

# Climate MRV for Africa – Phase 2 Development of National GHG Inventory : Emissions from Managed Soils



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## Project of the European Commission DG Climate Action

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Amr Osama Abdel-Aziz, Assen Gasharov, Mike Bess  
and Laura Lahti

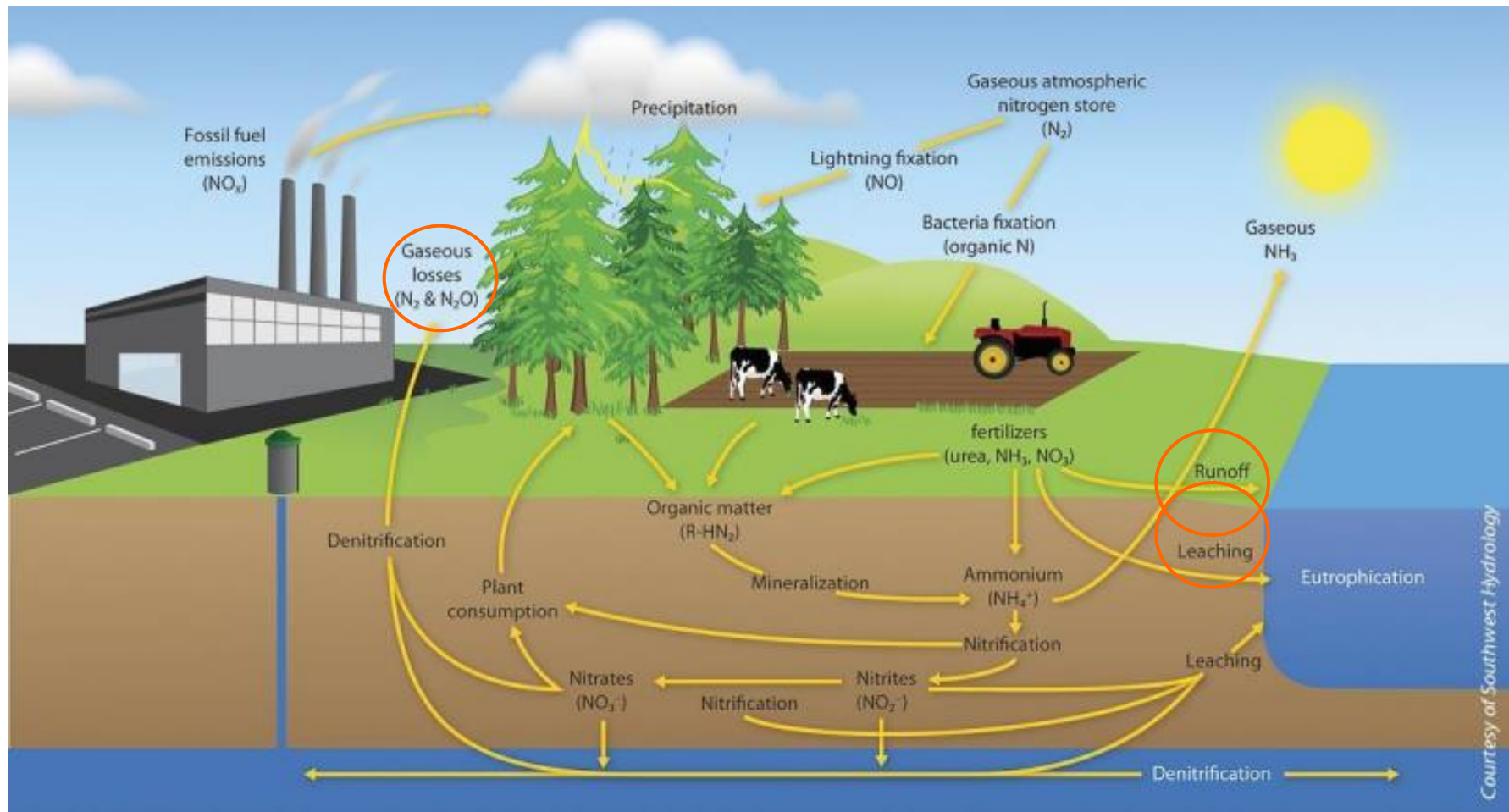
Team Leader and Key Experts

April 2017

# Lesson Contents

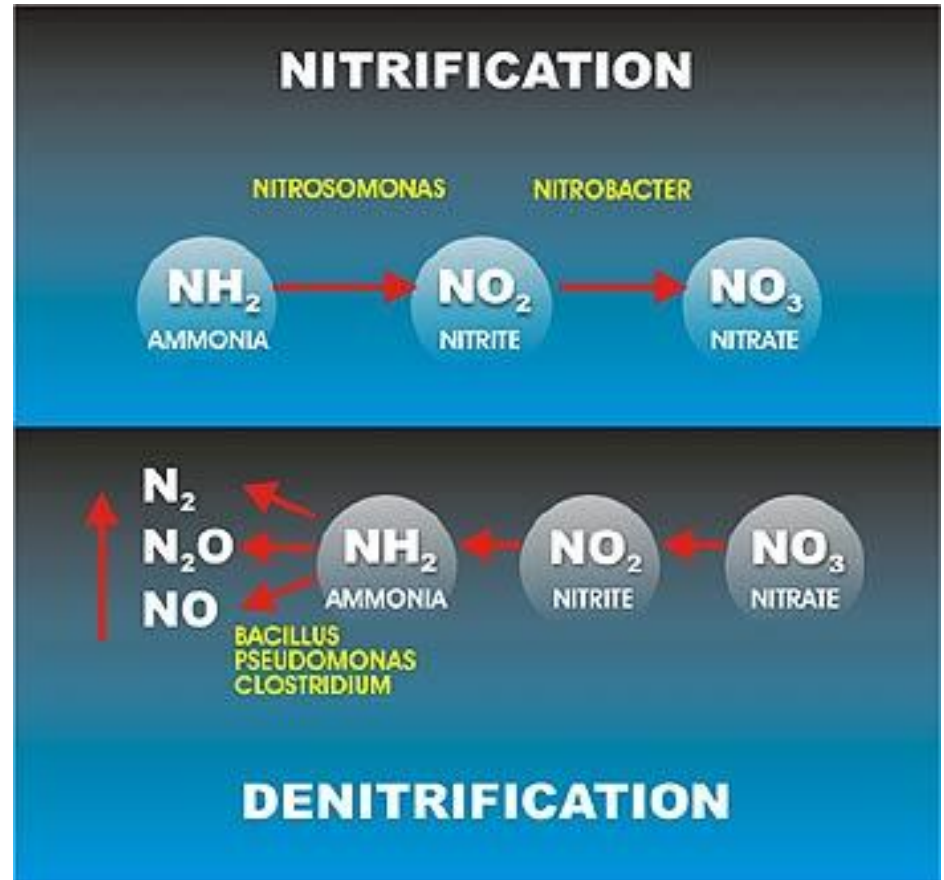
- **Direct N<sub>2</sub>O emissions from managed soils**
- **Indirect N<sub>2</sub>O emissions**

# Direct and Indirect N<sub>2</sub>O emissions from soils (and water)



# Nitrification and Denitrification

- Aerobic process
- Anaerobic process



- Main factor is how much nitrogen (N) is added in the soil.

# Key Considerations

- Great volume of activity data. Highly unlikely that any Party would fulfil all the requirements.
- Activity data (collectable, field measurement):
  - Nitrogen content of substrates (manure, crop residues, sewage sludge)
  - Synthetic fertilizers: amount of N applied to soils;
  - Animal manure: total amount produced, disaggregated by confinement and direct grazing;
  - Nitrogen-fixing crops: area of nitrogen-fixing crops, nitrogen-fixing, and residue/crop ratios;
  - Crop residues: area of residue-producing crops, residue/crop ratios and residue percentage which is applied to soils;<sup>3</sup>
  - Sewage sludge: amount of sewage sludge applied to soils and nitrogen content in sewage sludge.

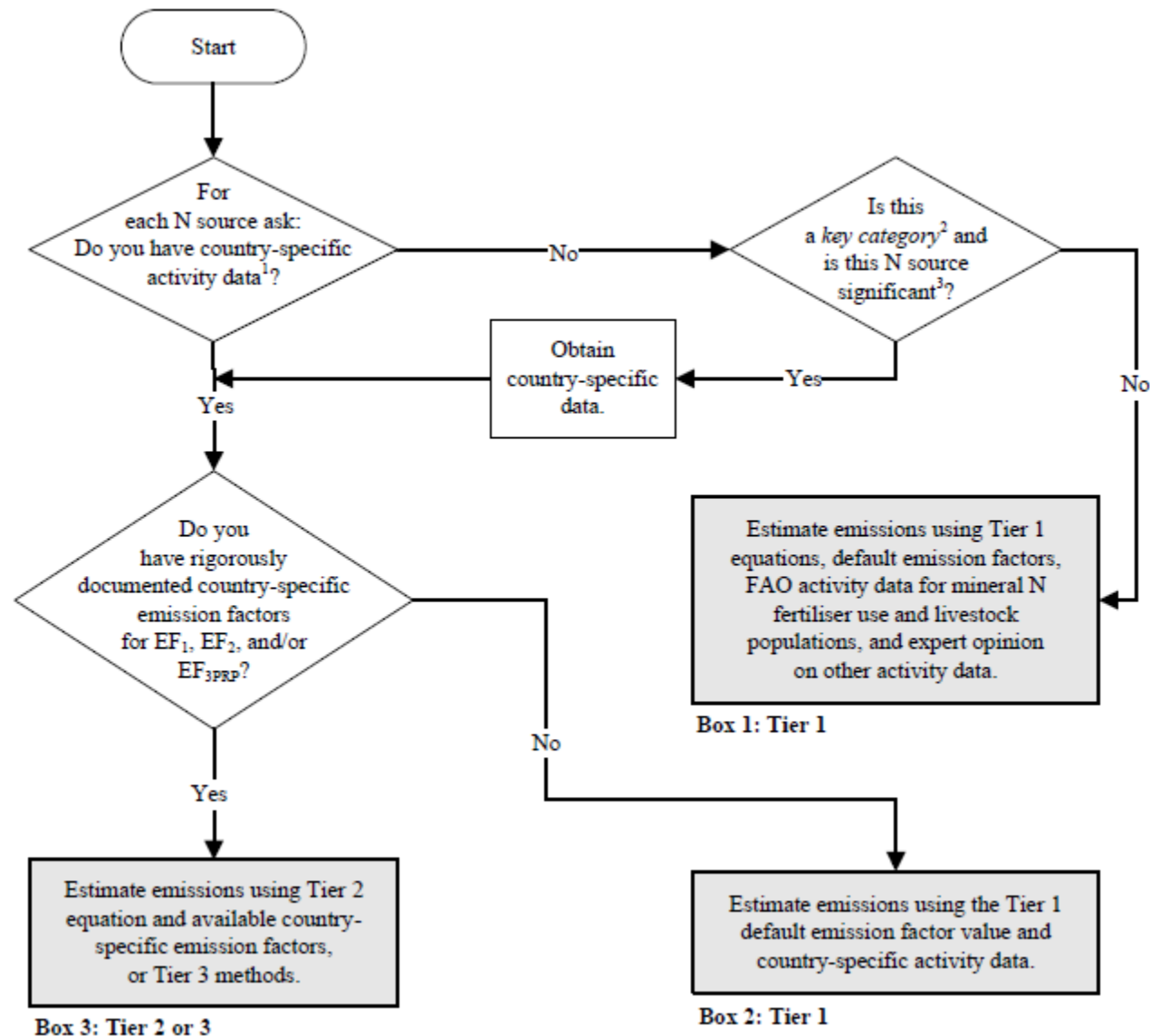
→ Needed for both direct and indirect N<sub>2</sub>O

# Direct Nitrous Oxide Emissions

# Direct N<sub>2</sub>O Emissions

Decision tree for direct N<sub>2</sub>O Emissions

- If no N applied to soils, then "NO"
- If N applied but not key category, Tire 1
- If N applied and key category, then CS activity data must be provided for the significant N inputs (tire 2 or 3)



# IPCC Methodology – Overview

## Direct N<sub>2</sub>O Emissions

<i>N<sub>2</sub>O</i> Direct–N	=	<i>N<sub>2</sub>O</i> –N <sub>N</sub> inputs	+	<i>N<sub>2</sub>O</i> –N <sub>OS</sub>	+	<i>N<sub>2</sub>O</i> –N <sub>RPR</sub>
Total direct N <sub>2</sub> O–N emissions from managed soils (kg/N <sub>2</sub> O–N/y)		Direct N <sub>2</sub> O–N emissions from N inputs to managed soils (kg/N <sub>2</sub> O–N/y)		Direct N <sub>2</sub> O–N emissions from managed organic soils (kg/N <sub>2</sub> O–N/y)		Direct N <sub>2</sub> O–N emissions from urine and dung inputs to grazed soils (kg/N <sub>2</sub> O–N/y)

$$N_2O - N_{N \text{ inputs}} = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_1] + [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \times EF_{1FR}]$$

Excel 1 of 2

$$N_2O - N_{OS} = [(F_{OS,CG,Temp} \times EF_{2CG,Temp}) + [(F_{OS,CG,Trop} \times EF_{2CG,Trop}) + [(F_{OS,F,Temp,NR} \times EF_{2F,Temp,NR}) + [(F_{OS,F,Temp,NP} \times EF_{2F,Temp,NP}) + [(F_{OS,F,Trop} \times EF_{2F,Trop})]]]]]$$

Excel 2 of 2

$$N_2O - N_{RPR} = [(F_{RPR,CPR} \times EF_{3PRP,CP}) + (F_{PRP,SO} \times EF_{3PRP,SO})]$$

Excel 2 of 2



# IPCC Methodology – Detail

## Direct N<sub>2</sub>O Emissions

Sector		Agriculture, Forestry and Other Land Use			
Category		Direct N <sub>2</sub> O Emissions from Managed Soils			
Category code		3C4			
Sheet		1 of 2			
Equation		Equation 11.1			
Anthropogenic N input type		Annual amount of N applied	Emission factor for N <sub>2</sub> O emissions from N inputs	Annual direct N <sub>2</sub> O-N emissions produced from managed soils	
		(kg N yr <sup>-1</sup> )	[kg N <sub>2</sub> O-N (kg N input) <sup>-1</sup> ]	(kg N <sub>2</sub> O-N yr <sup>-1</sup> )	
			Table 11.1	$N_{2O-N \text{ inputs}} = F * EF$	
		F	EF	$N_{2O-N \text{ inputs}}$	
Anthropogenic N input types to estimate annual direct N <sub>2</sub> O-N emissions produced from managed soils	synthetic fertilizers	F <sub>SN</sub> : N in synthetic fertilizers	EF <sub>1</sub>		
	animal manure, compost, sewage sludge	F <sub>ON</sub> : N in animal manure, compost, sewage sludge, other			
	crop residues	F <sub>CR</sub> : N in crop residues			
	changes to land use or management	F <sub>SOM</sub> : 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			
Anthropogenic N input types to estimate annual direct N <sub>2</sub> O-N emissions produced from flooded rice	synthetic fertilizers	F <sub>SN</sub> : N in synthetic fertilizers	EF <sub>1FR</sub>		
	animal manure, compost, sewage sludge	F <sub>ON</sub> : N in animal manure, compost, sewage sludge, other			
	crop residues	F <sub>CR</sub> : N in crop residues			
	changes to land use or management	F <sub>SOM</sub> : 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			
<b>Total</b>					

Sheet 1 of 2

# IPCC Methodology – Detail

## Direct N<sub>2</sub>O Emissions

← Sheet 2 of 2

<b>Sector</b>		<b>Agriculture, Forestry and Other Land Use</b>					
<b>Category</b>		<b>Direct N<sub>2</sub>O Emissions from Managed Soils</b>					
<b>Category code</b>		<b>3C4</b>					
<b>Sheet</b>		<b>2 of 2</b>					
<b>Equation</b>		<b>Equation 11.1</b>					
Anthropogenic N input type <sup>1,2</sup>	Annual area of managed/drained organic soils	Emission factor for N <sub>2</sub> O emissions from drained/managed organic soils	Annual direct N <sub>2</sub> O-N emissions produced from managed organic soils	Amount of urine and dung N deposited by grazing animals on pasture, range and paddock	Emission factor for N <sub>2</sub> O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals	Annual direct N <sub>2</sub> O emissions from urine and dung inputs to grazed soils	Annual direct N <sub>2</sub> O emissions from urine and dung inputs to grazed soils
	(ha)	(kg N <sub>2</sub> O-N ha <sup>-1</sup> yr <sup>-1</sup> )	(kg N <sub>2</sub> O-N yr <sup>-1</sup> )	(kg N yr <sup>-1</sup> )	[kg N <sub>2</sub> O-N (kg N input) <sup>-1</sup> ]	(kg N <sub>2</sub> O-N yr <sup>-1</sup> )	(kg N <sub>2</sub> O-N yr <sup>-1</sup> )
		Table 11.1	$N_2O-N_{OS} = F_{OS} * EF_2$		Table 11.1	$N_2O-N_{PRP} = F_{PRP} * EF_{3PRP}$	$N_2O_{Direct-N} = N_2O-N_{N input} + N_2O-N_{OS} + N_2O-N_{PRP}$
	<b>F<sub>OS</sub></b>	<b>EF<sub>2</sub></b>	<b>N<sub>2</sub>O-N<sub>OS</sub></b>	<b>F<sub>PRP</sub></b>	<b>EF<sub>3PRP</sub></b>	<b>N<sub>2</sub>O-N<sub>PRP</sub></b>	<b>N<sub>2</sub>O<sub>Direct-N</sub></b>
Managed organic soils	CG, Temp						
	CG, Trop						
	F, Temp, NR						
	F, Temp, NP						
	F, Trop						
Urine and dung inputs to grazed soils	CPP						
	SO						
<b>Total</b>							



Area must be disaggregated by Cropland and Grassland (CG), Forest (F), Temperate (Temp), Tropical (Trop), Nutrient Rich (NR), and Nutrient Poor (NP);  
 The amount must be disaggregated by CPP and SO, which refer to Cattle, Poultry and Pigs, and Sheep and Other animals,

# Parameters

## Direct N<sub>2</sub>O Emissions

Parameter	Symbol	Equation/table
Amount of synthetic fertiliser N applied to soils (kg/N/y)	F <sub>SN</sub>	National statistics, or FAO
Amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (kg/N/y)	F <sub>ON</sub>	Equation 11.3 & 11.4 <a href="#">Links to manure management / Chp. 10</a>
Amount of N in crop residues (above-ground and below-ground) (kg/N/ y)	F <sub>CR</sub>	Equation 11.6 <a href="#">Links to residue burning / Chp. 2</a>
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/ y)	F <sub>SOM</sub>	Equation 11.8 <a href="#">Links to land-use change / Chp. 2</a>
Area of managed/drained organic soils (ha)	F <sub>OS</sub>	National statistics, FAO or expert judgment
Amount of urine and dung N deposited by grazing animals on pasture, range and paddock, (kg N /y)	F <sub>PRP</sub>	Equation 11.5 <a href="#">Links to manure management / Chp. 10</a>

# Parameters

## Direct N<sub>2</sub>O Emissions

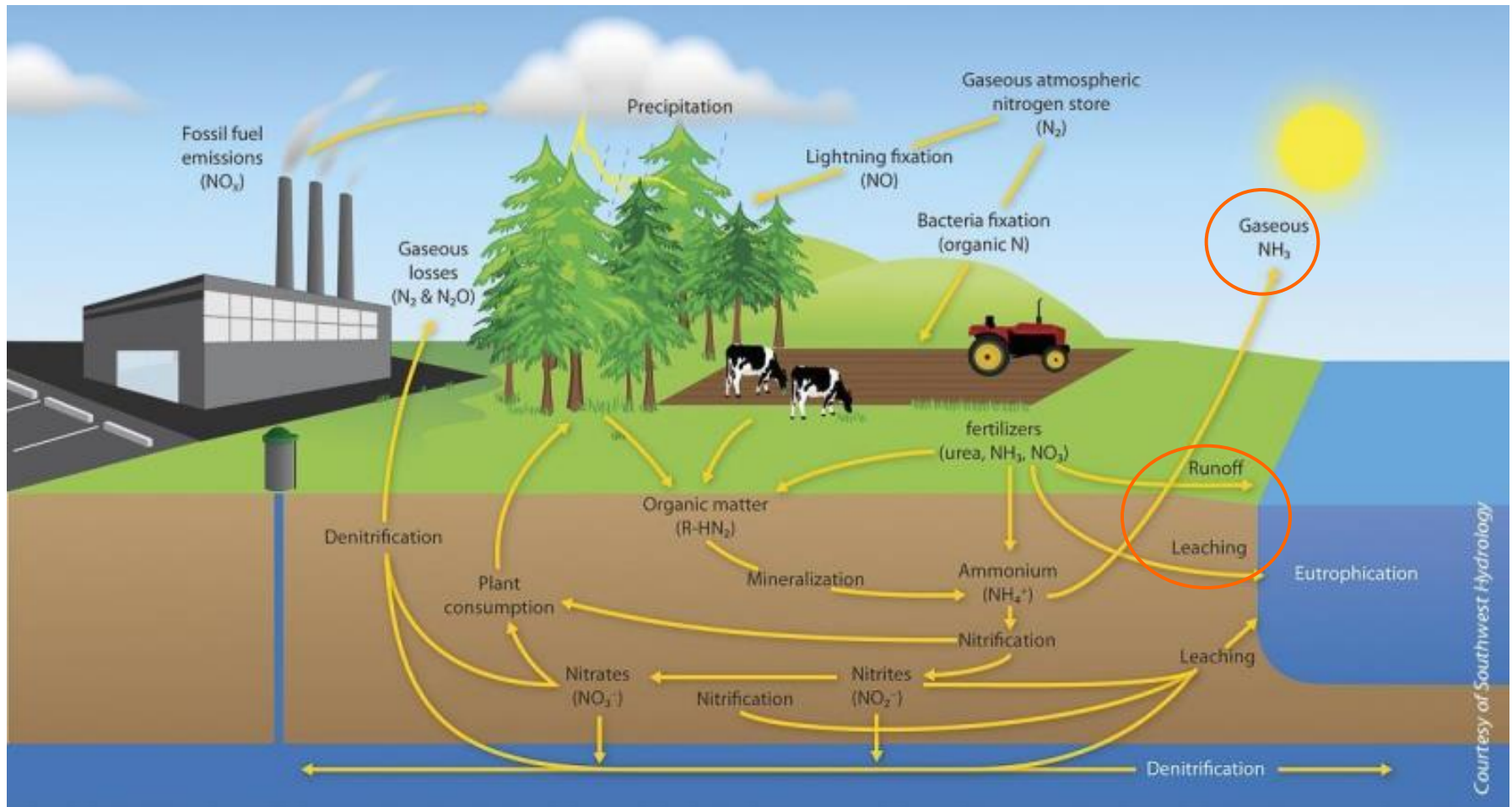
Parameter	Symbol	Equation/table
Emission factor for N <sub>2</sub> O emissions from N inputs (kg N <sub>2</sub> O–N /kg N input)	EF <sub>1</sub>	Table 11.1
Emission factor for N <sub>2</sub> O emissions from N inputs to flooded rice (kg N <sub>2</sub> O–N /kg N input)	EF <sub>1FR</sub>	Table 11.1
Emission factor for N <sub>2</sub> O emissions from drained/managed organic soils, (kg N <sub>2</sub> O–N /ha/y)	EF <sub>2</sub>	Table 11.1
Emission factor for N <sub>2</sub> O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, (kg N <sub>2</sub> O–N /kg N input)	EF <sub>3PRP</sub>	Table 11.1

### NOTE:

- subscripts CG, F, Temp, Trop, NR, NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively;
- subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively.

# Indirect Nitrous Oxide Emissions

# Indirect N<sub>2</sub>O Emissions from Soils and Water



# IPCC Methodology – Overview

## Indirect N<sub>2</sub>O emissions

*Equation 11.9 – N volatilized*

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

*Excel 1 of 2*

*Equation 11.10 – N leaching / run-off*

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

*Excel 2 of 2*

Note:

- Use the same quantities of N used above ( $F_{SN}$ ,  $F_{ON}$ ,  $F_{PRP}$ ,  $F_{SOM}$ ,  $F_{CR}$ ) for estimating direct N<sub>2</sub>O emissions;
- There are no indirect emissions from drained organic soils ( $F_{OS}$ ).

# IPCC Methodology – Detail

## Indirect N<sub>2</sub>O emissions

Category	Indirect N <sub>2</sub> O Emissions from Managed Soils: N <sub>2</sub> O from Atmospheric Deposition of N Volatilised from Managed Soils						
Category code	3C5						
Sheet	1 of 2						
Equation	Equation 11.9						
Anthropogenic N input type	Annual amount of synthetic fertilizer N applied to soils	Fraction of synthetic fertilizer N that volatilises	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	Fraction of applied organic N fertilizer materials (F <sub>ON</sub> ) and of urine and dung N deposited by grazing animals (F <sub>PRP</sub> ) that volatilises	Emission factor for N <sub>2</sub> O emission from atmospheric deposition of N on soils and water surfaces	Annual amount of N <sub>2</sub> O-N produced from atmospheric deposition of N volatilised from managed soils
	(kg N yr <sup>-1</sup> )	(kg NH <sub>3</sub> -N + NO <sub>x</sub> -N) (kg of N applied) <sup>-1</sup>	(kg N yr <sup>-1</sup> )	(kg N yr <sup>-1</sup> )	(kg NH <sub>3</sub> -N + NO <sub>x</sub> -N) (kg of N applied or	(kg N <sub>2</sub> O-N) (kg NH <sub>3</sub> <sup>-</sup> -N + NO <sub>x</sub> -N	(kg N <sub>2</sub> O-N yr <sup>-1</sup> )
		Table 11.3			Table 11.3	Table 11.3	$N_{2}O_{(ATD)}-N = [(F_{SN} * Frac_{GASF}) + (F_{ON} + F_{PRP}) * Frac_{GASM}] * EF_4$
	F <sub>SN</sub>	Frac <sub>GASF</sub>	F <sub>ON</sub>	F <sub>PRP</sub>	Frac <sub>GASM</sub>	EF <sub>4</sub>	N <sub>2</sub> O <sub>(ATD)-N</sub>
(a)							
(b)							
(c)							
<b>Total</b>							

← Sheet 1 of 2

### NOTE:

➤ The results need to be converted to mass of N<sub>2</sub>O by multiplying with 44/28



# IPCC Methodology – Detail

## Indirect N<sub>2</sub>O emissions

← Sheet 2 of 2

<b>Sector</b>		<b>Agriculture, Forestry and Other Land Use</b>						
<b>Category</b>		<b>Indirect N<sub>2</sub>O Emissions from Managed Soils: N<sub>2</sub>O from N leaching/runoff from Managed Soils</b>						
<b>Category code</b>		<b>3C5</b>						
<b>Sheet</b>		<b>2 of 2</b>						
<b>Equation</b>		<b>Equation 11.10</b>						
Anthropogenic N input type	Annual amount of synthetic fertilizer N applied to soils	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	Amount of N in crop residues (above and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually	Annual amount of N mineralized/immobilized in mineral soils associated with loss/gain of soil C from soil organic matter as a result of changes to land use or management	Fraction of all N additions to managed soils that is lost through leaching and runoff	Emission factor for N <sub>2</sub> O emission from N leaching and runoff	Annual amount of N <sub>2</sub> O-N produced from managed soils in regions where leaching and runoff occurs
	(kg N yr <sup>-1</sup> )	(kg N yr <sup>-1</sup> )	(kg N yr <sup>-1</sup> )	(kg N yr <sup>-1</sup> )	(kg N yr <sup>-1</sup> )	[kg N (kg of N additions) <sup>-1</sup> ]	[kg N <sub>2</sub> O-N (kg N leaching and runoff) <sup>-1</sup> ]	(kg N <sub>2</sub> O-N yr <sup>-1</sup> )
						Table 11.3	Table 11.3	N <sub>2</sub> O <sub>(L)-N</sub> = (F <sub>SN</sub> + F <sub>ON</sub> + F <sub>PRP</sub> + F <sub>CR</sub> + F <sub>SOM</sub> ) * Frac <sub>LEACH-(H)</sub> * EF <sub>5</sub>
	<b>F<sub>SN</sub></b>	<b>F<sub>ON</sub></b>	<b>F<sub>PRP</sub></b>	<b>F<sub>CR</sub></b>	<b>F<sub>SOM</sub></b>	<b>Frac<sub>LEACH-(H)</sub></b>	<b>EF<sub>5</sub></b>	<b>N<sub>2</sub>O<sub>(L)-N</sub></b>
(a)								
(b)								
(c)								
<b>Total</b>								

**NOTE:**

➤ The results need to be converted to mass of N<sub>2</sub>O by multiplying with 44/28

# Thank you!

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