Aggregated Sources and Non-CO_2 Emission Sources 3C4,3C5 N_2O emissions from managed soil

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Outline

- N sources and pathway to soil
- Equations for direct N_2O emissions and indirect N_2O emissions
- How to estimate activity data
- Exercise of using the IPCC Software

N sources included in the methodology

- N inputs are the origin of direct N_2O emissions from agricultural soil
  - Application of synthetic fertilizers (F_{SN})
  - Application of organic N (such as animal manure, sewerage sludge) as fertilizers (F_{ON})
  - Urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP})
  - Incorporation of crop residues including from N-fixing crops and from forages into soils (F_{CR})
  - Soil N mineralization associated with loss of organic matter resulting from change of land use or management of mineral soils (F_{SOM})
  - Drainage/management of organic soil (F_{ON})

- Cultivation of nitrogen-fixing crops which was included in the previous IPCC guidelines is excluded in the 2006GL due to lack of evidence.
- Emissions are estimated by “N input * EF”

Sources and pathway of N

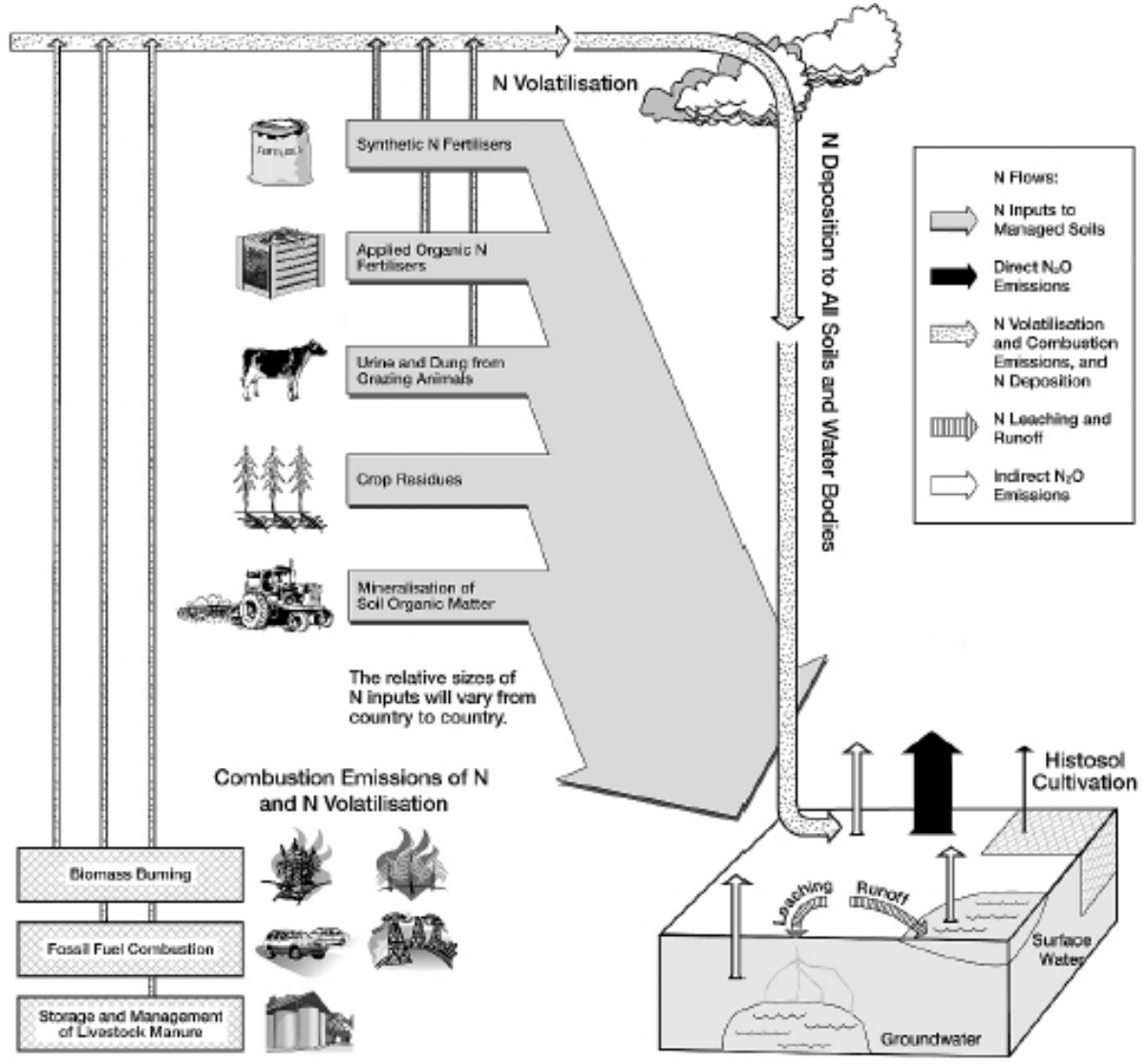


Figure 11.1, 2006GL

Equations: Tier.1

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:

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

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

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

N sources and the correspondent EFs of direct N_2O emissions

- EF1 is used for N inputs : F_{SN} , F_{ON}, F_{CR}, F_{SOM}
  - A single world wide default EF is provided in the 2006GL

- EF2 is used for drainage/management of organic soil: F_{ON}
  - Default EFs are provided by land use type (forest, cropland/grassland), and by climate zone.
  - Updated default EFs are available from the 2013 Wetlands Supplement.

- EF3 is used for Urine and dung N deposit from grazing animal: F_{PRP}
  - Different default EFs are established for CPP (Cattle, Poultry and Pigs), and SO (Sheep and Other animals).

Default EFs for direct N2O emissions

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

Methodologies for indirect N_2O emissions

- Volatilization
  - F_{SN} , F_{ON} and F_{PRP} are covered
  - Fraction of N volatilized, $Frac_{GASF}$ (for SN), $Frac_{GASM}$ (for ON and PRP) is multiplied to F, to calculated amount of N volatilized
  - EF4 is used

EQUATION 11.9
N_2O FROM ATMOSPHERIC DEPOSITION OF N VOLATILISED FROM MANAGED SOILS (TIER 1)

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

- Leaching/Runoff
  - F_{SN} , F_{ON} , F_{PRP} , F_{CR} and F_{SOM} are covered
  - Fraction of N lost through leaching/runoff (applicable to all) is multiplied to total F, to calculated amount of N leaching/runoff.
  - EF5 is used

EQUATION 11.10
N_2O FROM N LEACHING/RUNOFF FROM MANAGED SOILS IN REGIONS WHERE LEACHING/RUNOFF OCCURS (TIER 1)

$$N_2O_{(L)}\text{-}N = \left(F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}\right) \bullet Frac_{LEACH\text{-}(H)} \bullet EF_5$$

How to estimate activity data: Synthetic N fertilizer

- F_{SN}
  - Annual amount of N fertilizer applied is collected by annual N fertilizer consumption data from official country statistics or international data (IFIA, FAO)
  - In the 2006GL, tier.1 estimation does not have adjust for the amount of NH_3 and NOx volatilization. Tier.2 or 3 should be aware this correction.

How to estimate activity data: Organic N input

- F_{ON}
  - Organic N fertilizer referred in the 2006GL include, 1) animal manure, 2) sewage N, 3) compost N, and 4)other organic amendments(brewery waste, guano ,etc)
  - Animal manure applied to soil is estimated by subtracting manure used for feed, fuel, construction from the total amount of manure N estimated in 3A2 manure management.(like top-down type estimation)
  - Amount of animal manure applied to soil may be directly obtained by survey or statistics (case of RM in 2015 inv.). This may give more accurate estimation in this category, however, may generate missing N flow when compared to the top-down style estimation and overall certainty of the Agriculture sector may not good very much.

EQUATION 11.4
N FROM ANIMAL MANURE APPLIED TO SOILS (TIER 1)

$$F_{AM} = N_{MMS\_Avb} \bullet \left[1 - \left(Frac_{FEED} + Frac_{FUEL} + Frac_{CNST}\right)\right]$$

Where:

F_{AM} = annual amount of animal manure N applied to soils, kg N yr^{-1}

N_{MMS_Avb} = amount of managed manure N available for soil application, feed, fuel or construction, kg N yr^{-1} (see Equation 10.34 in Chapter 10)

$Frac_{FEED}$ = fraction of managed manure used for feed

$Frac_{FUEL}$ = fraction of managed manure used for fuel

$Frac_{CNST}$ = fraction of managed manure used for construction

How to estimate activity data: Urine and dung on grazing land

- F_{PRP}
  - The estimation equation of urine and dung N deposit is the exactly same one used in N_2O manure management. The amount manure treated in the management system of direct deposit on pasture, rangeland and paddock is used as the activity data here.
  - This data is calculated in 3A2 Manure Management. In the IPCC software, data is reflected to 3C4 automatically.

EQUATION 11.5
N IN URINE AND DUNG DEPOSITED BY GRAZING ANIMALS ON PASTURE, RANGE AND PADDOCK (TIER 1)

$$F_{PRP} = \sum_T \left[\left(N_{(T)} \bullet Nex_{(T)} \right) \bullet MS_{(T,PRP)} \right]$$

Where:

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

$N_{(T)}$ = number of head of livestock species/category T in the country (see Chapter 10, Section 10.2)

$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country, kg N $animal^{-1}$ yr^{-1} (see Chapter 10, Section 10.5)

$MS_{(T,PRP)}$ = fraction of total annual N excretion for each livestock species/category T that is deposited on pasture, range and paddock[12] (see Chapter 10, Section 10.5)

How to estimate activity data: Crop residue

- F_{CR}
  - Estimated from crop yield statistics and default factors for above-/belowground residue: yield ratios and residue N contents. The effect of residue burning or removal are also taken into account. To convert from Yield fresh (usual statistical data) to dry fresh is implemented by using dry matter fraction of harvested crop.
  - Table 11.2 provides the default parameters of this estimation.

EQUATION 11.6
N FROM CROP RESIDUES AND FORAGE/PASTURE RENEWAL (TIER 1)

$$F_{CR} = \sum_{T} \left\{ \begin{array}{l} \left[Crop_{(T)} \bullet \left(Area_{(T)} - Area\,burnt_{(T)} \bullet C_f \right) \bullet Frac_{Renew(T)} \bullet \right] \\ \left[R_{AG(T)} \bullet N_{AG(T)} \bullet \left(1 - Frac_{Remove(T)} \right) + R_{BG(T)} \bullet N_{BG(T)} \right] \end{array} \right\}$$

EQUATION 11.7
DRY-WEIGHT CORRECTION OF REPORTED CROP YIELDS

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

How to estimate activity data: Crop residue

TABLE 11.2
DEFAULT FACTORS FOR ESTIMATION OF N ADDED TO SOILS FROM CROP RESIDUES [a]

Crop	Dry matter fraction of harvested product (DRY)	Above-ground residue dry matter $AG_{DM(T)}$ (Mg/ha): $AG_{DM(T)} = Crop_{(T)} * slope_{(T)} + intercept_{(T)}$					N content of above-ground residues (N_{AG})	Ratio of below-ground residues to above-ground biomass (R_{BG-BIO})	N content of below-ground residues (N_{BG})
		Slope	± 2 s.d. as % of mean	Intercept	± 2 s.d. as % of mean	R^2 adj.			
Major crop types									
Grains	0.88	1.09	± 2%	0.88	± 6%	0.65	0.006	0.22 (± 16%)	0.009
Beans & pulses[b]	0.91	1.13	± 19%	0.85	± 56%	0.28	0.008	0.19 (± 45%)	0.008
Tubers[c]	0.22	0.10	± 69%	1.06	± 70%	0.18	0.019	0.20 (± 50%)	0.014
Root crops, other[d]	0.94	1.07	± 19%	1.54	± 41%	0.63	0.016	0.20 (± 50%)	0.014
N-fixing forages	0.90	0.3	± 50% default	0	-	-	0.027	0.40 (± 50%)	0.022
Non-N-fixing forages	0.90	0.3	± 50% default	0	-	-	0.015	0.54 (± 50%)	0.012
Perennial grasses	0.90	0.3	± 50% default	0	-	-	0.015	0.80 (± 50%)[l]	0.012
Grass-clover mixtures	0.90	0.3	± 50% default	0	-	-	0.025	0.80 (± 50%)[l]	0.016[p]
Individual crops									
Maize	0.87	1.03	± 3%	0.61	± 19%	0.76	0.006	0.22 (± 26%)	0.007
Wheat	0.89	1.51	± 3%	0.52	± 17%	0.68	0.006	0.24 (± 32%)	0.009
Winter wheat	0.89	1.61	± 3%	0.40	± 25%	0.67	0.006	0.23 (± 41%)	0.009
Spring wheat	0.89	1.29	± 5%	0.75	± 26%	0.76	0.006	0.28 (± 26%)	0.009
Rice	0.89	0.95	±19%	2.46	± 41%	0.47	0.007	0.16 (± 35%)	NA
Barley	0.89	0.98	± 8%	0.59	± 41%	0.68	0.007	0.22 (± 33%)	0.014
Oats	0.89	0.91	± 5%	0.89	± 8%	0.45	0.007	0.25 (± 120%)	0.008
Millet	0.90	1.43	± 18%	0.14	± 308%	0.50	0.007	NA	NA
Sorghum	0.89	0.88	± 13%	1.33	± 27%	0.36	0.007	NA	0.006
Rye[e]	0.88	1.09	± 50% default	0.88	± 50% default	-	0.005	NA	0.011

How to estimate activity data: N supply from mineralization

- F_{SOM}
  - Average annual loss of carbon in mineral soil estimated under 3B Land is the base data of this source. Using C:N ratio of soil to derive N input from ΔC loss.
  - N immobilization (estimated from carbon gain in mineral soil) is only considered under Tier.3 method.

EQUATION 11.8
N MINERALISED IN MINERAL SOILS AS A RESULT OF LOSS OF SOIL C THROUGH CHANGE IN LAND USE OR MANAGEMENT (TIERS 1 AND 2)

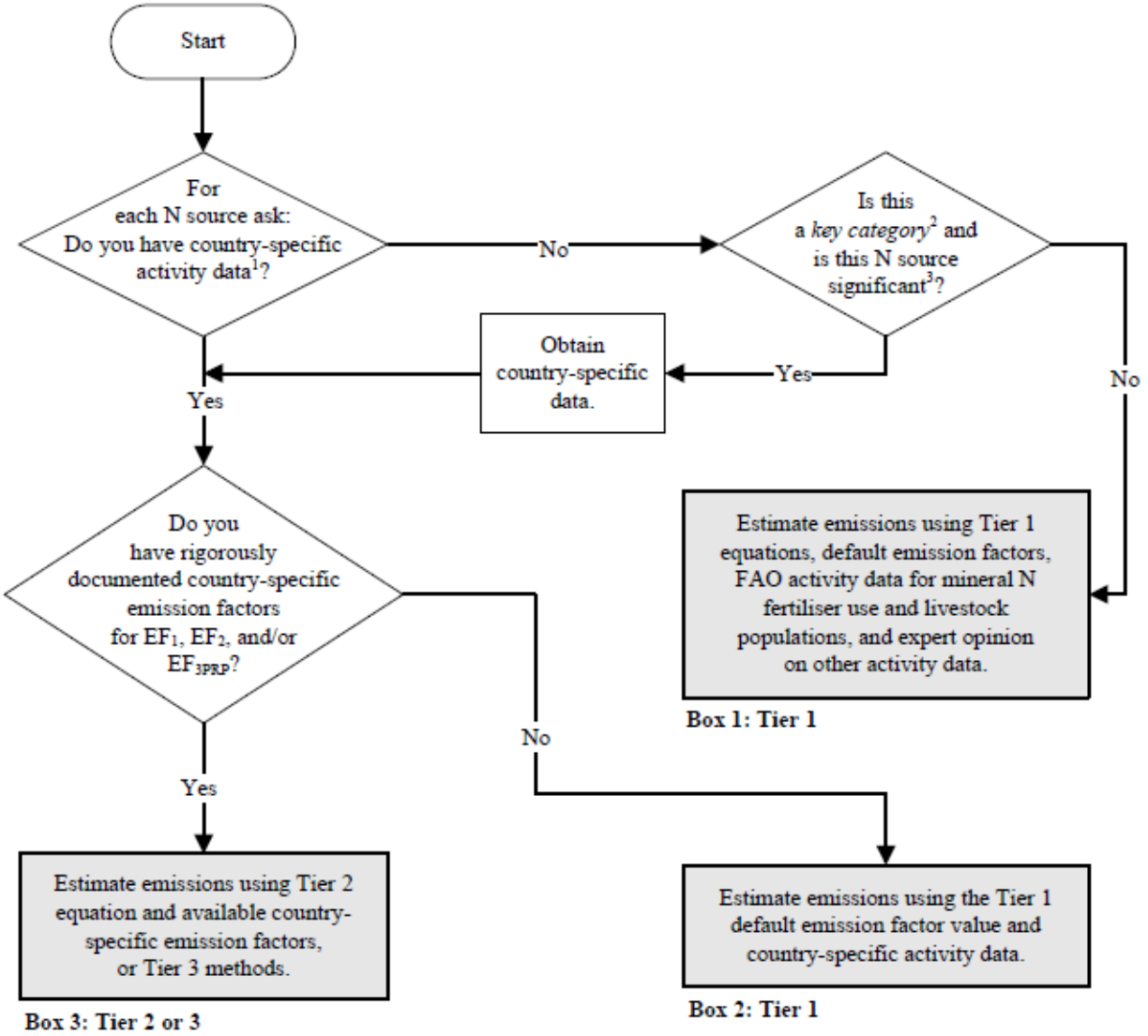
$$F_{SOM} = \sum_{LU}\left[\left(\Delta C_{Mineral,\ LU} \bullet \frac{1}{R}\right) \bullet 1000\right]$$

How to estimate activity data: Cultivation of histosol

- F_{ON}
  - Area of drained or cultivated organic soil is the activity data. This is the common AD used for N_2O and CO_2 (covered in 3B Land) (or CH_4 in the case the 2013 WLSL applied).

Decision of Tier

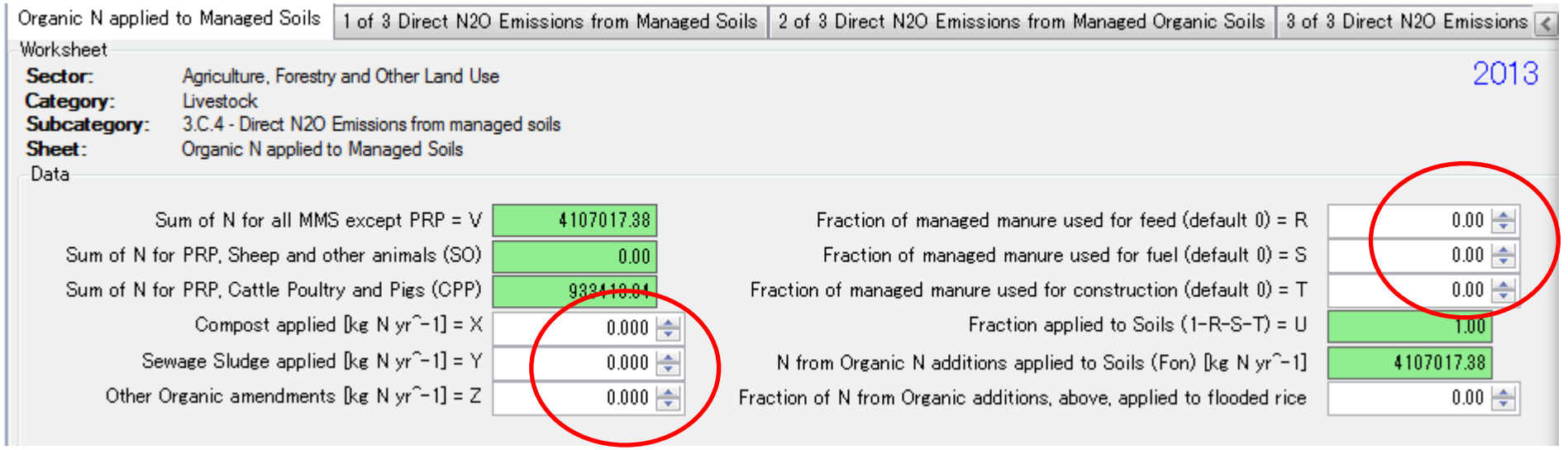
Figure 11.2 Decision tree for direct N_2O emissions from managed soils



- For key category and significant N input, using CS data or estimation with detailed level (= Tier.2) is encouraged.

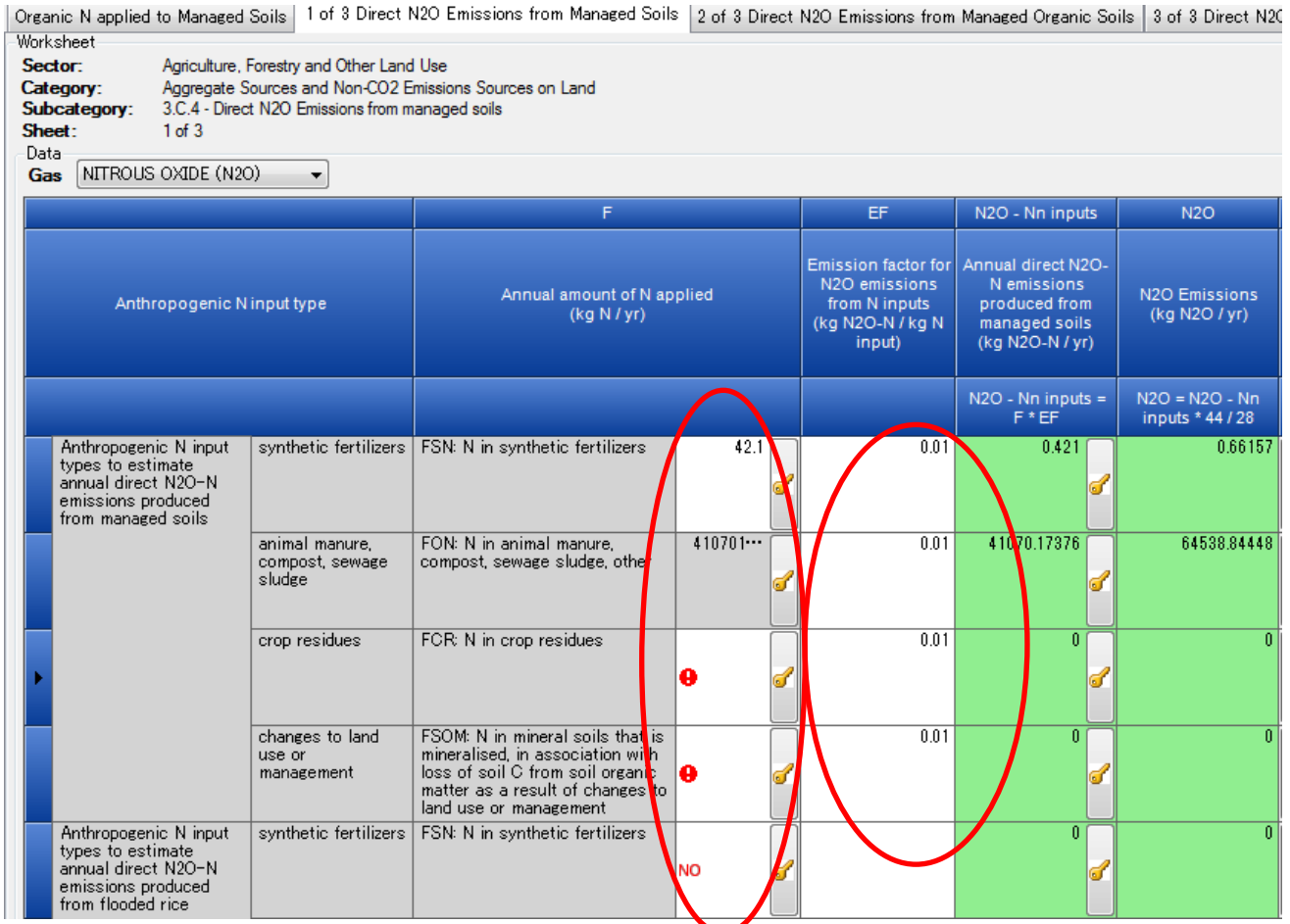
Exercise of using IPCC software

- Four worksheets exist.
- Base data of organic input from animal manure is automatically calculated by the input data into “Livestock Manager”
- When other organic N input other than animal manure exist, enter its data in ” Organic N applied to Managed Soils” sheet.
- Enter the three fractions of animal manure about the use of manure in the same sheet. Usually these factors are 0 for industrial countries…



Exercise of using IPCC software

- 1of 3 worksheet deals with EF1 type emission estimation.
- Enter the relating N applied into the cells and select appropriate EF.
- For flooded rice, Moldova can enter notation key “NO”



Organic N applied to Managed Soils | 1 of 3 Direct N2O Emissions from Managed Soils | 2 of 3 Direct N2O Emissions from Managed Organic Soils | 3 of 3 Direct N2O

Worksheet

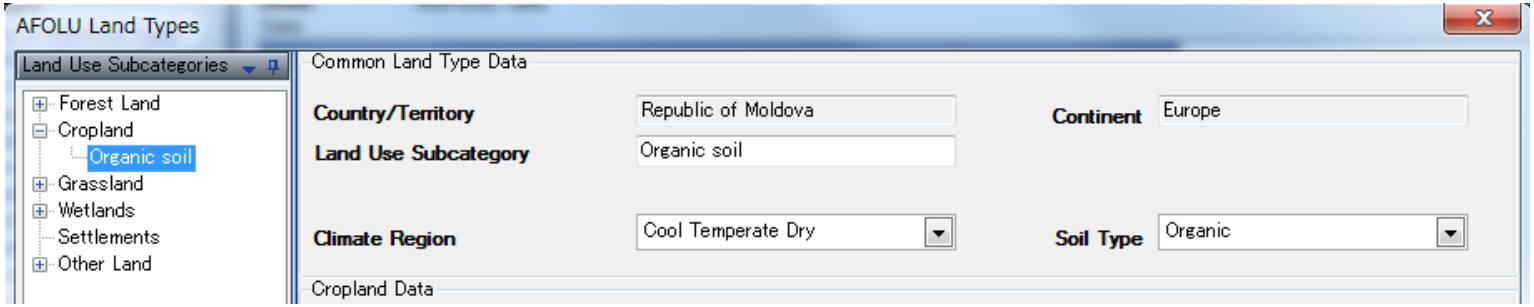
Sector: Agriculture, Forestry and Other Land Use
Category: Aggregate Sources and Non-CO2 Emissions Sources on Land
Subcategory: 3.C.4 - Direct N2O Emissions from managed soils
Sheet: 1 of 3

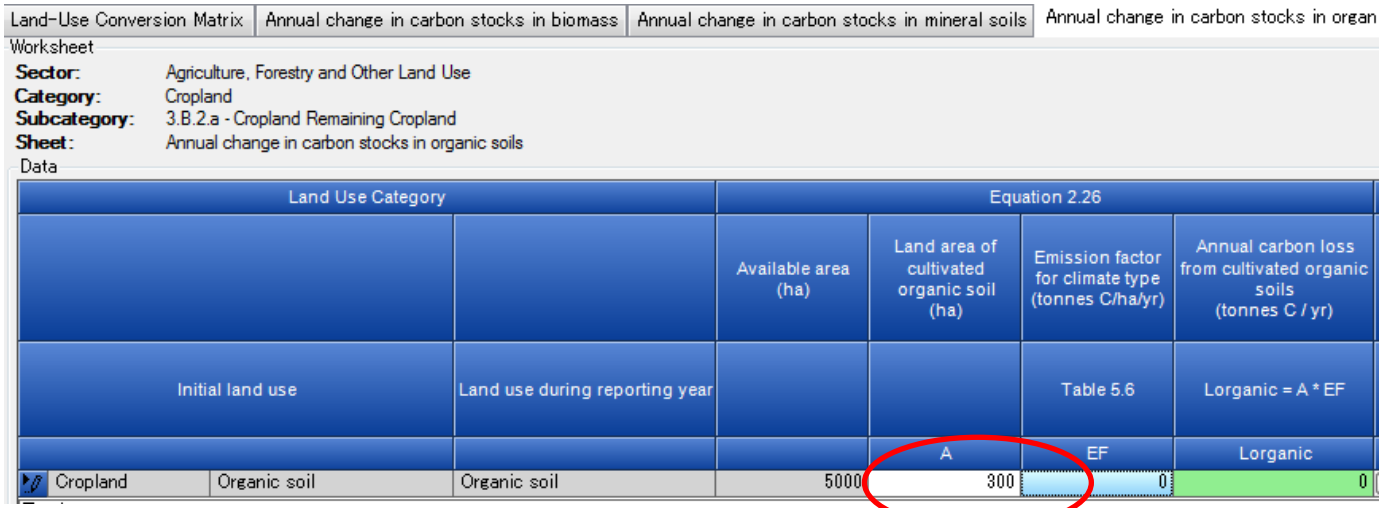
Data
Gas NITROUS OXIDE (N2O)

		F		EF	N2O - Nn inputs	N2O
Anthropogenic N input type		Annual amount of N applied (kg N / yr)		Emission factor for N2O emissions from N inputs (kg N2O-N / kg N input)	Annual direct N2O-N emissions produced from managed soils (kg N2O-N / yr)	N2O Emissions (kg N2O / yr)
					N2O - Nn inputs = F * EF	N2O = N2O - Nn inputs * 44 / 28
Anthropogenic N input types to estimate annual direct N2O-N emissions produced from managed soils	synthetic fertilizers	FSN: N in synthetic fertilizers	42.1	0.01	0.421	0.66157
	animal manure, compost, sewage sludge	FON: N in animal manure, compost, sewage sludge, other	410701…	0.01	41070.17376	64538.84448
	crop residues	FCR: N in crop residues		0.01	0	0
	changes to land use or management	FSOM: 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		0.01	0	0
Anthropogenic N input types to estimate annual direct N2O-N emissions produced from flooded rice	synthetic fertilizers	FSN: N in synthetic fertilizers	NO		0	0

Exercise of using IPCC software

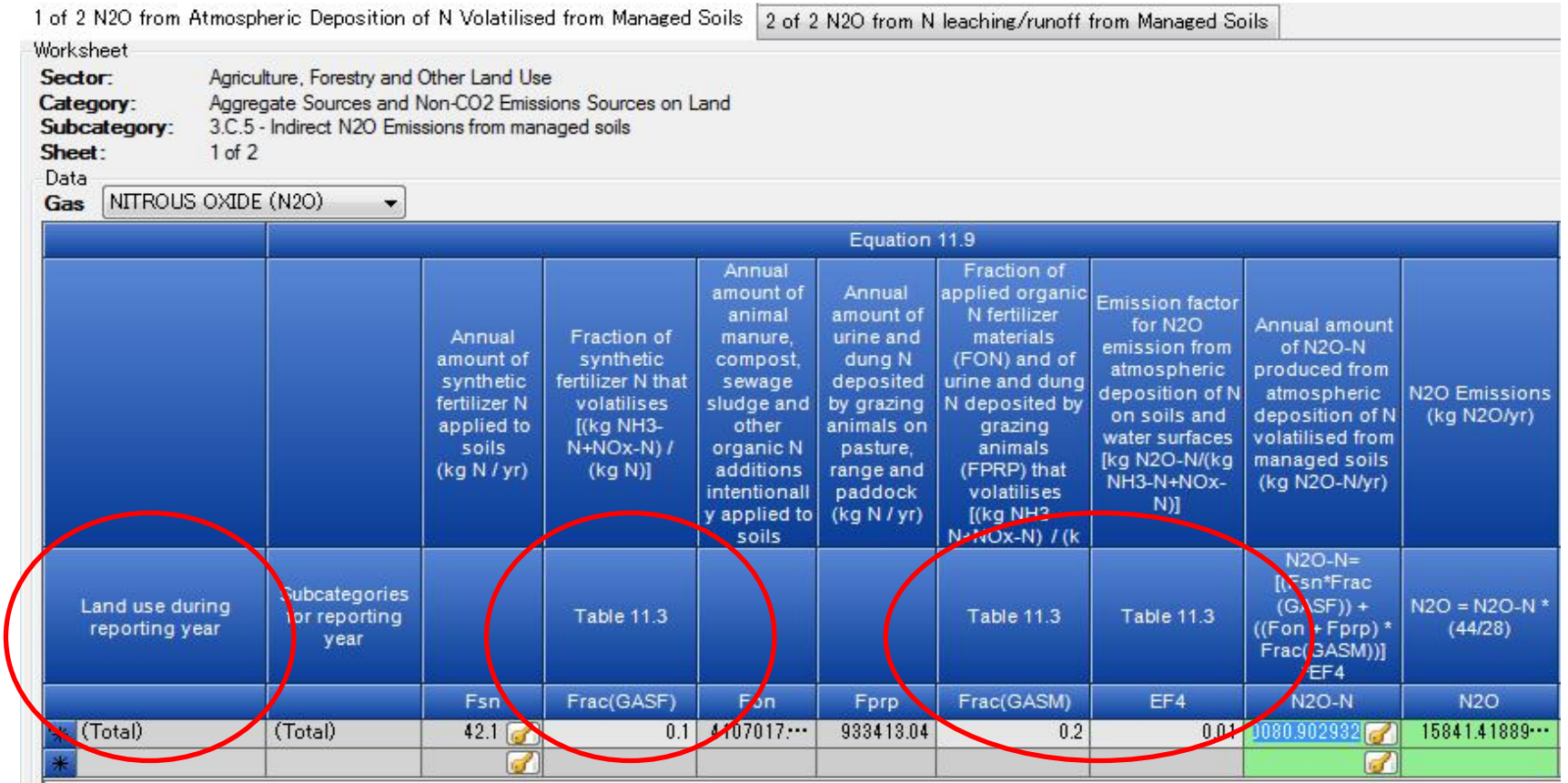
- 2of 3 worksheet deals with EF2 type emission estimation.
- Area of managed/drained organic soil must be enter by “Land Type Manager tool” which only shown in 3B Land.
- Then select appropriate EF2 in the 2 of 3 sheet under 3C4.





Exercise of using IPCC software

- For indirect N2O emission, two worksheets exist, for Vitalization and Leaching/runoff.
- To continue estimation, a user has to identify Land use type, then estimated figure under 3C4 is automatically reflected.
- Then select appropriate Frac vaules and EF4/EF5.



1 of 2 N2O from Atmospheric Deposition of N Volatilised from Managed Soils | 2 of 2 N2O from N leaching/runoff from Managed Soils

Worksheet

Sector: Agriculture, Forestry and Other Land Use
Category: Aggregate Sources and Non-CO2 Emissions Sources on Land
Subcategory: 3.C.5 - Indirect N2O Emissions from managed soils
Sheet: 1 of 2

Data

Gas NITROUS OXIDE (N2O)

	Equation 11.9									
		Annual amount of synthetic fertilizer N applied to soils (kg N / yr)	Fraction of synthetic fertilizer N that volatilises [(kg NH3-N+NOx-N) / (kg N)]	Annual amount of animal manure, compost, sewage sludge and other organic N additions intentionally applied to soils	Annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock (kg N / yr)	Fraction of applied organic N fertilizer materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises [(kg NH3-N+NOx-N) / (k	Emission factor for N2O emission from atmospheric deposition of N on soils and water surfaces [kg N2O-N/(kg NH3-N+NOx-N)]	Annual amount of N2O-N produced from atmospheric deposition of N volatilised from managed soils (kg N2O-N/yr)	N2O Emissions (kg N2O/yr)
Land use during reporting year	Subcategories for reporting year		Table 11.3			Table 11.3	Table 11.3	N2O-N= [(Fsn*Frac (GASF)) + ((Fon + Fprp) * Frac(GASM))] *EF4	N2O = N2O-N * (44/28)
		Fsn	Frac(GASF)	Fon	Fprp	Frac(GASM)	EF4	N2O-N	N2O
(Total)	(Total)	42.1	0.1	4107017…	933413.04	0.2	0.01	3080.902932	15841.41889…
*									