Report on

Calculation of typical greenhouse gas emissions from the cultivation of agricultural raw materials (for the purposes of Article 31 (2) -(4) of Directive (EU) 2018/2001

Country: <u>Latvia</u>

Report prepared to meet the requirements of the Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources

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Updated Country Report of Latvia **LV_NUTS2report_v2_FINAL_UPDATE.docx**	Updated submission taken into account MS objections during voting process.

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Glossary of Abbreviations

Abbreviations	Definitions
AD	Activity data
CH_4	Methane
CO_2	Carbon dioxide
CO_2eq	Term for describing the different greenhouse gases as a common unit relative to the global warming potential of CO_2
DM	Dry matter
EC	European Commission
EF	Emission factor
ERT	UNFCCC GHG inventory expert review team
EU	European Union
GHG	Greenhouse gas
GWP_{100}	Relative measure of radiative forcing of a GHG compared to CO_2 over a 100-year time interval
IR	Implementing Regulation (EU) 2022/996 of 14 June 2022 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria (Text with EEA relevance)
IPCC	Inter-Governmental Panel on Climate Change
IPCC 2006 guidelines	2006 IPCC Guidelines for National Greenhouse Gas Inventories
IPCC 2019 Refinement	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
N	Nitrogen
N_2O	Nitrous oxide
NAAR	Net acid addition rate
NIR	National Inventory Report (submitted to the UNFCCC)
NUTS2	Nomenclature of Territorial Units for Statistics Level 2
pH	Measure of soil acidity
P	Phosphorus
REDII	Renewable Energy Directive 2018/2001/EU
REDIII	Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652
UNFCCC	United Nations Framework Convention on Climate Change
CSB	Central Statistical Bureau of Latvia

EXECUTIVE SUMMARY

In Latvia, biodiesel fuel is produced from rapeseed that are mainly cultivated for food and feed products. Latvia provided the European Commission with reports on actual GHG emission values in the cultivation of feedstock for the production of biofuels in 2012[1].

Plant cultivation agricultural technologies and machinery as well as agricultural practices are subject to constant changes. Such changes precondition changes in GHG emissions from cultivation of raw material for the production of biofuels. In recent years but especially after 2022 Latvia's agricultural sector has implemented many improvements mainly considering energy and resource efficiency because of drastic increases in energy, feedstock and other materials prices and problems with availability and disruptions in supply chain. As the improvements in agricultural practices are implemented rapidly and it will not be reflected as rapidly in agricultural statistics and / or Latvia's annual GHG inventory, Latvia's "Report on Calculation of typical greenhouse gas emissions from the cultivation of agricultural raw materials (for the purposes of Article 31 (2) -(4) of Directive (EU) 2018/2001" is based on data and information from largest canola farming and processing enterprises in Latvia together with the data of CSB also using the expert judgment of experts preparing Latvia's GHG emission inventory and industry experts from biggest canola production companies and associations.

Calculation of GHG was based on the IPCC Guidelines and IR. The estimations in this report is performed according to the GHG inventory procedures set in Cabinet of Ministers Regulations No 675 of 25th October 2022 "Procedures for Establishing and Maintaining the System for Greenhouse Gas Inventories, the Projection System, and the System for Reporting on the Adaptation to Climate Change" (https://likumi.lv/ta/en/en/id/336733-procedures-for-establishing-and-maintaining-the-system-for-greenhouse-gas-inventories-the-projection-system-and-the-system-for-reporting-on-the-adaptation-to-climate-change) that sets the GHG emission estimation and reporting obligations (including data sources) and was done by the same experts involved in GHG emissions estimation for GHG inventory under United Nations Framework Convention on Climate Change and was done taken into account the IPCC Guidelines that the same experts use in annual GHG inventory preparation. Latvia's GHG inventory system has been reviewed in several desk and on-site reviews by international UNFCCC review team (ERT). The estimation was reviewed by the Ministry of Climate and Energy and by industry representatives.

GHG emissions were estimated for one NUTS2 region for whole territory of Latvia.

It has been determined that the total GHG emission from cultivation of rapeseed for the production of biodiesel fuel reaches **704.73 kg CO_2eq/t DM**.

[1]https://energy.ec.europa.eu/document/download/02e1dc12-0cea-4fd1-a887-8cebb914812d_en?filename=19_2_latvia_annex_en.pdf

1. INTRODUCTION

1.1 THE RENEWABLE ENERGY DIRECTIVE

According to Article 26 (1) of the REDIII: "For the calculation of a Member State's gross final consumption of energy from renewable sources referred to in Article 7 and of the minimum share of renewable energy and the GHG intensity reduction target referred to in Article 25(1), first subparagraph, point (a), the share of biofuels and bioliquids, as well as of biomass fuels consumed in transport, where produced from food and feed crops, shall be no more than one percentage point higher than the share of such fuels in the final consumption of energy in the transport sector in 2020 in that Member State, with a maximum of 7 % of final consumption of energy in the transport sector in that Member State."

According to Article 21 (2) of the REDIII: "Member States may submit to the Commission reports including information on the typical greenhouse gas emissions from the cultivation of agricultural raw materials of the areas on their territory classified as level 2 in the nomenclature of territorial units for statistics (NUTS) or as a more disaggregated NUTS level …. Those reports shall be accompanied by a description of the method and data sources used to calculate the level of emissions. That method shall take into account soil characteristics, climate and expected raw material yields."

1.2 PURPOSE OF THIS COUNTRY REPORT

This report is submitted by Latvia in line with Article 31 (2) of the REDII.

2. SYSTEM BOUNDARY

This document compiles information from available statistical data in Latvia over the past five years, as well as data from field studies and farming practices. Many of the calculations are based on the management practices followed by the largest canola farming and processing enterprises in Latvia.

3. SUBDIVISIONS OF AREAS: NUTS2

In Latvia, one NUTS2 territory has been established with the code LV00, which is not further subdivided based on soil or climate characteristics.

4. BACKGROUND ACTIVITY DATA

4.1 CULTIVATED AREAS AND YIELDS AT NUTS2 LEVEL

Image 1 shows the spatial distribution of sown areas for winter and summer canola in Latvia.

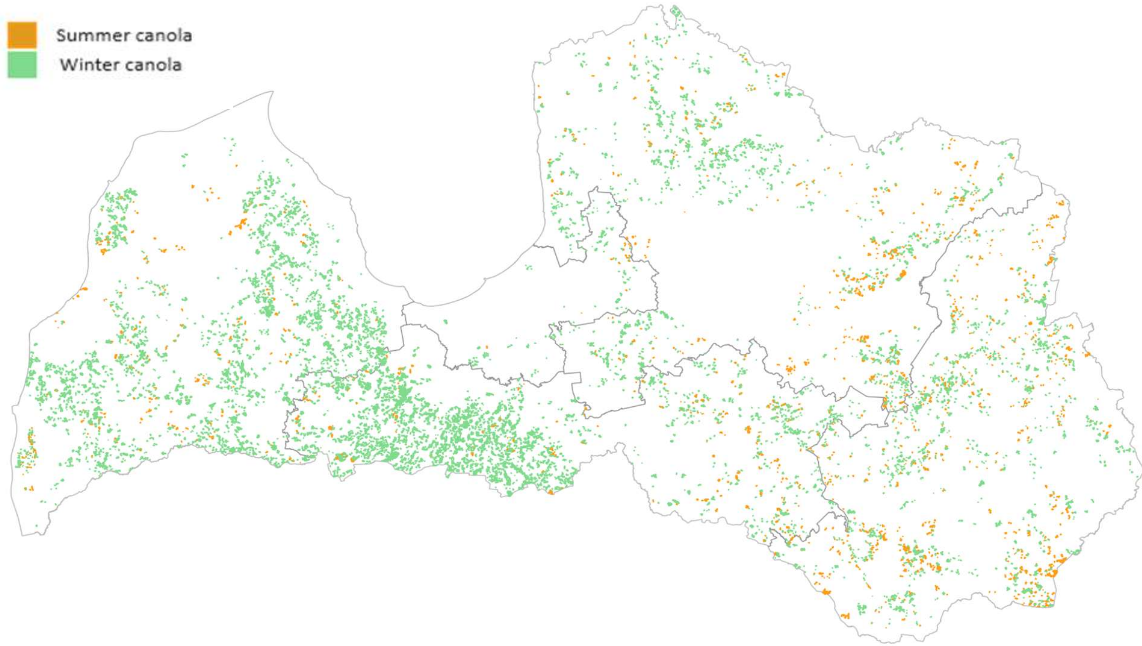

Image 1. Canola plantations

Table 1 presents the cultivated areas and yields of canola in Latvia, comparing the 5-year average with the most recent year.

Table 1. Cultivated areas and yields of canola in 2019-2023[2]

	Area planted (ha)		Production (tonnes)		Yield (fresh weight) (tonne/ha)		DM		Yield at 8% moisture (tonne /ha)	
	2019-2023 average	year 2023	2019-2023 average	year 2023	2019-2023 average	year 2023	2019-2023 average	year 2023	2019-2023 average	year 2023
LATVIA	148880	151200	397260	349500	2.68	2.31	92%	92%	2.47	2.13

4.2 Seeding rates

Under normal conditions, the average seeding rate for winter oilseed rape varies by sowing period: approximately 40 viable seeds per m^2 are sown during earlier periods, and around 60 viable seeds per m^2 in later ones. These are standard seeding parameters for hybrid oilseed canola intended for planting the following season's crop in an average year. Certified seed is the predominant source, accounting for about 95% of the total used.

$$L = \frac{(T \times D)}{100}$$

L - seeding efficiency,%
T- field germination (80%)
D – seed germination (90%)

$$\frac{L - 80 \times 90}{100} = 72\%$$

$$N = \frac{K \times G}{L}$$

[2] https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__LA__LAG/LAG020/table/tableViewLayout1/

N – seeding rate
G - 1000 seed weight (5 grams)
K - target plant density (50 plants/m2)
L - seeding efficiency (72%)

$$N = 50 \times \frac{5}{72} = 3.47(kg/ha)$$

For spring oilseed canola 80 viable seeds per m^2 are sown and 1000 seed weight is 4 grams. Sowing norm for spring oilseed canola in average conditions is 4.44 kg/ha. EF of 756.5 g CO_2eq per kg (Annex IX) is used in the calculations. Table 2 presents the canola seeding rates and associated GHG emissions for 2019-2023.

Table 2. Canola seeding rates and GHG emissions, for 2019-2023 and areas 1 LV00

Period	Winter canola sown area, thsd. ha	Summer canola sown area, thsd. ha	Winter seeding rate kg/ha	Summer seeding rate kg/ha	Total canola seeds, kg	Total emissions gCO_2eq	GHG emissions g CO_2 eq/kg crop DM
2019	116.4	23.7	3.47	4.44	509136.0	385161384.0	1.0322
2020	127.7	18.2	3.47	4.44	523927.0	396350775.5	0.9546
2021	132.2	14.7	3.47	4.44	524002.0	396407513.0	1.0138
2022	139.3	21.0	3.47	4.44	576611.0	436206221.5	1.3360
2023	141.1	10.1	3.47	4.44	534461.0	404319746.5	1.2574

4.3 FIELD OPERATIONS AND CULTIVATION PRACTICES

In Latvia, winter canola is primarily grown using minimal soil cultivation. Summer canola, on the other hand, is cultivated traditionally, with fields ploughed in the autumn. The soil preparation operations for winter canola are as follows: minimal tillage of fields to a depth of 10-15 cm, followed by sowing with a seed drill that incorporates NPK mineral fertilizers. For summer canola, the fields are ploughed in autumn, cultivated twice in spring, and then sown. Before sowing, NPK fertilizers are applied according to the expected yield level. As the canola grows, nitrogen and sulphur-containing fertilizers are used. In Latvia, a combination of contact and soil-acting herbicides is predominantly used (Belcar 0.25 l/ha + metazachlor 0.6 l/ha). For winter canola, growth regulators along with micronutrients are applied in autumn. In spring, one or two insecticide sprays are used to control pests. Fungicides are applied in all rape fields during the flowering stage. Growth regulators are not used for summer canola. The canola is usually harvested dry, and if necessary, it is dried and cleaned. The harvested canola is not stored on farms but is sold immediately.

4.4 SOIL TYPES – ORGANIC/INORGANIC

In Latvia, canola is grown only on inorganic soil. Oilseed rape does not overwinter in organic soils because it dies due to root damage in organic soils during the winter. Summer canola is usually / typically not seeded in organic soils due to poor drainage, high disease pressure, nutrient imbalance, and unfavourable thermal and structural properties that hinder optimum crop establishment and yield. Consequently, the cultivation of summer canola is limited to very small areas because of these factors.

There is no precise information or data on the types of soil where the rapeseed is grown. So, to estimate possible / theoretical share of organic soils that could be used for this specific activity the share or organic soils in total used agriculture area could be used – 7% of total used agriculture land is organic soils. The summer canola is grown only on 6,7% of total area of canola and only summer canola can be grown on organic soils so organic soils can cover only 700ha that is 0,5% of total area used for canola production. It is a very small area, and the area of possible organic soils would result in small impact on emission estimation. Still, the organic soils are not included in the emission estimations due to the theoretically small area that could be used in canola cultivation as well as considering national agronomic data and expert consultations that strongly confirms that the canola is not grown on organic soils (as these soils are used in the cultivation of grains and other food crops). Therefore, including emissions from organic soils would not reflect actual canola cultivation practices.

5. Fuel use

In Latvia, precise data on fuel consumption for farming operations is not available at either the farm or national level. When describing cultivation techniques and machinery operations, we rely on calculations based on data from farm associations located in different regions of Latvia. These associations compile information from their accounting records, which includes details on the operations performed and the corresponding fuel consumption. Diesel fuel consumption is estimated as follows: ploughing requires 13.9 liters per hectare, cultivating uses 4.9 liters per hectare for winter canola and 7 liters per hectare for summer canola. Sowing cereals with a combined unit consumes 23.8 liters per hectare. Spraying requires 4.8 liters per hectare for winter canola and 3.3 liters per hectare for summer canola. Applying mineral fertilizers uses 2.5 liters per hectare for winter canola and 1.7 liters per hectare for summer canola. Spreading lime for winter canola consumes 0.8 liters per hectare, and harvesting requires 16.2 liters per hectare, with churning (winter canola) using 0.7 liters per hectare. In total, the fuel consumption per hectare is 53.6 liters for winter canola and 65.8 liters for summer canola. Table 3 shows the fuel consumption associated with various field operations.

Table 3. Fuel consumption of field operations[3]

Field operations	Number of operations per hectare		Fuel consumption (liter per ha)	Total fuel consumption, liter per hectare	
	Winter canola	Sumer canola		Winter canola	Summer canola
Ploughing	0.0	0.5	27.8	0.0	13.9
Cultivation: disc harrow	0.6	0	4.6	2.6	0.0
Cultivation: cultivator flat	0.2	0.5	6.9	1.2	3.5
Cultivation: cultivator deep	0.0	0	15.9	0.0	0.0
Cultivation: preparation seedbed	0.1	0.5	6.9	0.4	3.5
Cultivation: harrow	0.1	0	3.9	0.4	0.0
Cultivation: roller	0.1	0	2.5	0.3	0.0
Spraying	5.8	4	0.8	4.8	3.3
Sprinkling mineral fertilizer	3.0	2	0.8	2.5	1.7

[3] Representative data from largest canola enterprises data operating in several regions of Latvia

Spreading chalk	0.3	0	2.8	0.8	0.0
Sowing	1.0	1	23.8	23.8	23.8
Churning	0.0	0	20.8	0.7	0.0
Harvesting	1	1	16.2	16.2	16.2
In total				53.6	65.8

$$GHG\ emissions = \frac{(Sa * Fs + Wa * Fw) * Efd * Edd}{Yd}$$

Sa – sumer canola area (ha)
Wa – winter canola area (ha)
Fs – summer canola total fuel consumption, liter per hectare
Fw – winter canola total fuel consumption, liter per hectare
Efd – GHG EF 95.10 g CO2 eq./MJ (Annex IX of the IR)
Edd – energy density of diesel fuel 35.8 (MJ/liter)
Yd – yield (dry weight) (ton)

The GHG emissions associated with various field operations are detailed in Table 4.

Table 4. GHG emissions from field operations

	Period	Summer canola (ha)	Winter canola (ha)	Fuel consumption (liter)	Yield (dry weight) (tonnes)	GHG emissions g CO_2 eq/kg crop DM
TOTAL	2019	23 700	116 400	7 798 500	373 152	71,15
	2020	18 200	127 700	8 042 280	415 196	65,95
	2021	14 700	132 200	8 053 180	391 000	70,12
	2022	21 000	139 300	8 848 280	326 508	92,26
	2023	10 100	141 100	8 227 540	321 540	87,12

The average GHG emissions from field operations in 2019 – 2023 amounted to 77.32 g CO_2 equivalent per kilogram of crop DM.

Fuel consumption for drying materials is summarized in Table 5.

Table 5. Fuel consumption of material drying

Year	Moisture above the base (%))	kg of gas per ton of grain for drying 1% moisture	Calorific value MJ/kg	GHG EF (g CO_2 eq/MJ)	GHG emissions g CO_2 eq/kg crop DM
2019	2.76	1.88	46	66.31	17.20
2020	2.59	1.88	46	66.31	16.14
2021	2.16	1.88	46	66.31	13.46
2022	2.65	1.88	46	66.31	16.52
2023	2.81	1.88	46	66.31	17.52

The second column of the table indicates the moisture content above the baseline level for the given period. Since no global statistics are available for this measurement in Latvia, the average moisture data is sourced from the Agricultural Services Cooperative Society

"LATRAPS"[4]. The data is expert judgment data as no other data is available in national statistics. So, the data used is data provided by industry experts from the companies – the biggest agricultural cooperative joining 1200 members that covers 30%-40% of all agriculture companies in several parts of Latvia and one of the largest agricultural companies covering at least 20 thsnd. ha. Similarly, the data on the amount of gas required to reduce moisture by 1% per ton of rapeseed is also based on LATRAPS data.

6. AGROCHEMICALS (CHEMICAL FERTILISERS, PESTICIDES, HERBICIDES, OTHER CROP PROTECTION CHEMICALS, GROWTH REGULATORS, DESSICANTS)

6.1 DESCRIPTION OF METHODOLOGY

The calculations were performed using available statistical data (CSB) and the farming practices of leading canola growers for fertilizing rapeseed crops.

6.2 RESULTS

Table 6 details the main nitrogen fertilizer types applied in Area 1 (LV00) in 2019-2023, along with the associated GHG emissions per hectare.

Table 6. Main nitrogen fertiliser types used in Area 1 (LV00) for 2019-2023 and corresponding GHG emissions per hectare

	EF, gCO_2-eq/kg	Quantity fertiliser applied for summer canola, kg/ha	Quantity N applied for summer canola, kg/ha	Quantity fertiliser applied for winter canola, kg/ha	Quantity N applied for winter canola, kg/ha	Emission summer canola, gCO_2-eq/ha	Emission winter canola, gCO_2-eq/ha
Mono ammonium phosphate (MAP) 11 %N 52 %P2 O	1 029	0	0	120	13.2	0	13582.8
Muriate of Potash (MOP) 60 %K2 O	413	0	0	120	0	0	0
Ammonium nitrate	3 469	125	42.5	300	102	147432.5	353838
Ammonium sulfate	2 724	125	26.25	250	52.5	71505	143010
NPK 15-15-15	5 013	250	37.5	0	0	187987.5	0

The types of nitrogen fertilizers used in Area 1 (LV00) for and their corresponding GHG emissions are summarized in Table 7.

Table 7. Main nitrogen fertiliser types used in Latvia in 2019-2023 and corresponding GHG emissions per kg of DM

Year	Canola sown area, thsd. ha		Total production, thousand tons		Canola emission, gCO_2-eq		DM fraction	Canola emission, gCO_2-eq/kg DM		Average emission gCO_2-eq/kg
	Winter	Summer	Winter	Summer	Summer	Winter		Summer	Winter	
2019	116.4	23.7	362.1	43.5	9644122500	59414145120	0.92	240.98	178.35	185.1
2020	127.7	18.2	415.1	36.2	7406035000	65182013160	0.92	222.38	170.68	174.8
2021	132.2	14.7	403.2	21.8	5981797500	67478951760	0.92	298.25	181.91	187.9
2022	139.3	21.0	321.9	33.0	8545425000	71103010440	0.92	281.47	240.09	243.9

[4] https://www.latraps.lv/ , www.llkc.lv

2023	141.1	10.1	334.5	15.0	4109942500	72021785880	0.92	297.82	234.03	236.8

Pesticide usage statistics for 2022 (the most up-to-date data) are summarized in Table 8.

Table 8. Pesticide usage statistics for year 2022[5]

Pesticides	**Winter canola (active ingredient kg/ha)**	**Summer canola (active ingredient kg/ha)**
Fungicides and bacterocides	0.32	0.13
Hebicides, grasses and moss destroyers	0.59	0.58
Insecticides and acaricides	0.04	0.03
Plant growth regulators	0.04	0.01
Total	0.99	0.75

Information on pesticide consumption per hectare is available in CSB data only for the year 2022, so these values are used in further calculations. To calculate the GHG emissions in relation to production of pesticides a value of 10.97 kg CO_2eq per kg of active ingredient was used (ISCC EU 205). Table 9 presents pesticide consumption according to 2022 statistical data.

Table 9. Pesticide consumption from statistical data for the year 2022

	Period	**Summer canola (ha)**	**Winter canola (ha)**	**Yield (dry weight) (ton)**	**GHG emissions kg CO_2 eq/kg crop DM**
TOTAL	2019	23 700	116 400	373 152	3.91
	2020	18 200	127 700	415 196	3.70
	2021	14 700	132 200	391 000	3.98
	2022	21 000	139 300	326 508	5.16
	2023	10 100	141 100	321 540	5.02

The primary pesticide types used for canola cultivation in 2023 are summarized in Table 10.

Table 10. Main pesticide types used in Latvia for canola, for year 2023

Pesticide name (active ingredient)	**Pesticide product applied (litres/ha)**	**Active ingredient in product (g/l)**	**Active ingredient applied (g/ha)**
e.g. Belkar metil- halauxifene picloram	0.25	methyl-haloxyphene - 10 picloram - 48	methyl-haloxyphene – 2.5 picloram – 12
e.g. Metazamix	0.6	metazachlor- 500 aminopyralid – 5.3 picloram – 13.3	metazachlor – 300 aminopyralid – 3.18 picloram – 7.98
e.g. Targa Super	1.0	ethyl-quizalofop-P - 50	ethyl-quizalofop-P - 50
e.g. Folicur	1	tebuconazole - 250	tebuconazole - 250
e.g. Delmetros	0.05	deltamethrin – 100	deltamethrin - 5

[5] https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__ENV__AV__AVZ/LAV030/table/tableViewLayout1/

Pesticide name (active ingredient)	Pesticide product applied (litres/ha)	Active ingredient in product (g/l)	Active ingredient applied (g/ha)
e.g. Karate Zeon	0.2	lambda - cyhalothrin - 50	lambda - cyhalothrin - 10
e.g. Pictor Active	1.0	boscalid - 150 pyraclostrobin - 250	boscalid - 150 pyraclostrobin - 250

The products used are not manufactured in Latvia.

7. NEUTRALISATION OF FERTILISER ACIDIFICATION AND LIME APPLICATION

7.1 DESCRIPTION OF METHODOLOGY

Direct liming is not applied before canola crops are sown, but lime remains from other crop production. The calculations include an estimated amount of liming attributed to canola cultivation. Calculations are based on GHG inventory methodology and have been specifically recalculated for the canola cultivation area. Data on lime application practices specific to canola are currently lacking.

Calculation of GHG emissions from fertiliser acidification and liming application was performed according to methodology presented in VII Annex of IR (Chapter 1.4). The emissions resulting from acidification caused by nitrogen fertiliser use in the field were based on the amount of nitrogen fertilisers used. Value for emissions from the neutralization of nitrogen fertilizers was 0.806 kg CO_2/kg N.

CO_2 emissions from liming and nitrogen fertilizers acidification were compered and as the emissions from fertilizer acidification exceed those attributed to liming the net liming emissions was counted as zero and the fertilizer-acidification emissions that occur anyway is taken into account final estimations.

7.2 RESULTS

The amount of nitrogen fertilizers and lime were used for calculations. GHG emissions from fertilizer acidification are demonstrated in the Table 11.

Table 11. GHG emissions from fertilizer applications in agriculture during cultivation of oilseed rape

	N rate kg/ha	CO_2 EF	GHG emissions, kg CO_2eq/ha	Yield (mean average) t/ha	GHG emissions kg CO_2 eq/t	DM fraction	GHG emissions kg CO_2 eq/ tDM
LATVIA	136.98	0.806	110.40	2.77	39.87	0.92	36.68

CO_2 emission from application of lime that can be associated with canola cultivation areas are shown in Table 12.

Table 12. CO_2 emission from application of lime

	year	GHG emissions kg CO_2 eq/ canola sown area	Emission CO_2 kg per t canola DM
LATVIA	**2019**	4 954 655.019	13.3
	2021	7 068 379.558	17.0
	2022	8 319 784.065	21.3
	2023	9 585 958.052	29.4

	year	GHG emissions kg CO_2 eq/ canola sown area	Emission CO_2 kg per t canola DM
	2024	8 038736.163	25.0

8. EMISSIONS FROM SOIL

8.1 DESCRIPTION OF METHODOLOGY

Emissions from managed soils, and emissions from lime and urea application in Latvia have been calculated by using methodologies presented in the 2006 IPCC Guidelines (Volume 4, Chapter 11). For estimation of N_2O emissions from managed soils the Tier 1 methodology was used. Direct N_2O emissions from agricultural soils have been calculated using the following equation according to the 2006 IPCC Guidelines (Equation 11.1, page 11.7):

$$N_2O_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

$$N_2O - N_{N\ inputs} = (F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1$$

N_2O_{Direct} –N - annual direct N_2O–N emissions produced from managed soils, kg N_2O–N yr^{-1}

N_2O–$N_{N\ inputs}$ - annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N yr^{-1}

N_2O–N_{OS} - annual direct N_2O–N emissions from managed organic soils, kg N_2O–N yr^{-1}

N_2O–N_{PRP} - annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kg N_2O–N yr^{-1}

F_{SN} - annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1}

F_{ON} - annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}

F_{CR} - annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1}

F_{SOM} - annual amount of N in mineral soils that is mineralised, in association with loss of soils C from soils organic matter as a result of changes to land use or management, kg N yr^{-1}

F_{OS} - annual area of managed/drained organic soils in grasslands and croplands, ha

F_{PRP} - annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{1}

EF_1 - EF for N_2O emissions from N inputs, kg N_2O–N kg^{-1} N input

8.1.1. Activity data

8.1.1.1. Inorganic N fertilizers:

Annual amount of the synthetic fertilizer N is one of the parameters to estimate direct N_2O emission from N inputs to managed soils. Data of inorganic fertilizer N applied to soils are used based on farming practices of leading canola growers.

8.1.1.2. Crop residue N input

The annual production of the amount of crop residue N (F_{CR}) is estimated based on 2006 the IPCC Guidelines Tier 1 methodology (Equation 11.6, page 11.14) :

$$\sum_T^{F_{CR}} \{Crop_{(T)} \times Frac_{Renew\ (T)} \times \left[\left(Area_{(T)} - Area\ burnt_{(T)} \times C_f\right) \times R_{AG\ (T)} \times N_{AG\ (T)} \times \left(1 - Frac_{Remove\ (T)}\right) + Area_{(T)} \times R_{EG\ (T)} \times N_{EG\ (T)}\right]\}$$

F_{CR} - annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N yr^{-1}

$Crop_{(T)}$ - harvested annual DM yield for crop T, kg DM ha^{-1}

$Area_{(T)}$ - total annual area harvested of crop T, ha yr^{-1}

Area burnt $_{(T)}$ - annual area of crop T burnt, ha yr^{-1}

C_f - combustion factor

$Frac_{Renew\ (T)}$ - fraction of total area under crop T

$R_{AG(T)}$ - ratio of above-ground residues DM to harvested yield for crop T

$N_{AG(T)}$ - N content of above-ground residues for crop T, kg N (kg DM)$^{-1}$

$Frac_{Remove(T)}$ - fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$

$R_{BG(T)}$ - ratio of below-ground residues to harvested yield for crop T, kg DM(kg DM)$^{-1}$

$N_{BG(T)}$ - N content of below-ground residues for crop T, kg N (kg DM)$^{-1}$

T - crop or forage type.

Correction factor to estimate DM yields ($Crop_{(T)}$) is determined as:

$$Crop_{(T)} = Yield\ Fresh_{(T)} \times DRY$$

$Crop_{(T)}$ - harvested DM yield for crop T, kg DM ha^{-1}

Yield $Fresh_{(T)}$ - harvested fresh yield for crop T, kg fresh weight ha^{-1}

DRY – DM fraction of harvested crop T, kg DM (kg fresh weight)$^{-1}$

Mainly default data were used to estimate N that is returned to soils by crop residues, except data of crop production (area and yield) that originates from CSB Database. DM fractions of harvested crop are collected as combination of 2006 IPCC default and national values[6].

Calculations on annual amount of N in crop residues are done based on default factors represented in the 2006 IPCC Guidelines.

There is no field burning of agricultural residues observed in Latvia and area burnt is set to zero. It is typical practice in Latvia that all of above-ground residues of canola are not removed form fields ($Frac_{Remove}$ =0).

According to the industry experts from Latvia's biggest canola production companies – agricultural cooperative consisting of ~1200 agriculture companies and other company that is one of the largest agricultural companies covering at least 20 thsnd. ha., no organic fertilizers or urea are used in canola cultivation (the confidential expert judgment is reported as attachment).

8.1.2. EF and crop parameters

8.1.2.1. N_2O emissions

Table 13 presents the N_2O EF applied according to the national GHG inventory methodology. The total amount of indirect emissions has been recalculated specifically to reflect the area under canola cultivation.

[6] Kārkliņš A., Līpenīte I. (2018). Aprēķinu metodes un normatīvi augsnes iekultivēšanai un mēslošanas līdzekļu lietošanai. Jelgava: LLU. 200 lpp (NIR 2025, page 322-323)

Table 13. N_2O EF

Factor	Value	Uncertainty range	Source
EF_1 for N additions from mineral fertilizers, organic amendments and crop residues [kg N_2O–N (kg N)$^{-1}$]	0.01	0.003 – 0.03	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.11, Table 11.1
EF_4 [N volatilization and re-deposition], kg N_2O–N [kg NH_3–N + NO_X– volatilized]	0.010	0.002 – 0.05	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4., page 11.24, Table 11.3
EF_5 (leaching/runoff), kg N_2O–N [kg N leaching/runoff]	0.0075	0.0005 -0.025	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.24, Table 11.3
$Frac_{GASF}$ (Volatilization from synthetic fertilizer), (kg NH_3–N + NO_x–N) [kg N applied] $^{-1}$	0.10	0.03 – 0.3	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.24, Table 11.3
$Frac_{LEACH-(H)}$,N losses by leaching/runoff [kg N lost from kg N input]	0.23	0.18 – 0.27	Sudars R., Berzina L., Grinberga L. Analysis of Agricultural Run-Off Monitoring Program Results for Estimation of Nitrous Oxide Indirect Emissions in Latvia[7].

8.1.2.2. CO2 emissions

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite (CA $Mg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O). CO_2 emission from additions of carbonate limes to soils are estimated using Tier 1 methodology with the formula from the 2006 IPCC Guidelines:

$$CO_2 - C\ Emission = (M_{Limestone} \times EF_{Limestone}) + (M_{Dolomite} \times EF_{Dolomite})$$

where:

CO_2–C Emission - annual C emissions from lime application, tons C yr^{-1}

M - annual amount of calcic limestone ($CaCO_3$) or dolomite (CA $Mg(CO_3)_2$), tons yr^{-1}

EF - EF, ton of C (ton of limestone or dolomite) $^{-1}$

2006 IPCC default EF: EF=0.12 for limestone and EF=0.13 for dolomite is used for inventory purposes. These emissions are represented as NEUTRALISATION OF FERTILISER ACIDIFICATION AND LIME APPLICATION emissions.

[7] Sudars R., Berzina L., Grinberga L. (2016) Analysis of Agricultural Run-Off Monitoring Program Results for Estimation of Nitrous Oxide Indirect Emissions in Latvia. ENGINEERING FOR RURAL DEVELOPMENT. Jelgava. Available: http://tf.llu.lv/conference/proceedings2016/Papers/N198.pdf

8.1.2.3. Indirect N2O emissions

Atmospheric deposition: The N_2O emission from atmospheric deposition of N volatilised from managed soil is estimated using the 2006 IPCC Guidelines (Equation 11.9, page 11.21):

$$N_2O_{(ATD)} - N = \left[(F_{SN} \times Frac_{GASF}) + ((F_{ON} + F_{PRP}) \times Frac_{GASM})\right] \times EF_4$$

$N_2O_{(ATD)}$-N – annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O–N yr^{-1}

F_{SN} – annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1}

$Frac_{GASF}$ - fraction of synthetic fertilizer N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$

F_{ON} – annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}

F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}

$Frac_{GASM}$ – fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied or deposited)$^{-1}$

EF_4 – EF for N_2O emissions from atmospheric deposition of N on soils and water surfaces, kg N_2O-N/kg NH_3-N and NO_x-N emitted

Nitrogen leaching and run-off: N_2O emissions from nitrogen loss from agricultural soils through leaching and runoff is estimated as shown in the 2006 IPCC Guidelines:

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) * Frac_{LEACH-(H)} * EF_5$$

where:

$N_2O_{(L)}$–N – annual amount of N_2O–N produced from leaching and runoff, kg N_2O–N yr^{-1}

F_{CR} – amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, kg N yr^{-1}

F_{SOM} – annual amount of N mineralised in mineral soils, kg N yr^{-1}

$Frac_{LEACH-(H)}$ – Fraction of N input that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$

EF_5 - EF for N_2O emissions from N leaching and runoff, kg N_2O–N (kg N leached and runoff)$^{-1}$

8.2 RESULTS

Emissions of N_2O from soil, expressed as CO_2 eq per tonne of canola feedstock, are presented in Table 14.

Table 14. Emissions of N_2O from soil, per tonne of feedstock.

	Year	Direct N_2O emissions (kg CO_2 eq per tonne of feedstock)	Indirect N_2O emissions from leaching and run-off (kg CO_2eq per tonne of feedstock)	Indirect N_2O emissions from volatilisation (kg CO_2eq per tonne of feedstock)	Total N_2O emissions from soils (kg CO_2eq per tonne of feedstock)
LATVIA	2019	301.47	18.13	10.00	329.59
	2020	288.88	17.50	9.66	316.04

	Year	Direct N_2O emissions (kg CO_2 eq per tonne of feedstock)	Indirect N_2O emissions from leaching and run-off (kg CO_2eq per tonne of feedstock)	Indirect N_2O emissions from volatilisation (kg CO_2eq per tonne of feedstock)	Total N_2O emissions from soils (kg CO_2eq per tonne of feedstock)
	2021	308.16	18.35	10.16	336.67
	2022	385.14	23.97	12.92	422.04
	2023	378.54	22.00	12.07	412.61
Average		**332.44**	**19.99**	**10.96**	**363.39**

9. EMISSIONS FOR CANOLA

The calculation process for data in Table 15 is described in Section 8.1.2.2. IPCC AR5 global warming potentials are used in calculations.

Table 15. Emissions of CO_2 eq for Canola

	Year	Fuel use	Agrochemicals	Seed and other planting materials	Neutralisation of fertiliser acidification	Emissions from soil	Emissions from fertilizers	Collection, drying and storage of raw materials	Bioenergy feedstock drying	Total
	2019	71.15	3.91	1.03	36.68	329.59	185.07	17.20	0	644.64
	2020	65.95	3.70	0.95	36.68	316.04	174.83	16.14	0	614.30
LATVIA	2021	70.12	3.98	1.01	36.68	336.67	187.88	13.46	0	649.81
	2022	92.26	5.16	1.34	36.68	422.04	243.94	16.52	0	817.94
	2023	87.12	5.02	1.26	36.68	412.61	236.77	17.52	0	796.98
Average		**77.32**	**4.36**	**1.12**	**36.68**	**363.39**	**205.70**	**16.17**	**0.00**	**704.73**

10. TYPICAL GHG EMISSIONS FROM THE CULTIVATION OF AGRICULTURAL RAW MATERIALS AT THE NUTS2 LEVEL REGIONS ON LATVIA

Tables 16 presents data about typical GHG emissions in agriculture from cultivation of feedstock for biofuel production.

Table 16. Greenhouse gas emissions from cultivation of rapeseed in Latvia for NUTS-2 regions (tonnes CO_2eq/tonne rapeseed harvested on dry matter basis)

NUTS-2 region according to Regulation (EC) No 1059/2003		Soil N_2O		Embedded			Fuel use	Seed	Total
		Direct	Indirect	Fertilizer	Neutralisation	Pesticide			
LV000	Latvija	0,332	0,03	0,206	0,037	0,004	0,093	0,001	0,705