KZR INiG System/8.3

Soil (nitrous oxide/N2O) emissions from crop cultivation

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1. Soil (nitrous oxide/N_2O) emissions from crop cultivation

The calculation of N_2O emissions from managed soils shall follow the IPCC methodology. The use of disaggregated crop-specific emission factors for different environmental conditions (corresponding to Tier 2 of the IPCC methodology) shall be used to calculate the N_2O emissions resulting from crop cultivation. Specific emission factors for different environmental conditions, soil conditions and different crops should be taken into account. Economic operators could use validated models to calculate those emission factors provided that the models take these aspects into account. In line with the IPCC guidelines [1], both direct and indirect N_2O emissions shall be taken into account. The GNOC tool shall be used, which is based on the formulas below, following the naming conventions in the IPCC (2006) guidelines:

$$N_{total} - N = N_2O_{direct} - N_2O + N_2O_{indirect} - N$$

Where:

For mineral soils:

$$N_2O_{Direct} - N = [(F_{SN} + F_{ON}) \bullet EF_{1ij}] + [F_{CR} \bullet E_{F1}]$$

For organic soils:

$$N_2O_{Direct} - N = [(F_{SN} + F_{ON}) \bullet EF_{1}] + [F_{CR} \bullet E_{F1}] + [(F_{OS,CG,Temp} \bullet EF_{2CG,\,Temp}] + [F_{CROS,CG\,,Trop} \bullet E_{2CG,\,Trop}];$$

For both mineral and organic soils:

$$N_2O_{Direct} - N = [((F_{SN} \bullet Frac_{GASF}) + (F_{ON} \bullet Erac_{GASM}) \bullet EF_{4}] + [(F_{SN} + F_{ON} + F_{CR}) \bullet Frac_{Leach\text{-}(H)} \bullet EF_{5}].$$

1.1. Crop residue N input

It must be calculated for:

a) sugar beet, sugar cane according to IPCC (2006) Vol. 4 Chapter 11 Eq. 11.6, not considering below-ground residues and with the addition of N input from vignasse and filter cake in the case of sugar cane;

$$F_{CR} = Yield \bullet DRY \bullet (1\text{-}Frac_{Burnt} \bullet C_f) \bullet [R_{AG} \bullet N_{AG} \bullet (1 - Frac_{Remove})] + F_{VF}$$

b) coconut and oil palm plantations applying a fixed N input based on literature as IPCC (2006) provides no default calculation method for standard emission factors, pursuant to Annex IX;

c) for all other crops according to IPCC (2006) Vol. 4 Chapter 11 Eq. 11.7a 11.11, 11.12, as

$F_{CR} = (1\text{-}Frac_{Burnt} \bullet C_f) \bullet AG_{DM} \bullet N_{AG} \bullet (1\text{-}Frac_{Remove}) + (AG_{DM} + Yield \bullet DRY) \bullet R_{BG\text{-}BIO} \bullet N_{BG}$

Where:

$N_2O_{total} - N$	=	direct and indirect annual N_2O–N emissions produced from managed soils; kg N_2O–N ha^{-1} a^{-1}
$N_2O_{direct} - N$	=	annual direct N_2O–N emissions produced from managed soils; kg N_2O–N ha^{-1} a^{-1}
$N_2O_{indirect} - N$	=	annual indirect N_2O–N emissions (that is to say, the annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils and annual amount of N_2O–N produced from leaching and run-off of N additions to managed soils in regions where leaching/run-off occurs); kg N_2O–N ha^{-1} a^{-1}
F_{SN}	=	annual synthetic nitrogen fertiliser input; kg N ha^{-1} a^{-1}
F_{ON}	=	annual animal manure N applied as fertiliser; kg N ha^{-1} a^{-1}
F_{CR}	=	annual amount of N in crop residues (above ground and below ground); kg N ha^{-1} a^{-1}
$F_{OS,CG,Temp}$	=	annual area of managed/drained organic soils under cropland in temperate climate; ha^{-1} a^{-1}
$F_{OS,CG,Trop}$	=	annual area of managed/drained organic soils under cropland in tropical climate; ha^{-1}
$Frac_{GASF}$	=	0.10 (kg N NH_3–N + NOx–N) (kg N applied)$^{-1}$. Volatilisation from synthetic fertiliser
$Frac_{GASM}$	=	0.20 (kg N NH_3–N + NOx–N) (kg N applied)$^{-1}$. Volatilisation from all organic nitrogen fertilisers applied
$Frac_{Leach\text{-}(H)}$	=	0.30 kg N (kg N additions) -1. N losses by leaching/run-off for regions where leaching/run-off occurs
EF_{1ij}	=	Crop and site-specific emission factors for N_2O emissions from synthetic fertiliser and organic N application to mineral soils (kg N_2O–N (kg N input)$^{-1}$);
EF_1	=	0.01 [kg N_2O–N (kg N input) $^{-1}$]
$EF_{2CG,Temp}$	=	8 kg N ha^{-1} a^{-1} for temperate organic crop and grassland soils
$EF_{2CG,Trop}$	=	16 kg N ha^{-1} a^{-1} for tropical organic crop and grassland soils
EF_4	=	0.01 [kg N_2O–N (kg N NH_3–N + NOx–N volatilised) $^{-1}$]
EF_5	=	0.0075 [kg N_2O–N (kg N leaching/run-off) $^{-1}$]
Yield	=	annual fresh yield of the crop (kg ha^{-1})
DRY	=	dry matter fraction of harvested product [kg d.m. (kg fresh weight)$^{-1}$] (see Table 1)
$Frac_{Burnt}$	=	Fraction of crop area burnt annually [ha (ha)-1]

C_f = Combustion factor [dimensionless] (see Table 1)

R_{AG} = Ratio of above-ground residues, dry matter to harvested dry matter yield, for the crop [kg d.m. (kg d.m.)$^{-1}$] (see Table 1)

N_{AG} = N content of above-ground residues [kg N (kg d.m.)-1] (see Table 1)

$Frac_{Remove}$ = Fraction of above-ground residues removed from field [kg d.m. (kg AGDM)$^{-1}$]

F_{VF} = Annual amount of N in sugar cane vignasse and filter cake returned to the field [kg N ha^{-1}], calculated as Yield * 0.000508.

AG = Above-ground residue dry matter [kg d.m. ha^{-1}]

1.2. Crop and site-specific emission factors for N_2O emissions from synthetic fertiliser and organic N application

N_2O emissions from soils under agricultural use, in different agricultural fields under different environmental conditions and agricultural land use classes can be determined following the Stehfest and Bouwman (2006) statistical model (hereinafter referred to as 'the S&B model'):

$$E = exp(-1.516 + \sum ev)$$

Where:

E = N_2O emission (in kg N_2O-N ha^{-1} a^{-1})

ev = effect value for different drivers (see Table 2)

The EF_{1ij} for the biofuel crop i at location j is calculated (S&B model) as:

$$EF_{1ij} = (E_{fert,ij} - E_{unfert,ij})/N_{appl,ij}$$

The IPCC (2006) factor (EF1) for direct N_2O emissions from fertiliser input based on a global mean shall be replaced by the crop- and site-specific EF1ij for direct emissions from mineral fertiliser and manure N input, based on the crop- and site-specific EF1ij, applying the S&B model.

Where:

$E_{fert,ij}$ = N_2O emission (in kg N_2O-N ha$_{-1}$ a^{-1}) based on S&B, where the fertiliser input is the actual N application rate (mineral fertiliser and manure) to the crop *i* at location *j*

$E_{unfert,ij}$ = N_2O emission of the crop *i* at location j (in kg N_2O-N ha$_{-1}$ a^{-1}) based on S&B. The N application rate is set to 0, all the other parameters are kept the same.

$N_{appl,ij}$ = N input from mineral fertiliser and manure (in kg N ha^{-1} a^{-1}) to the crop *i* at location *j*

Table 1

Crop-specific parameters to calculate N input from crop residues [2]

Crop	Calculation method	DRY	LHV	N_{AG}	slope	intercept	R_{BG_RS}	N_{BG}	Cf	R_{AG}	Fixed amount of N in crop residues (kg N ha^{-1})	Data sources*
Barley	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.865	17	0.007	0.98	0.59	0.22	0.014	0.8			1, 2
Cassava	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.302	16.15	0.019	0.1	1.06	0.2	0.014	0.8			1, 2
Coconuts	Fixed N from crop residues	0.94	32.07								44	1, 3
Cotton	No inform. on crop residues	0.91	22.64									
Maize	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	17.3	0.006	1.03	0.61	0.22	0.007	0.8			1, 2
Oil palm fruit	Fixed N from crop residues	0.66	24								159	1, 4
Rapeseed	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.91	26.976	0.011	1.5	0	0.19	0.017	0.8			1, 5
Rye	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	17.1	0.005	1.09	0.88	0.22	0.011	0.8			1, 6
Safflower seed	No inform.on crop residues	0.91	25.9									
Sorghum (grain)	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.89	17.3	0.007	0.88	1.33	0.22	0.006	0.8			1, 7
Soybeans	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.87	23	0.008	0.93	1.35	0.19	0.087	0.8			1, 8
Sugar beets	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.6	0.25	16.3	0.004					0.8	0.5		1, 9
Sugar cane	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.6	0.275	19.6	0.004					0.8	0.43		1, 10
Sunflower seed	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.9	26.4	0.007	2.1	0	0.22	0.007	0.8			1, 11
Triticale	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	16.9	0.006	1.09	0.88	0.22	0.009	0.8			1, 2
Wheat	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.84	17	0.006	1.51	0.52	0.24	0.009	0.9			1, 2

Table 2

Constant and effect values for calculating N_2O emissions from agricultural fields based on the S&B model

Constant value	-1.516	
Parameter	**Parameter class or unit**	**Effect value (ev)**
Fertilizer input		0.0038 * N application rate in kg N ha^{-1} a^{-1}
Soil organic C content	<1 %	0
	1-3 %	0.0526
	>3 %	0.6334
pH	<5.5	0
	5.5-7.3	-0.0693
	>7.3	-0.4836
Soil texture	Coarse	0
	Medium	-0.1528
	Fine	0.4312
Climate	Subtropical climate	0.6117
	Temperate continental climate	0
	Temperate oceanic climate	0.0226
	Tropical climate	-0.3022
Vegetation	Cereals	0
	Grass	-0.3502
	Legume	0.3783
	None	0.5870
	Other	0.4420
	Wetland rice	-0.8850
Length of experiment	1 yr	1.9910

2. Changes compared to the previous edition

Date	Section	Previous requirement	Current requirement
05.05.2025	Whole document	RED II	RED III
05.05.2025	Whole document	Directive 2018/2001	Directive 2018/2001 as amended by Directive 2023/2413

Sources:

[1] IPCC (2006), Vol. 4, Chapter 11: N_2O emissions from managed soils, and CO_2 emissions from lime and urea application.

[2] Data source: JRC report 'Definition of input data to assess GHG default emissions from biofuels in EU legislation' JRC 2019 (EUR 28349 EN). https://op.europa.eu/en/publication-detail/-/publication/7d6dd4ba-720a-11e9-9f05-01aa75ed71a1

[3] Nomenclature of territorial units for statistics.