N2O Emissions from Managed Soils

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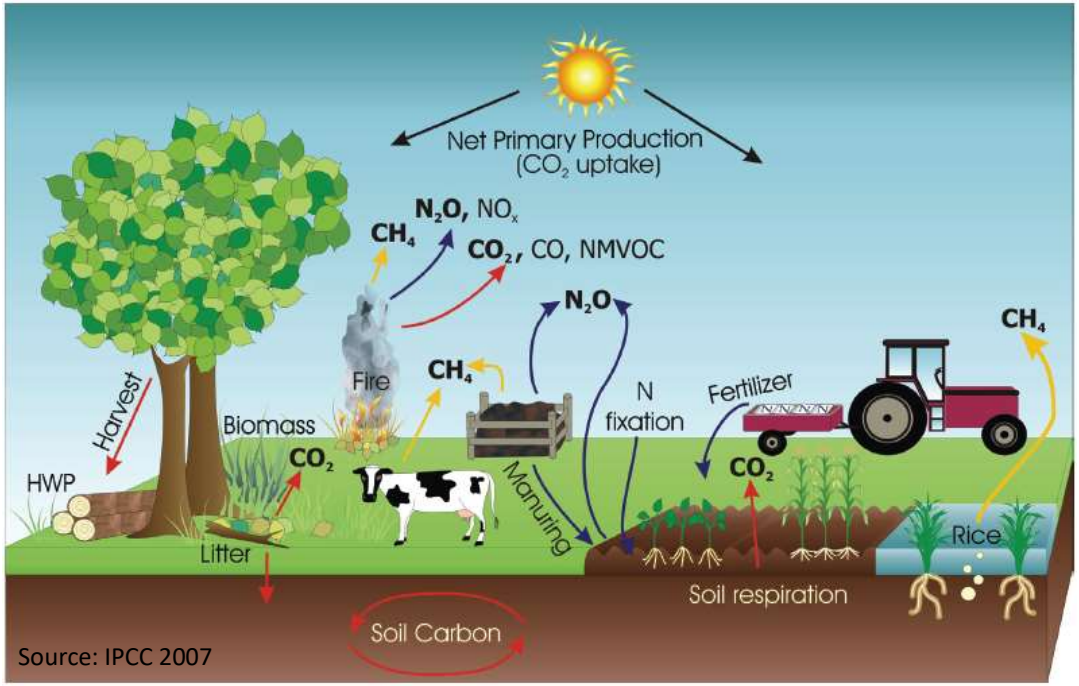
AFOLU Categories in the 2006 IPCC Guidelines

Biomass C Stock Changes (3B)

GHG Emissions from Biomass Burning [wild fires, crop residues (3C1)]



CO2 Emission from Liming (3C2)

CO2 Emission from Urea Application (3C3)

Soil N_2O Emissions (3C4, 3C5, and 3C6)

CH4 Emission from Rice Cultivation (3C7)

Soil C Stock Changes (3B)

CH4 Emission from Enteric Fermentation (3A1)

CH_4 and N_2O Emission from Manure Management (3A2)

Important Points

Difference between direct and indirect N_2O emissions

- **Direct N_2O emissions** come from the N applied to soils, while **Indirect N_2O emissions** occur offsite from the N that is lost to volatilization (to the atmosphere) and leaching/runoff

N sources for calculating N_2O emissions

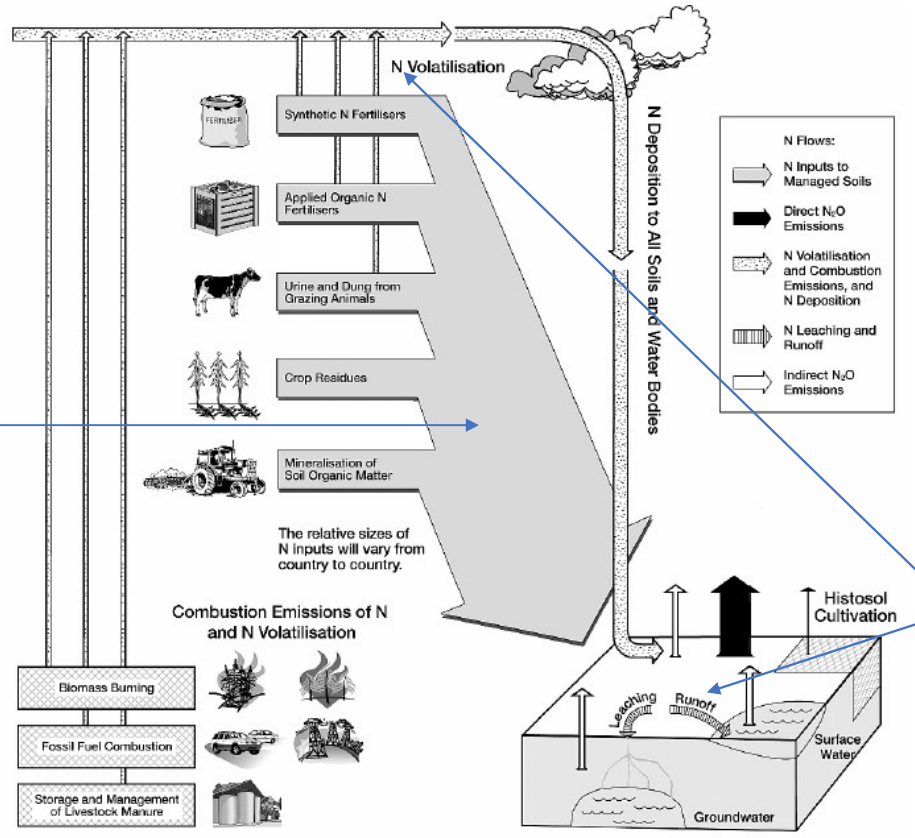
1. Synthetic N fertilizers
2. Organic N applications
3. Urine and dung N deposited on pasture range and paddock
4. N in crop residues
5. N mineralization from soils subject to land use change
6. Drainage/management of organic soils

Difference between N_2O-N and N_2O?

- N_2O-N refers to the mass of N in the N_2O gas, while N_2O refers to the mass of N_2O gas
- For reporting purposes, N_2O-N is converted to N_2O by multiplying the former with 44/28

N2O Emissions from Managed Soils

Direct N_2O emissions result from N input to soils (e.g. fertilizer, urine, manure, crop residues), and soil disturbance



Indirect N_2O emissions occur when those N inputs move from the site where they are applied (thru volatilization, leaching, and run-off)

Direct N2O Emissions from Managed Soils

EQUATION 11.1
DIRECT N_2O EMISSIONS FROM MANAGED SOILS (TIER 1)

$$N_2O_{Direct}\text{–}N = N_2O\text{–}N_{N\ inputs} + N_2O\text{–}N_{OS} + N_2O\text{–}N_{PRP}$$

Where:

$$N_2O\text{–}N_{N\ inputs} = \left[\begin{array}{l}\left[\left(F_{SN}+F_{ON}+F_{CR}+F_{SOM}\right)\bullet EF_1\right]+\\ \left[\left(F_{SN}+F_{ON}+F_{CR}+F_{SOM}\right)_{FR}\bullet EF_{1FR}\right]\end{array}\right]$$

$$N_2O\text{–}N_{OS} = \left[\begin{array}{l}\left(F_{OS,CG,Temp}\bullet EF_{2CG,Temp}\right)+\left(F_{OS,CG,Trop}\bullet EF_{2CG,Trop}\right)+\\ \left(F_{OS,F,Temp,NR}\bullet EF_{2F,Temp,NR}\right)+\left(F_{OS,F,Temp,NP}\bullet EF_{2F,Temp,NP}\right)+\\ \left(F_{OS,F,Trop}\bullet EF_{2F,Trop}\right)\end{array}\right]$$

$$N_2O\text{–}N_{PRP} = \left[\left(F_{PRP,CPP}\bullet EF_{3PRP,CPP}\right)+\left(F_{PRP,SO}\bullet EF_{3PRP,SO}\right)\right]$$

Where:

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}

Direct N2O Emissions from Managed Soils

$$N_2O\text{–}N_{N\ inputs} = \left[\begin{array}{l}[(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \bullet EF_1] + \\ [(F_{SN} + F_{ON} + F_{CR} + F_{SOM})_{FR} \bullet EF_{1FR}]\end{array}\right]$$

F_{SN} = annual amount of synthetic fertiliser 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 (Note: If including sewage sludge, cross-check with Waste Sector to ensure there is no double counting of N_2O emissions from the N in sewage sludge), 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 soil C from soil 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, ha (Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)

F_{PRP}= annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

EF_1 = emission factor for N_2O emissions from N inputs, kg N_2O–N (kg N input)$^{-1}$(Table 11.1)

EF_{1FR} is the emission factor for N_2O emissions from N inputs to flooded rice, kg N_2O–N (kg N input)$^{-1}$ (Table 11.1) [5]

Emission Factor for N2O Emission in Managed Soils

TABLE 11.1
DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM MANAGED SOILS

Emission factor	Default value	Uncertainty range
EF_1 for N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon [kg N_2O–N (kg N)$^{-1}$]	0.01	0.003 - 0.03
EF_{1FR} for flooded rice fields [kg N_2O–N (kg N)$^{-1}$]	0.003	0.000 - 0.006
$EF_{2\ CG,\ Temp}$ for temperate organic crop and grassland soils (kg N_2O–N ha^{-1})	8	2 - 24
$EF_{2\ CG,\ Trop}$ for tropical organic crop and grassland soils (kg N_2O–N ha^{-1})	16	5 - 48
$EF_{2F,\ Temp,\ Org,\ R}$ for temperate and boreal organic nutrient rich forest soils (kg N_2O–N ha^{-1})	0.6	0.16 - 2.4
$EF_{2F,\ Temp,\ Org,\ P}$ for temperate and boreal organic nutrient poor forest soils (kg N_2O–N ha^{-1})	0.1	0.02 - 0.3
$EF_{2F,\ Trop}$ for tropical organic forest soils (kg N_2O–N ha^{-1})	8	0 - 24
$EF_{3PRP,\ CPP}$ for cattle (dairy, non-dairy and buffalo), poultry and pigs [kg N_2O–N (kg N)$^{-1}$]	0.02	0.007 - 0.06
$EF_{3PRP,\ SO}$ for sheep and 'other animals' [kg N_2O–N (kg N)$^{-1}$]	0.01	0.003 - 0.03

Sources:

EF_1: Bouwman et al. 2002a,b; Stehfest & Bouwman, 2006; Novoa & Tejeda, 2006 in press; EF_{1FR}: Akiyama *et al.*, 2005; $EF_{2CG,\ Temp}$, $EF_{2CG,\ Trop}$, $EF_{2F,Trop}$: Klemedtsson *et al.*, 1999, IPCC Good Practice Guidance, 2000; $EF_{2F,\ Temp}$: Alm *et al.*, 1999; Laine *et al.*, 1996; Martikainen *et al.*, 1995; Minkkinen *et al.*, 2002: Regina *et al.*, 1996; Klemedtsson *et al.*, 2002; $EF_{3,\ CPP}$, $EF_{3,\ SO}$: de Klein, 2004.

Would be good to know how much N fertilizer went to rice field …

Hands-on exercise …

Using available country-specific data for N inputs to soils, let us use the ALU Software to:

1. Enter primary data for mineral N fertilizer and organic amendments (e.g. compost)
2. Assign emission factors, including documentation
3. Calculate Direct and Indirect N_2O Emissions from application of Mineral N fertilizer and Organic Amendments in Managed Soils
4. Report activity data, other related information, and estimates in CRT for BTR.