)} \{[\Sigma_{(T)} (N_{(T)} * Nex_{(T)} * MS_{(T,S)})] * EF_{3(S)}\}$$

where:

$N_{(T)}$ = Number of head of livestock species/category T in the country (Table 0.2);
$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country, kg N/animal/yr (Table 0.30);
$MS_{(T,S)}$ = Fraction of total annual excretion for each livestock species/category T that is managed in manure management system S in the country (Table 0.15-Table 0.28);
$EF_{3(S)}$ = N_2O emission factor for manure management system S in the country, kg N_2O-N/kg N in manure management system S (Table 0.29);
S = Manure management system;
T = Species/category of livestock.

The amount of nitrogen excreted annually per animal has been divided between different manure management systems and multiplied with the IPCC default emission factor for each manure management system. The manure management systems (S) reported in the inventory is liquid system, solid storage and dry lot, pasture range and paddock and anaerobic digester. Nitrous oxide emissions

[10] IPCC GPG 2000, p. 4.40

from pasture are calculated under manure management, but are reported under pasture, range and paddock manure in CRF 4.D.

The distribution of animal waste management systems (AWMS) according to national studies is shown in the Table 0.15 - Table 0.28.

Table 0.15 Distribution of different manure management systems for 1990-1999 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	3.5	56.5	40
Non - Dairy cattle	2.1	52.7	45.2
Sheep		57.5	42.5
Goats		57.5	42.5
Horses		49.3	50.7
Swine	46	54	
Poultry	39	61	

Table 0.16 Distribution of different manure management systems for 2000 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	12.3	61.4	26.3
Non - Dairy cattle	8.6	36.6	54.8
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	42.5	53.8	3.7
Poultry		91.5	8.5

Table 0.17 Distribution of different manure management systems for 2001 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	13.3	60.8	25.9
Non - Dairy cattle	9.5	36.2	54.3
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	48.5	48.2	3.3
Poultry		92.1	7.9

Table 0.18 Distribution of different manure management systems for 2002 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	12.5	61.2	26.3
Non - Dairy cattle	8.8	36.5	54.7
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	54.8	42.4	2.8
Poultry		92.3	7.7

Table 0.19 Distribution of different manure management systems for 2003 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	13	60.9	26.1
Non - Dairy cattle	9.1	36.4	54.5
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	60	37.5	2.5
Poultry		92.6	7.4

Table 0.20 Distribution of different manure management systems for 2004 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	14	60.2	25.8
Non - Dairy cattle	9.8	36.1	54.1
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	65.6	32.2	2.2
Poultry		92.9	7.1

Table 0.21 Distribution of different manure management systems for 2005 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	15.3	59.3	25.4
Non - Dairy cattle	10.7	35.9	53.4
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	69.4	28.6	2
Poultry		93.1	6.9

Table 0.22 Distribution of different manure management systems for 2006 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	19.5	56.3	24.2
Non - Dairy cattle	13.7	34.5	51.8
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	77.4	21.2	1.4
Poultry		93.2	6.8

Table 0.23 Distribution of different manure management systems for 2007 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	20.5	55.6	23.9
Non - Dairy cattle	14.4	34.2	51.4
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	80.1	18.6	1.3
Poultry		93.3	6.7

Table 0.24 Distribution of different manure management systems for 2008 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock
Dairy cattle	22.5	54.2	23.3
Non - Dairy cattle	15.5	33.8	50.7
Sheep		40	60
Goats		70	30
Horses		50	50
Swine	80.8	17.8	1.4
Poultry		93.6	6.4

Table 0.25 Distribution of different manure management systems for 2009 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock	Anaerobic digester
Dairy cattle	23.8	53.3	22.8	0.1
Non - Dairy cattle	16.7	33.3	50	
Sheep		40	60	
Goats		70	30	
Horses		50	50	
Swine	81.8	16.9	1.3	
Poultry		93.8	6.2	

Table 0.26 Distribution of different manure management systems for 2010 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock	Anaerobic digester
Dairy cattle	25.1	52.1	22.3	0.5
Non - Dairy cattle	18.6	32.5	48.6	0.3
Sheep		40	60	
Goats		70	30	
Horses		50	50	
Swine	83.2	15.6	1.2	
Poultry		65.5	4.5	30

Table 0.27 Distribution of different manure management systems for 2011 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock	Anaerobic digester
Dairy cattle	26.5	50.9	21.8	0.8
Non - Dairy cattle	19.3	31.1	49.2	0.4
Sheep		40	60	
Goats		70	30	
Horses		50	50	
Swine	84.1	14.7	1.1	0.1
Poultry		56.0	4.0	40

Table 0.28 Distribution of different manure management systems for 2012 (%)

Animal category	Liquid system	Solid storage and dry lot	Pasture range and paddock	Anaerobic digester
Dairy cattle	28.3	50.3	20.5	0.9
Non - Dairy cattle	20.9	30.4	48.3	0.4
Sheep		40	60	
Goats		70	30	
Horses		50	50	
Swine	85.3	13.4	1.1	0.2
Poultry		52.2	3.8	44

Calculation of nitrous oxide emissions from manure management is based on default EF_3 emission factors[11] (Table 0.29).

Table 0.29 IPCC default emission factors for nitrous oxide from Manure Management

Manure Management System	Emission factor (kg N_2O – N/kg), EF_3
Liquid system	0.001
Solid storage and dry lot	0.020
Anaerobic digester	0.001

N excretion during the year per each animal type and the distribution of manure management systems are country specific calculated values. Data about annual N excretion ($Nex_{(T)}$) per animal until 2004 are obtained from national studies. National expert made an account, based on a research, in which livestock manure amount and nitrogen amount was analyzed over a long time period as well as different available information. Since 2005, annual N excretion per animal for emission calculation is corrected according to results of studies on development of manure normative and livestock units carried out by the State Ltd. "Agrochemical Research Centre". Results of project [LAD110507/S109] activities from 11.05.2007 till 01.12.2007 described by project leader R.Timbare are available at

[11] IPCC GPG 2000,Table 4.12

Latvia University of Agriculture in Latvian[12]. This research was basis for animal N excretion values official declaring in Republic of Latvia Ministers Cabinet Regulation No. 33 *Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity* (Adopted 11 January 2011) that was issued pursuant to the *Law On Pollution.* The mass balance approach was used for estimating N excretion by farm livestock. It requires information on both input (N_{intake}) and output ($N_{products}$) factors. N_{intake} was calculated as feed intake (kg of dry matter) x N content of the feed. $N_{products}$ were evaluated by the N in live weight gain, milk, etc. Average N excretions values used for emissions calculations is included in (Table 0.30). According to information from national studies regarding average $Nex_{(T)}$ for sheep and goats there is lower than IPCC default[13] because of:

- basis of sheep and goats nutrition was rather poor as sheep and goats usually were not fed additionally;
- mainly local breed was used which is not very productive;
- in general sheep and goat farming as a branch is relatively narrow in Latvia.

Since Latvia entered to European Union (EU) in 2004 the increase in the number of animals is evident for sheep and goats. The reason for this is the increase of funding formed by EU budget and state subsidies. Technologies and quality of production were improved and the capacity of realization of products was increased.

Table 0.30 Average N excretions per head of animal

Types of animals	N, kg/year till 2004	N, kg/year starting from 2005
Other cattle	50	50
Dairy cattle	71	70
Swine	10	10
Sheep, Goats	6	13
Horse	46	48
Poultry	0.6	0.6

N excretion per swine 10 kg nitrogen per animal in a year is a low value compared with IPCC default (20 kg/animal/yr). The national studies show a big difference in N excretion (4.5-19.4 kg/animal/yr) by different sub-categories of swine, but in average N excretion is about 10 kg/animal/yr (Table 0.31).

Table 0.31 N excretion for swine in average

Livestock Category	N excretion, kg/head/yr*
Piglets (7.0-30.0 kg)	4.5
Fattening pigs (30-100 kg)	10.2
Young breeding sow (80-180 kg)	15.6
Breeding sows (180- 240 kg)	19.4
In average	9.7

**No. of production cycles/year: 6.4 for piglets, 3.2 for fattening pigs, 1,85 for young breeding sows, 2.35 for breeding sows*

The CSB of Latvia is collecting data on population of swine of such sub- categories:

- piglets, live weight less than 20 kg (including sucking piglets);
- young pigs, live weight 20- 50 kg;
- fattening pigs;

[12] http://www.llu.lv/projektu-apskate?projekti_id=501
[13] Revised 1996 IPCC, Table 4-20, page 4.99.

- young breeding sows;
- breeding sows.

Commercial pig production in Latvia mainly includes four or five phases, to take account of changes in nutrient requirements with increasing age of the pig: piglets with live weight 7-30 kg, fattening pigs 30-100 kg or 7-100 kg, young breeding sows and breeding sows. Therefore there are not researches data on N excretion by young pigs with live weight 20-50 kg.

Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures are applied to the category manure management. The QA/QC process for the agricultural sector includes the QC measures based on the guidelines of the IPCC (IPCC GPG 2000, Table 8.1). These activities are implemented every year in preparation process of agriculture inventory. If errors or inconsistencies are found they are documented and corrected. The QC checklist is used during the inventory.

Source-specific recalculations

For 2014 submission, recalculations of methane emissions from dairy cattle for period 2000-2011 are done based on ERT recommendation about different approach to calculate number of days on pasture.

Source-specific planned improvements

Elaboration of methodology to expand calculations on age subgroups of non-dairy livestock.

1.4 AGRICULTURAL SOILS (CRF 4.D)

Source category description

Nitrous oxide (N_2O) is produced naturally in soils through the microbial processes of nitrification and denitrification. The emissions of nitrous oxide that result from anthropogenic N inputs occur through a direct pathway (directly from the soils to which the N is added), and through two indirect pathways (through volatilisation as NH_3 and NOx and subsequent redeposition, and through leaching and runoff)[14]. This source category includes both direct and indirect nitrous oxide emissions from agricultural soils (Table 0.32). Direct nitrous oxide emissions include emissions from application of synthetic fertilizers and animal manure, biological nitrogen fixation via cultivation of N-fixing crops, incorporation of crop residues in to soils and cultivation of Histosols.

In the *IPCC Guidelines*, direct and indirect emissions of nitrous oxide from agricultural soils are estimated separately. The *IPCC Guidelines* methodology for estimating direct nitrous oxide emissions from agricultural soils has two parts:

1) estimation of direct N_2O emissions due to N-inputs to soils (excluding N-inputs from animals on pasture, range, and paddock);
2) estimation of direct N_2O emissions from manure deposited by animals on pasture, range, and paddock).

Indirect nitrous oxide emissions from atmospheric deposition of NH_4 and NO_x as well as from leaching and run-off of the applied or deposited nitrogen are included in the inventory.

Table 0.32 Reported emissions under the subcategory Agricultural Soils

CRF	Source	Emissions reported
4.D 1	Direct Soil Emissions	N_2O
4.D 2	Pasture, Range and Paddock Manure	N_2O
4.D 3	Indirect Emissions	N_2O

[14] IPCC GPG 2000,Table 4.53

CRF	Source	Emissions reported
4.D 4	Other	NO

Nitrous oxide emissions from agricultural soils were 4.91 Gg in 2012. Emissions have decreased in 2012 by 50% comparing with 1990. The main reason is decreasing of animal numbers that affected the amount of nitrogen excreted annually to soil and consumption of fertilizers. However, in 2012 nitrous oxide emissions increased by 0.27 Gg comparing with 2011 (Table 0.33). The main reason of the increase of emissions in the latest years is the growing demand of synthetic fertilizers and cultivation of organic soils. In 2012, total nitrous oxide emissions from agricultural soils originated as 66.7% from direct emissions, 27.5% from indirect emissions and 5.8% from emissions from pasture, range and paddock. Emissions from organic Histosols formed the major part of total direct emissions (49%), following by emissions from synthetic fertilizers (35%) and animal manure applied to soils (11%).

Table 0.33 Direct and indirect nitrous oxide emissions from agricultural soils by source category (Gg), 1990-2012

Year	SF	MS	N	C	H	MP	A	L	GT, N_2O	GT, CO_2 eq.
1990	2.32	0.94	0.010	0.11	1.69	1.16	0.54	2.80	9.57	2967.74
1991	1.99	0.90	0.010	0.09	1.69	1.12	0.50	2.52	8.82	2734.45
1992	1.17	0.70	0.000	0.08	1.69	0.93	0.36	1.74	6.67	2067.65
1993	0.70	0.43	0.000	0.08	1.69	0.57	0.22	1.06	4.75	1471.64
1994	0.51	0.38	0.000	0.06	1.68	0.48	0.18	0.85	4.14	1284.72
1995	0.20	0.38	0.000	0.05	1.68	0.46	0.15	0.64	3.56	1103.94
1996	0.26	0.35	0.000	0.06	1.68	0.44	0.15	0.64	3.58	1108.27
1997	0.34	0.33	0.000	0.07	1.67	0.41	0.15	0.67	3.64	1128.12
1998	0.35	0.30	0.010	0.06	1.66	0.37	0.14	0.63	3.52	1092.62
1999	0.34	0.27	0.000	0.05	1.66	0.32	0.13	0.58	3.35	1037.91
2000	0.41	0.32	0.002	0.06	1.65	0.29	0.13	0.62	3.48	1079.42
2001	0.56	0.34	0.002	0.06	1.65	0.30	0.15	0.74	3.80	1179.24
2002	0.49	0.35	0.002	0.07	1.64	0.31	0.14	0.70	3.70	1147.62
2003	0.66	0.33	0.003	0.07	1.63	0.30	0.16	0.80	3.95	1223.88
2004	0.62	0.33	0.002	0.08	1.63	0.29	0.15	0.77	3.87	1200.63
2005	0.72	0.34	0.002	0.10	1.61	0.30	0.16	0.85	4.08	1265.73
2006	0.75	0.34	0.001	0.09	1.61	0.29	0.16	0.87	4.11	1273.48
2007	0.81	0.35	0.001	0.12	1.60	0.30	0.17	0.92	4.27	1323.39
2008	0.84	0.34	0.002	0.13	1.60	0.29	0.17	0.92	4.29	1329.28
2009	0.92	0.34	0.003	0.13	1.59	0.29	0.18	0.97	4.42	1369.58
2010	1.05	0.35	0.003	0.12	1.59	0.28	0.19	1.07	4.65	1440.88
2011	1.06	0.34	0.004	0.11	1.59	0.28	0.19	1.06	4.64	1437.78
2012	1.15	0.36	0.006	0.17	1.59	0.28	0.20	1.15	4.91	1521.93
Share of total % in 2012	23.5%	7.4%	0.1%	3.4%	32.4%	5.8%	4.1%	23.4%	100.00%	+6% versus 2011

SF=synthetic fertilizers, MS=manure applied to soils, N=N-fixation, C=crop residues, H=cultivation of organic soils, MP=manure deposited on pastures, A=atmospheric deposition, L=leaching and run-off, GT=grand total

Methodological issues

Direct nitrous oxide emissions from agricultural soils are calculated according to *IPCC GPG 2000*, Equation 4.20 (Tier 1a):

$$N_2O_{Direct\text{-}N} = [(F_{SN} + F_{AM} + F_{BN} + F_{CR}) * EF_1] + (F_{OS} * EF_2)$$

where:

F_{SN} = Annual amount of synthetic fertiliser nitrogen applied to soils adjusted to account for the amount that volatilises as NH_3 and NO_x;
F_{AM} = Annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilises as NH_3 and NO_x;
F_{BN} = Amount of nitrogen fixed by N-fixing crops cultivated annually;
F_{CR} = Amount of nitrogen in crop residues returned to soils annually;
F_{OS} = Area of organic soils (histosoils) cultivated annually;
EF_1 = Emission factor for emissions from N inputs (kg N_2O-N/kg N input), (Table 0.37);
EF_2 = Emission factor for emissions from organic soil cultivation (kg N_2O-N/ha-yr), (Table 0.37).

Synthetic fertiliser nitrogen adjusted for volatilisation (**F_{SN}**) input emissions through application of mineral fertilizers are calculated according to *IPCC GPG 2000*, Equation 4.22:

$$F_{SN} = N_{FERT} * (1 - Frac_{GASF})$$

where:

N_{FERT} = annual amount of nitrogen in synthetic fertilizers applied to soils, thousand t (Table 0.34);
*$Frac_{GASF}$ = fraction of nitrogen lost through gaseous emissions of NH_3 and NOx (**0.1** kg NH_3-N +NOx-N/kg of synthetic fertilizer N applied, Revised 1996 IPCC, Table 4-19[15]).*

Total amount of nitrogen in fertilizers applied to soils is summarized in Table 0.34.

Table 0.34 Amount of Nitrogen used with synthetic fertilizers (thousand t)

Year	N in synthetic fertilizers
1990	131.4
1991	112.4
1992	66.0
1993	39.7
1994	29.0
1995	11.5
1996	14.5
1997	19.4
1998	19.6
1999	19.0
2000	23.0
2001	31.6
2002	27.6
2003	37.4
2004	35.2
2005	40.9
2006	42.7
2007	46.1
2008	47.5
2009	51.9
2010	59.5
2011	59.8
2012	65.2

Animal manure nitrogen used as fertiliser, adjusted for volatilisation (**F_{AM}**) refers to the amount of animal manure nitrogen intentionally applied to soils after adjusting to account for the amount that volatilises. Calculation of emissions from nitrogen input through application of animal manure is done according to *IPCC GPG 2000* Equation 4.23:

[15] Revised 1996 IPCC Guidelines (Volume 3). Reference Manual, Table 4-19. p. 4.94

$$F_{AM} = \sum_T(N_{(T)} * Nex_{(T)}) * (1 – Frac_{GASM})[1 – (Frac_{FUEL-AM} + Frac_{PRP})]$$

were:

$\sum_T (N_{(T)} * Nex_{(T)})$ = Total amount of animal manure nitrogen produced annually, kg/Nyr;
*$Frac_{GASM}$ = fraction of livestock nitrogen excretion that volatilizes as NH_3 and NOx (**0.2** kg NH_3-N+NOx-N/kg, Revised 1996 IPCC, Table 4-19);*
$Frac_{FUEL-AM}$ = amount of animal manure that is burned for fuel, such activities not occurred in Latvia;
$Frac_{PRP}$ = amount of animal manure that is deposited onto soils by grazing livestock.

The approach presented in the *IPCC Guidelines* for estimating the amount of nitrogen fixed by N-fixing crops cultivated annually (**F_{BN}**) is based on the assumption that the amount of N contained in the aboveground plant material (crop product plus residues) is a reasonable proxy for the total amount of N fixed by the crop. The method applied for calculation of emissions is *IPCC GPG 2000* Tier 1b, Equation 4.26:

$$F_{BN} = \sum_i [Crop_{BFi} * (1 + Res_{BFi} / Crop_{BFi}) * Frac_{DMi} * Frac_{NCRBFi}]$$

were:

$Crop_{BFi}$ = Yield of pulses (peas and beans) (Table 0.3);
$Res_{BFi}/Crop_{BFi}$ = Residue to crop product ratio (Table 0.35);
$Frac_{DMi}$ = Dry matter fraction (Table 0.35);
$Frac_{NCRBFi}$ = Nitrogen fraction (Table 0.35)

In the *IPCC Guidelines*, the amount of nitrogen returned to soils annually through incorporation of crop residues (**F_{CR}**) is estimated by determining the total amount of crop residue N produced (from both non-N-fixing crops and N-fixing crops). The method applied for calculation of emissions is *IPCC GPG 2000* Tier 1b, modified Equation 4.29:

$$F_{CR} = \sum_i [(Crop_{Oi} * Res_{SOi} / Crop_{Oi} * Frac_{DMi} * Frac_{NCROi}) * (1 – Frac_R)] + \sum_j [(Crop_{BFj} * \\ *Res_{SBFj}/Crop_{BFi} * Frac_{DMj} * Frac_{NCRBFj}) * (1 – Frac_R)]$$

where:

$Crop_{Oi}$ = Crop production (Table 0.3);
$Crop_{BFj}$ = Nitrogen-fixing crop production (Table 0.3);
$Res_{Oi}/Crop_{Oi}$; $Res_{SBFj}/ Crop_{BFj}$ = Residue to crop product ratio (Table 0.35);
$Frac_{DMi}$; $Frac_{DMj}$ = Dry Matter Fraction (Table 0.35);
$Frac_{NCROi}$; $Frac_{NCRBFj}$ = Nitrogen Fraction (Table 0.35);
$Frac_R$ = fraction of crop residue that is removed from the field as crop – 45 kg N/kg crop-N, (Revised 1996 IPCC, Table 4-19).

Values of residue to crop production ratio, dry matter fraction and nitrogen fraction are presented in the Table 0.35.

Table 0.35 Crop residue statistics

Crops	Dry Matter Fraction ($Frac_{DM}$)	Nitrogen Fraction ($Frac_{NCRBF}$)	Residue/Crop product ratio ($Res_{BFi}/Crop_{BFi}$)
Wheat*	0.86	0.005	1.2
Barley*	0.86	0.006	1
Triticale*	0.86	0.005	1.1
Oats*	0.86	0.006	1.1
Rye *	0.86	0.005	1.3

Crops	Dry Matter Fraction ($Frac_{DM}$)	Nitrogen Fraction ($Frac_{NCRBF}$)	Residue/Crop product ratio ($Res_{BFi}/Crop_{BFi}$)
Rape*	0.86	0.007	2
Mixed cereals and pulses*	0.86	0.01	1.1
Buckwheat**	0.86	0.0106	2
Potatoes*	0.16	0.003	0.3
Sugar beet*	0.13	0.004	0.8
Feedbeet*	0.11	0.003	0.5
Maize for silage and forage***	0.25	0.0028	0.3
Crops for green feed and silage***	0.18	0.004	0.3
Vegetable*	0.13	0.015	0.2
Peas and beans *	0.86	0.0148	1.1

*A. Kārkliņš. Plant nutrient off-take as agro-environmental indicator. Latvian Academy of Agricultural and Forestry sciences, Latvia University of Agriculture: Proceedings in agronomy, No. 3, Jelgava, 2001, pp. 14-19 (all values , excl. Residue/crop product ratio on maize and other crops for green feed and silage)

**Augkopība. A.Ružas red. Latvijas lauksaimniecības universitāte, 2004.,4. pielikums.

***Trockenmassebilding und Stickstoffmengen in den Stoppeln und Wurzeln bei vershiedenen Zwishenfruchtformen. Nach V. Boguslawski, 1981. Faustzahlen fur Landwirtschaft un Gartenbau. 12. Auflage. Verlagsunion Agrar, 1993, s. 278 (Values on Residue/crop product ratio on maize and other crops for green feed and silage).

The *IPCC GPG 2000* defines (**F_{OS}**) as the area of organic soils cultivated annually. Areas of cultivated Histosols are represented in Table 0.36 according to information provided by Latvian State Forest Research Institute "Silava". Area of organic farmlands is changed because of update of the National forest inventory data on cropland and grassland area. Both, organic soils in cropland and grassland are considered in estimation, assuming that share of organic soils is equal in cropland and grassland (5.18 % of the total area). The share of organic soils in farmlands is estimated by the L.U. Consulting Company (2009) by evaluation of historical soil maps (representing situation in 60ths to 80ths of the last century). Due to the fact that land use is changed since that (croplands converted to grasslands, grasslands to forest lands and vice versa) actual distribution of organic soils in cropland and grassland is not known. The study on spatial assessment of organic soils in cropland and grassland is started in 2012. Preliminary results of the study (20% of the NFI sample plots visited) shows, that actual share of organic soils in cropland is below 0.5%, in grassland - below 2% and in afforested areas - about 3%; therefore, these results approves that emissions from organic soils in cultivated farmlands are not underestimating. Actual figures from the NFI will be used as soon as at least 50% of sample plots will be visited. Detailed description is included under LULUCF chapter.

Table 0.36 Areas of Histosols (ha/year)

Year	Area of cultivated organic soils
1990	134698
1991	134496
1992	134418
1993	134211
1994	133976
1995	133724
1996	133244
1997	132769
1998	132411
1999	131893
2000	131468
2001	130855
2002	130426
2003	129964

Year	Area of cultivated organic soils
2004	129406
2005	128828
2006	128232
2007	127616
2008	126982
2009	126288
2010	126316
2011	126332
2012	126332

Indirect emissions calculation includes estimation of Atmospheric Deposition (NH_4 and NO_x) and Leaching and Runoff of applied or deposited nitrogen.

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NOx) and ammonium (NH_4) fertilises soils and surface waters, which results in enhanced biogenic N_2O formation. According to the *IPCC Guidelines*, the amount of applied agricultural N that volatilises and subsequently deposits on nearby soils is equal to the total amount of synthetic fertiliser nitrogen applied to soils (N_{FERT}) plus the total amount of animal manure nitrogen excreted in the country ($\sum_T(N_{(T)} * Nex_{(T)})$) multiplied by appropriate volatilisation factors. The volatilised N is then multiplied by an emission factor for atmospheric deposition (EF_4) to estimate N_2O emissions[16].The default *IPCC GPG 2000* Tier 1 method according to Equation 4.31 is used to estimate emissions (N_2O produced from atmospheric deposition of N, kg N/yr) from the atmospheric deposition:

$$N_2O_{(G)}\text{-}N = [(N_{FERT} * Frac_{GASF}) + (\sum_T(N_{(T)} * Nex_{(T)}) * Frac_{GASM})] * EF_4$$

where:

N_{FERT} = Total amount of synthetic nitrogen fertilizer applied to soil, kg N/yr (Table 0.34);
*$Frac_{GASF}$ = Fraction of synthetic N fertilizer volatilizes as NH_3 and NOx, (**0.1** kg NH_3-N+NOx-N/kg, Revised 1996 IPCC, Table 4-19[17];*
*$Frac_{GASM}$ = Fraction of animal manure N volatilizes as NH_3 and NOx, (**0.2** kg NH_3-N+NOx-N/kg, Revised 1996 IPCC, Table 4-19[18]);*
EF_4 = Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, kg N_2O-N/kg NH_3-N and NOx-N emitted (Table 0.37).

A large proportion of nitrogen is lost from agricultural soils through leaching and runoff. This nitrogen enters the groundwater, riparian areas and wetlands and rivers, where it enhances biogenic production of nitrous oxide[19]. The default IPCC *GPG 2000* Tier 1 method according to Equation 4.34 is used to estimate emissions from the leaching/runoff:

$$N_2O_{(L)}\text{-}N = [N_{FERT} + \sum_T(N_{(T)} * Nex_{(T)})] * Frac_{LEACH} * EF_5$$

where:

N_{FERT} = Total amount of synthetic nitrogen fertilizer applied to soil, kg N/yr (Table 0.34);
*$Frac_{LEACH}$ = Fraction of N input that is lost through leaching and runoff (**0.3** kg N/kg nitrogen of fertilizer or manure, IPCC Workbook, Table 4-17[20]);*
EF_5 = Emission factor for leaching and runoff, kg N_2O-N/kg N leached and runoff (Table 0.37).

[16] IPCC GPG 2000, p.4.68
[17] Revised 1996 IPCC Guidelines (Volume 3). Reference Manual, Table 4-19. p. 4.94
[18] Revised 1996 IPCC Guidelines (Volume 3). Reference Manual, Table 4-19. p. 4.94
[19] IPCC GPG 2000, p. 4.70.
[20] IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, Table 4-17. p. 4.35

Nitrous oxide emissions from pasture, range and paddock calculation methodology is explained in Chapter 6.3 Manure Management.

IPCC default emission factors used for emissions calculation from agricultural soils are presented in Table 0.37.

Table 0.37 Nitrous oxide emission factors for emissions calculation from agricultural soils

Categories	Emission factors	Reference
Synthetic fertilizers, EF_1	0.0125 kg N_2O-N/kg N	IPCC GPG 2000, Table 4.17
Animal manure nitrogen, EF_1	0.0125 kg N_2O-N/kg N	IPCC GPG 2000, Table 4.17
N-fixing Crops, EF_1	0.0125 kg N_2O-N/kg dry biomass	IPCC GPG 2000, Table 4.17
Crop residue, EF_1	0.0125 kg N_2O-N/kg dry biomass	IPCC GPG 2000, Table 4.17
Organic soils, EF_2	8 kg N_2O – N/ha	IPCC GPG 2000, Table 4.17
Atmospheric deposition, EF_4	0.01 kg N_2O-N/kg NH_3-N& NOx-N deposited	IPCC GPG 2000, Table 4.18
N-leaching and run-off, EF_5	0.025 kg N_2O-N/kg N yr	IPCC GPG 2000, Table 4.18
N excretion on pasture range and paddock	0.020 kg N_2O-N/kg N yr	Revised 1996 IPCC, Table 4-22

Uncertainties and time series consistency

For estimating uncertainty for this category was used following assumptions:

1) CSB assessed that for number of livestock uncertainty could be 2-3%;
2) For emission calculation was used default emission factors (Tier 1) and in the IPCC GPG 2000 is described that they are with very large uncertainty, therefore was used 30% uncertainty.

Source-specific QA/QC and verification

General (Tier 1) Quality Control (QC) procedures were applied. The QA/QC plan for the agricultural sector includes the QC measures based on the guidelines of the IPCC (IPCC GPG 2000, Table 8.1). These activities are implemented every year in preparation process of agriculture inventory. If errors or inconsistencies are found they are documented and corrected. The QC checklist is used during the inventory. Tier 2 QC for activity data was used to check consistency of the different sections of the agricultural inventory. The activity data was checked also by CSB and third part expert (not involved in GHG inventory preparation).

Source-specific recalculations

For submission 2014 recalculations of emissions from Histosols were done due to updating of data about Histosols areas.

Source-specific planned improvements

In the future submissions it is planned to evaluate new methodology for assessing area of cultivated organic soils (Histosols) for nitrous oxide emission calculation.

1.5 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 4.F)

Legislative measures and agricultural residue management practices prohibit field burning of agricultural residues. This is explained by Latvian Administrative Violations Code Section 179 Violation of Fire Safety Regulations[21]. Notation key – NO is used for reporting field burning of agricultural residues in Latvia.

[21] http://www.likumi.lv/doc.php?id=89648

Appendix include CD with

1. QQ documentation
2. Emissions calculation sheets