Food and Agriculture Organization of the United Nations

FAO and the Enhanced transparency framework

Agriculture, Forestry and Other Land Use

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Office of Climate Change, Environment and Biodiversity
Food and Agriculture Organization

FAO support on transitioning towards ETF

“Building a National GHGI for Agriculture, Forestry and Other Land Use”

- ✓ Preparing a greenhouse gas inventory under the enhanced transparency framework

  https://elearning.fao.org/course/view.php?id=618

- ✓ The national greenhouse gas inventory for agriculture: https://elearning.fao.org/course/view.php?id=327
- ✓ The national greenhouse gas inventory for land use: https://elearning.fao.org/course/view.php?id=453
- ✓ Estimating enteric fermentation at Tier 2: https://elearning.fao.org/course/view.php?id=893
- ✓ Uncertainty analysis: a focus on land use: https://elearning.fao.org/course/view.php?id=788

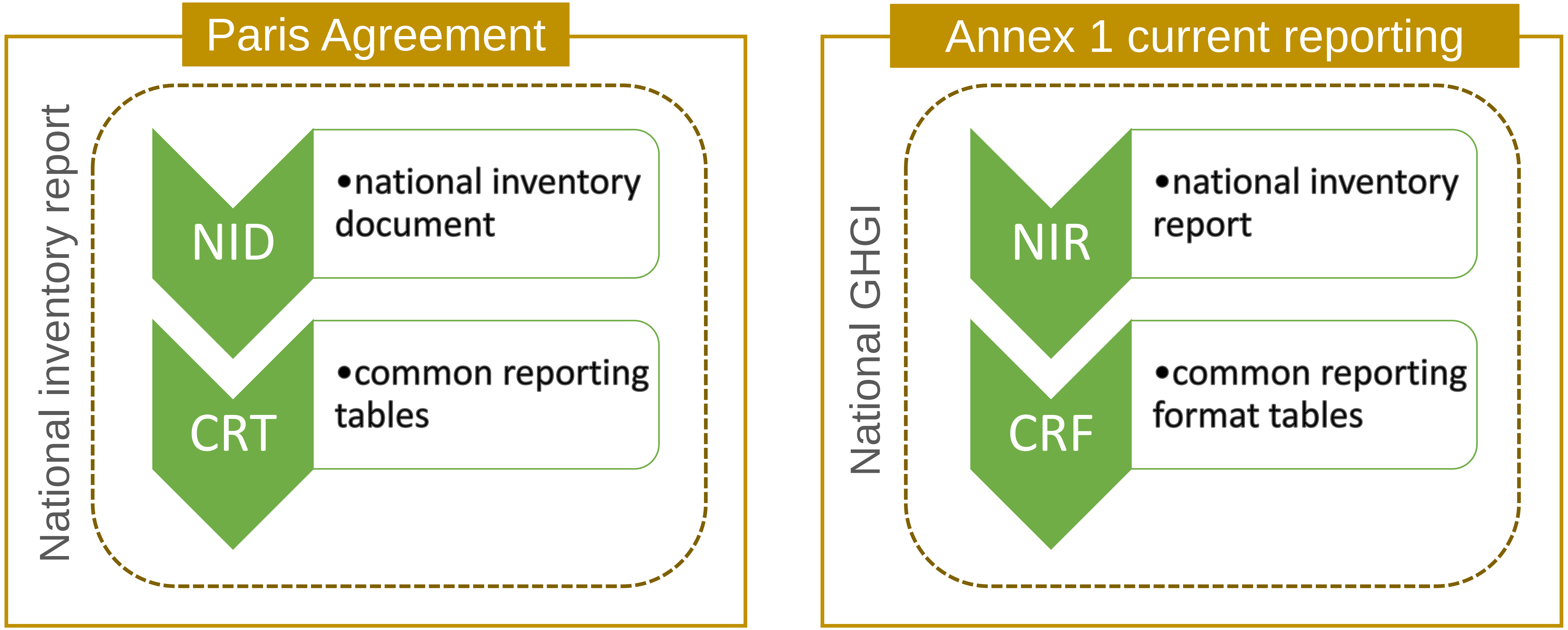
- FAO Transparency in agriculture and land use sectors network

  http://www.fao.org/climate-change/our-work/what-we-do/transparency/network/en/?

  JOIN US!

  - Webinar series to address ETF requirements
  - E-mail based discussions to learn from peers

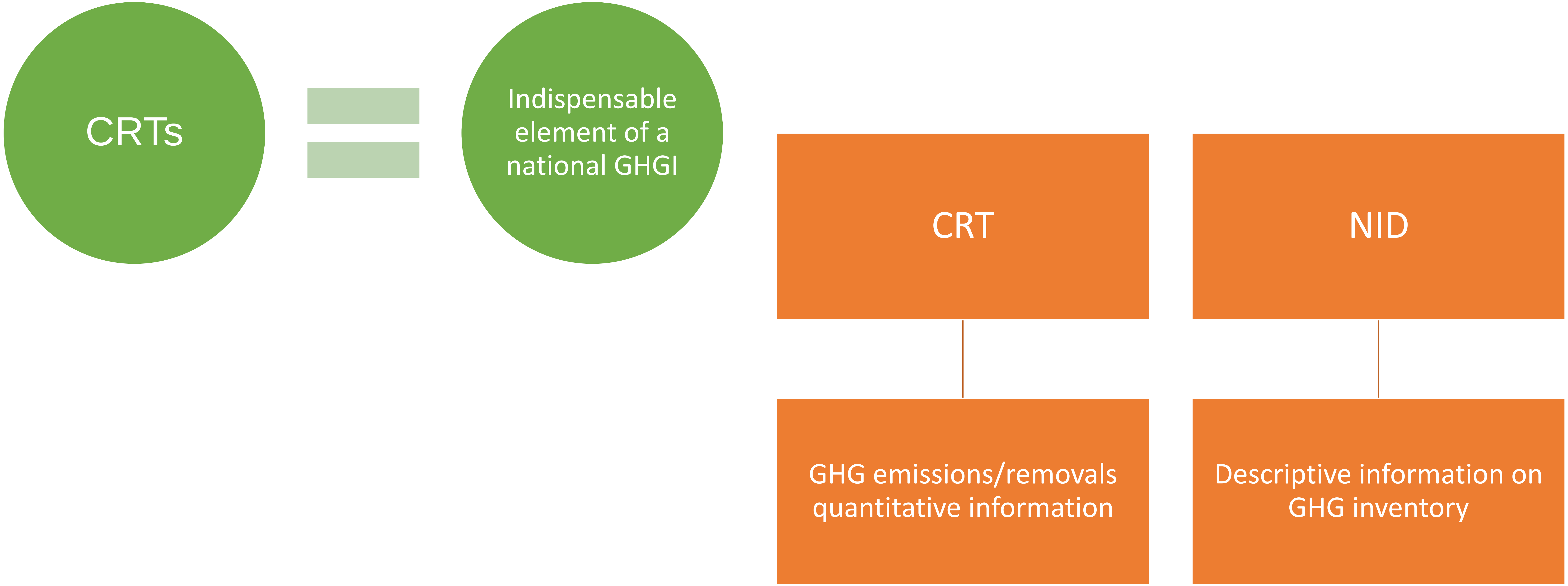
Reporting GHGIs under the ETF



CRTs have been adopted through decision 5/CMA.3 (COP 26)

https://unfccc.int/documents/311076

Reporting GHGIs under the ETF



Reporting GHGIs under the ETF

To put it simply:

✓CRTs: a set of standardized tables that Parties must use to accompany the NID. Contain the ‘numbers’

✓NID: the national inventory document. Contains all related information about how the numbers are produced (together with additional information)

✓Developed Parties have long-lasting experience in common format tables reporting

✓Developing Parties need to build their experience from zero

?

Reporting GHGIs under the ETF

- ❑ UNFCCC secretariat will prepare a reporting tool (dedicated software application) for the preparation, filling, and electronic reporting of the CRTs by countries
- ❑ Test version is expected by June 2023 & final version of the tools expected to be completed by June 2024
- ❑ It is very important that GHG inventory compilers have adequate knowledge of the CRTs & the CRT reporting tool (structure, functionalities) → to prepare & submit appropriately the national GHG inventory

ADVANCE VERSION

United Nations FCCC/PA/CMA/2021/10/Add.2

Framework Convention on Climate Change

Distr.: General
8 March 2022

Original: English

Conference of the Parties serving as the meeting of the Parties to the Paris Agreement

Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on its third session, held in Glasgow from 31 October to 13 November 2021

Addendum

Part two: Action taken by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement at its third session

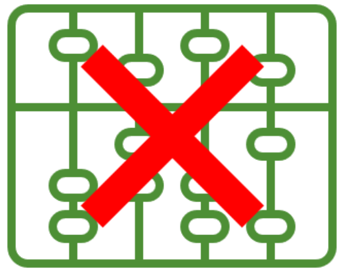
Contents

Decisions adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement

Reporting GHGIs under the ETF

WHAT ARE NOT CRTs?

- ➢They are ***NOT*** a GHGI estimation tool



- ➢They are tables in which Parties ***report*** their already estimated GHG emissions/removals, and related information

TABLE 5.C SECTORAL BACKGROUND DATA FOR WASTE ·entory 2019

Incineration and open burning of waste sion 2021 v1

(Sheet 1 of 1) ITALY

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA Amount of wastes (incinerated/open burned) (kt wet weight)	IMPLIED EMISSION FACTOR (kg/t waste)			EMISSIONS (kt)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1. Waste Incineration	91.36	551.78	0.06	0.14	50.41	0.01	0.01
Biogenic (1)	49.35	369.56	0.06	0.17	18.24	0.00	0.01
Municipal solid waste	49.35	369.56	0.06	0.17	18.24	0.00	0.01
Other *(please specify)* (2)	NO	NO	NO	NO	NO	NO	NO
Non-biogenic	42.01	1200.00	0.06	0.10	50.41	0.00	0.00
Municipal solid waste	42.01	1200.00	0.06	0.10	50.41	0.00	0.00
Other *(please specify)* (3)	NO	NO	NO	NO	NO	NO	NO
2. Open burning of waste	863.58	5.86	2.52	0.06	5.06	2.17	0.05
Biogenic (1)	858.16	NA	2.53	0.06	NA	2.17	0.05
Municipal solid waste	5.41	NA	NE	NE	NA	NE	NE
Other *(please specify)*	852.75	NA	2.55	0.06	NA	2.17	0.05
agricultural waste	852.75	NA	2.55	0.06	NA	2.17	0.05
Non-biogenic	5.41	935.00	NO,NE	NO,NE	5.06	NO,NE	NO,NE
Municipal solid waste	5.41	935.00	NE	NE	5.06	NE	NE
Other *(please specify)*	NO	NO	NO	NO	NO	NO	NO

Note: Only emissions from waste incineration without energy recovery are to be reported under the waste sector. Emissions from incineration with energy

(1) The CO_2 emissions from combustion of biomass materials (e.g. paper, food and wood waste) contained in the waste are biogenic emissions and should not be

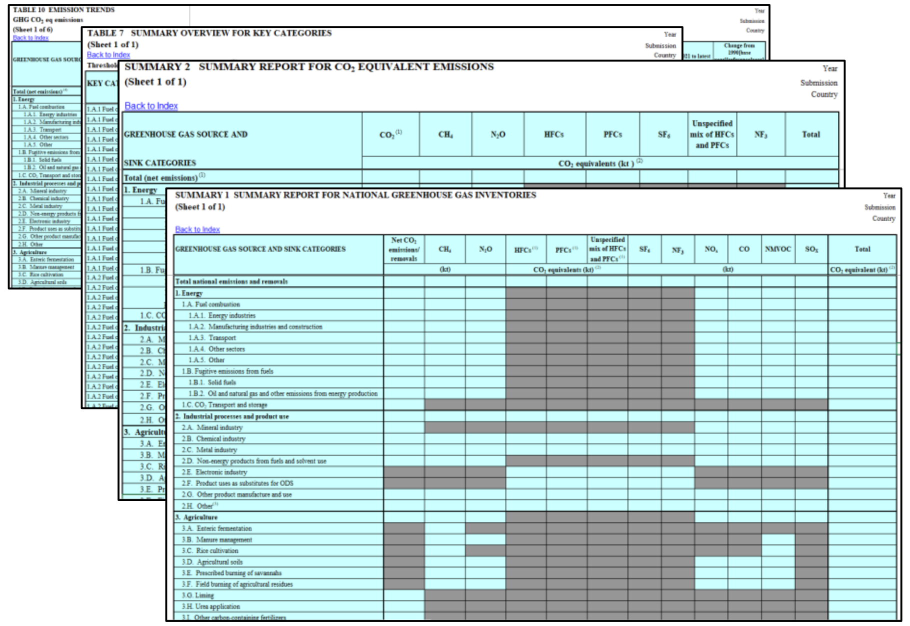
(2) If data are available, Parties are encouraged to report at the disaggregated level available from the pre-defined drop-down menu. Furthermore, Parties are encouraged to the extent possible to use the pre-defined category definitions rather than to create similar categories. This ensures the highest possible degree of

(3) If data are available, Parties are encouraged to report at the disaggregated level available from the pre-defined drop-down menu. Furthermore, Parties are encouraged to the extent possible to use the pre-defined category definitions rather than to create similar categories. This ensures the highest possible degree of

(4) This category includes lubricants, solvents and waste oil. Unless fossil liquid waste is included in other types of waste (e.g. industrial or hazardous waste),

Documentation box:	
• Parties should provide detailed explanations on the waste sector in Chapter 7: Waste (CRF sector 5) of the national inventory report (NIR). Use this • Parties that use country-specific models should provide a reference in the documentation box to the relevant section in the NIR where these models are • Provide a reference to the relevant section of the NIR, in particular with regard to the amount of incinerated waste (specify whether the reported data relate to	
Documentation box	

Reporting GHGIs under the ETF| CRT structure



- include data on all sectors, categories, C pools as defined in the MPGs + a number of summary tables
- source/sink definitions are based upon the 2006 IPCC GLs categorization
- 3 distinct levels are identified, with each level entailing a different degree of information aggregation

Allocation of GHG emissions/removals

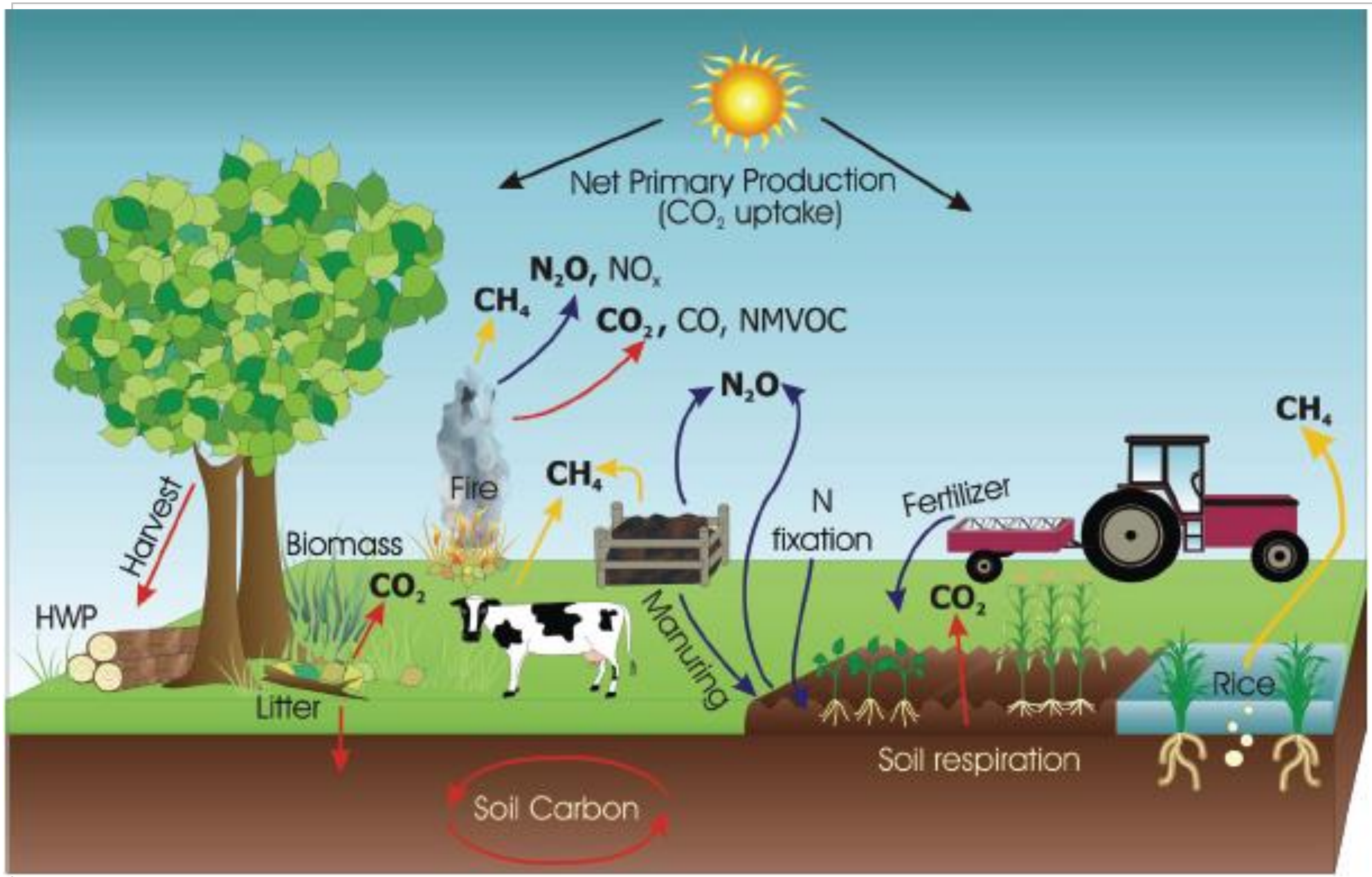
- Confusion may arise in the beginning
- Follow the agreed CRTs

TIP

CRT familiarity comes with time & practice

Footnotes crucial great guidance

Agriculture, Forestry and Other Land Use

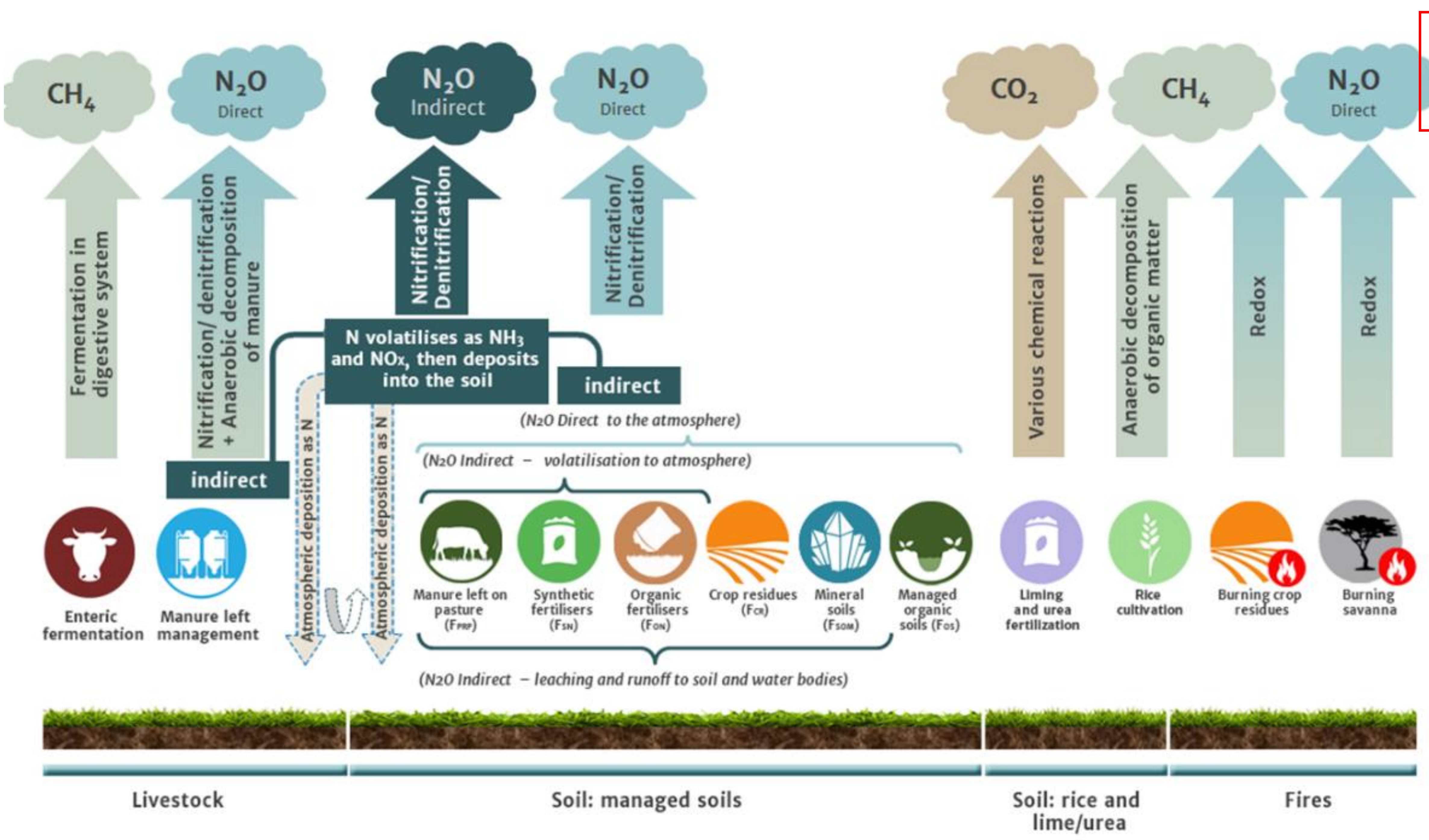


3A Livestock
- 3A1 Enteric Fermentation
- 3A2 Manure Management (MM)

3B Land
- 3B1 Forest Land
- 3B2 Cropland
- 3B3 Grassland
- 3B4 Wetlands
- 3B5 Settlements
- 3B6 Other Land

3C Aggregate sources and non-CO2 emissions on land
- 3C1 Emissions from Biomass Burning
- 3C2 Liming
- 3C3 Urea Application
- 3C4/5 Direct and Indirect N2O from Managed Soils
- 3C6 Indirect N2O from MM
- 3C7 Rice Cultivation
- 3C8 Other

Agriculture



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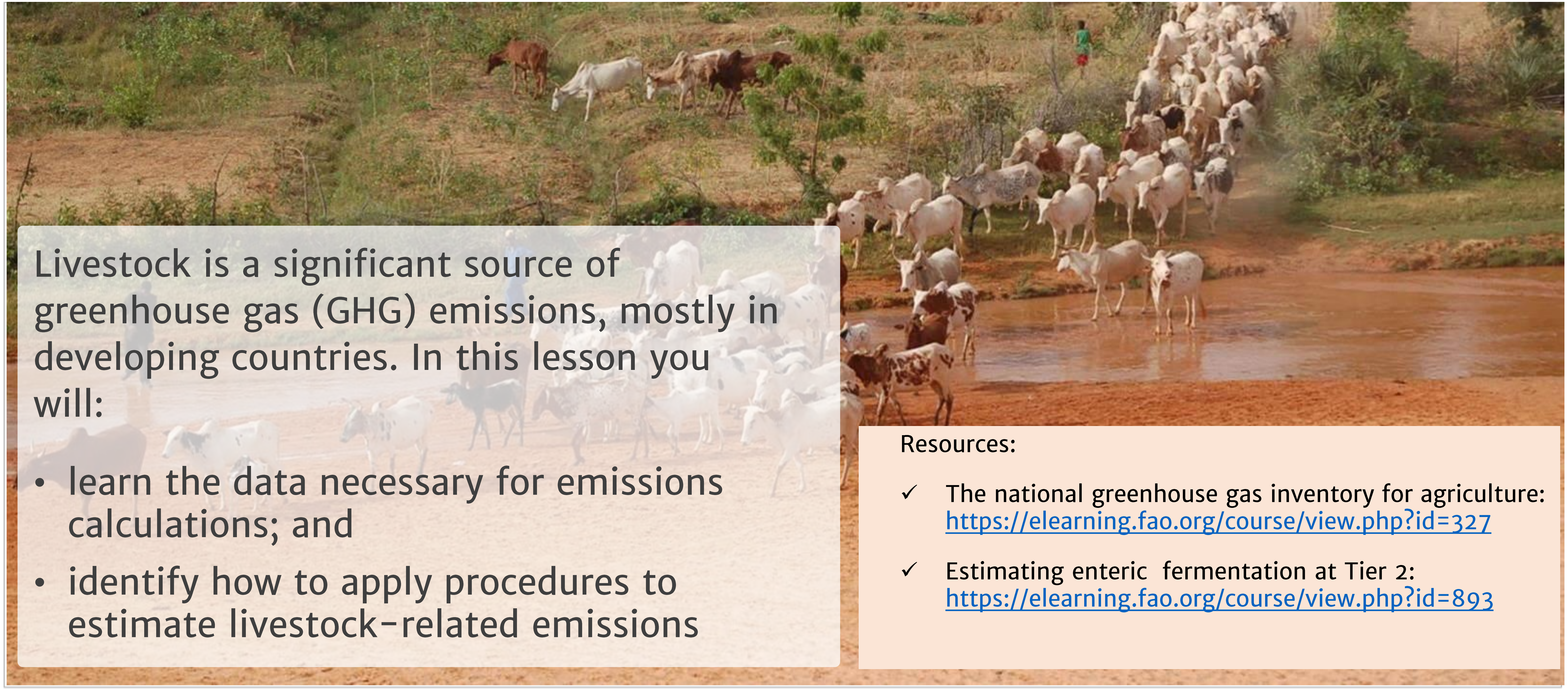
- 3C7 Rice Cultivation
- 3C8 Other

3A Livestock-related emissions



Livestock is a significant source of greenhouse gas (GHG) emissions, mostly in developing countries. In this lesson you will:

- learn the data necessary for emissions calculations; and
- identify how to apply procedures to estimate livestock-related emissions

Resources:

✓ The national greenhouse gas inventory for agriculture: https://elearning.fao.org/course/view.php?id=327

✓ Estimating enteric fermentation at Tier 2: https://elearning.fao.org/course/view.php?id=893

Introduction

The gases produced by these sources include:

CH_4

N_2O

The processes generating GHG emissions are the following ones:

Enteric fermentation in digestive systems

Decomposition of manure under low oxygen or anaerobic conditions

Combined **nitrification** and **denitrification** of nitrogen contained in manure. Leaching and volatilization losses of NH_3 and NO_x from manure management systems (MMS) leads to **indirect** GHG emissions (3C).

The main sources of livestock-related GHG emissions are:

Digestive system

Manure

Manure management

The five steps to estimate emissions

Collect data on livestock population and MMS.

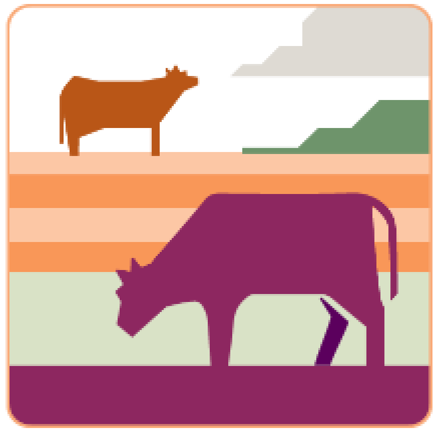
1 Assess domestic livestock population — **Step 1**

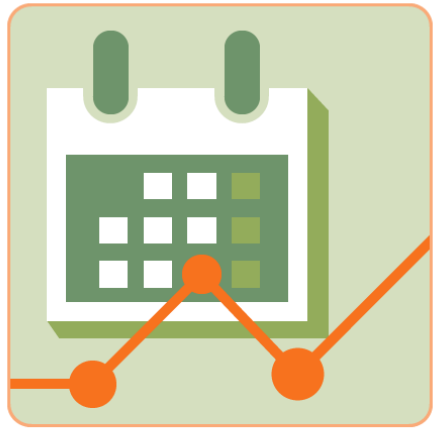
2 Produce a characterization of the animal species. — **Step 2**

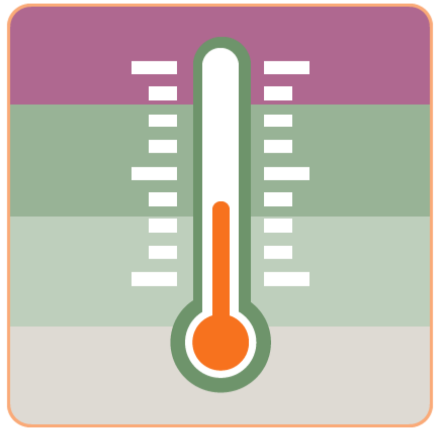
3 Calculate the annual average population (AAP). — **Step 3**

4 Stratify animals by annual average temperature (AAT). — **Step 4**

5 Collect data on manure management systems (MMS). — **Step 5**







The first three steps are common to all GHG livestock-related estimation methodologies, while the last two steps are specific for CH_4 and N_2O of manure management, respectively.

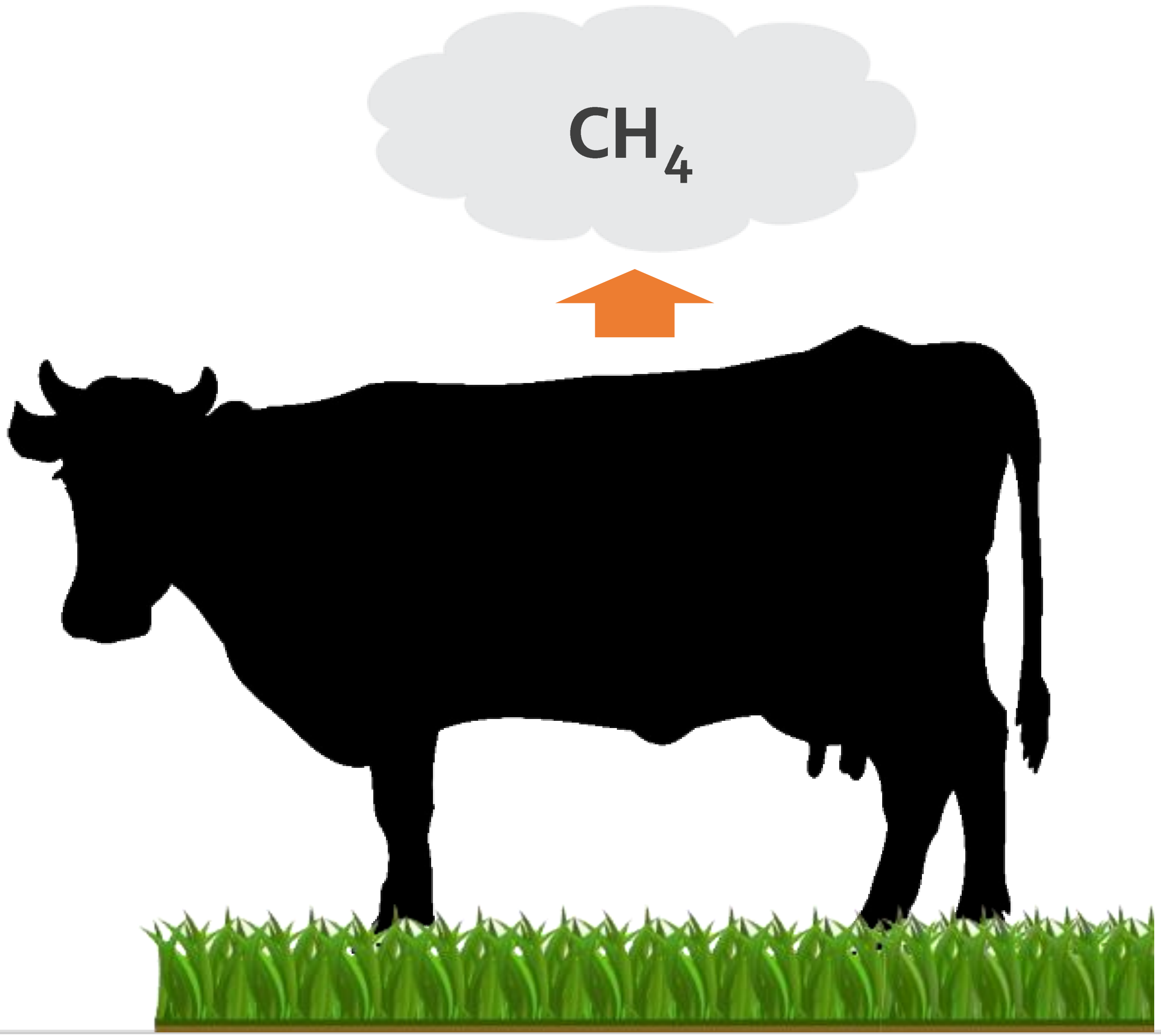
Defined Manure management System

IPCC provide the definitions for seventeen MMS, but provide the default factors on usage only for nine of them. Both lists are reported below:

Defined manure management systems		Default factor on MMS usage
1. Pasture/Ranged/Paddock	10. Cattle and swine deep bedding	1. Lagoon
2. Daily spread	11. Composting, in-vessel	2. Liquid slurry
3. Solid storage	12. Composting, static pile	3. Solid storage
4. Dry lot	13. Composting, intensive windrow	4. Dry lot
5. Liquid slurry	14. Composting, passive windrow	5. Pasture/Ranged/Paddock
6. Uncovered anaerobic lagoon	15. Poultry manure with litter	6. Daily spread
7. Pit storage below animal confinements	16. Poultry manure without litter	7. Digester
8. Anaerobic (digester)	17. Aerobic treatment	8. Burned for fuel
9. Burned for fuel		9. Other

CH_4 from enteric fermentation

CH_4 emissions from enteric fermentation are produced during digestion of carbohydrates, which are broken down into simple molecules for absorption into the bloodstream.



Ruminant livestock (e.g. cattle, sheep) are major sources of CH_4, while moderate amounts are produced from non-ruminant livestock (e.g. pigs, horses).

The amount of CH_4 produced is a function of:

- type of digestive system;
- age of the animal;
- weight of the animal; and
- quality and quantity of food.

CH_4 from enteric fermentation – How to do at Tier 1

Once you have collected data on AAP population of the livestock species, you can apply equation 10.19.

1. For each animal category, multiply the respective emission factor by the population.

$$Emissions = EF_{(T)} \left(\frac{N_{(T)}}{10^6} \right)$$

Equation 10.19

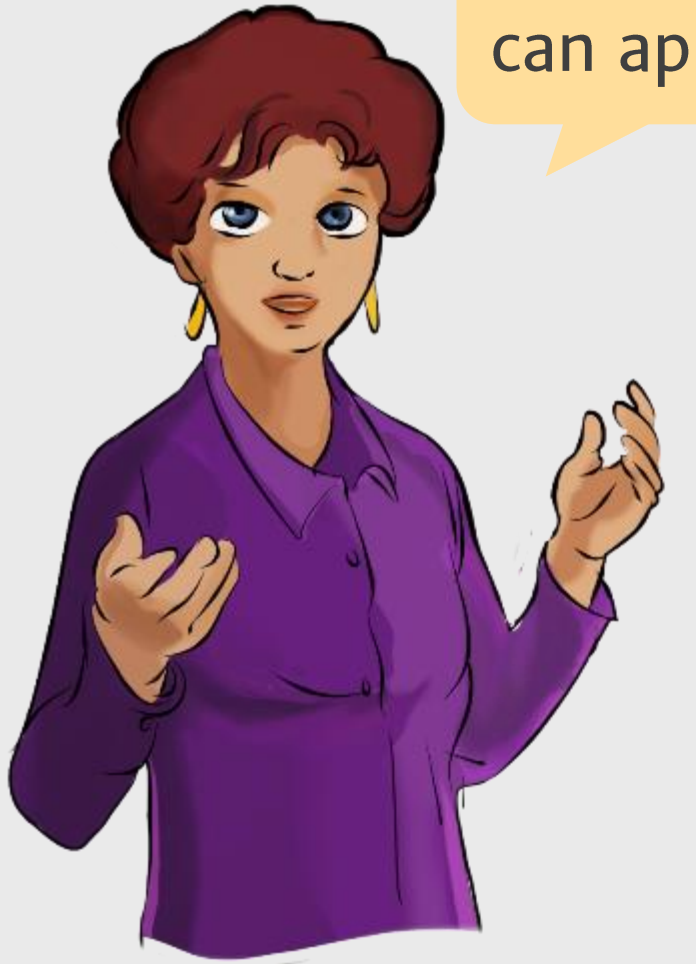
2. Then, sum emissions from all defined livestock categories to determine total national emissions from enteric fermentation.

$$\text{Total } CH_{4\ \text{Enteric}} = \sum_i E_i$$

Equation 10.20

CH_4 from enteric fermentation – How to do at Tier 1

HOW TO DO?



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$$\text{Total } CH_{4\ \text{Enteric}} = \sum_i E_i$$

Equation 10.20

CH_4 from enteric fermentation – Why at Tier 2

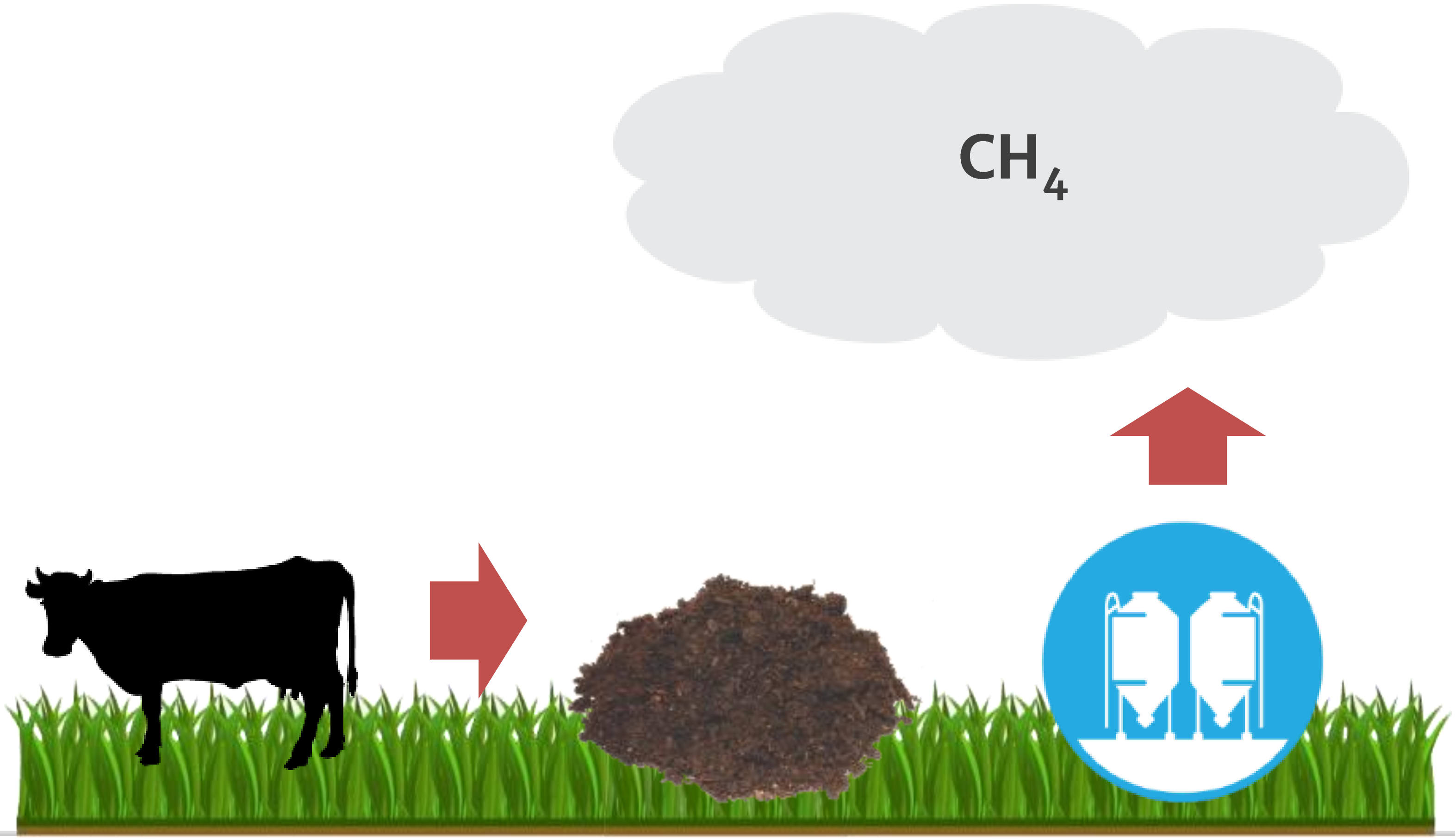
Reflect a country's national circumstance and actual production systems

Allow development of tailored national policy to accelerate productivity gains and enhance credibility of policy measures

Allow a much wider range of potential mitigation actions to be capture

CH_4 from manure management

CH_4 is generated during the storage and treatment of manure, produced from decomposition of manure under low oxygen or anaerobic conditions.



These conditions often occur when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed in lagoons or other types of MMS.

At Tier 1 the amount of CH_4 produced is a function of:

- number of animals;
- amount of manure produced; and
- temperature.

At higher tiers the amount is also a function of:

- type of MMS;
- portion of manure that decomposes anaerobically; and
- retention time.

CH_4 from manure management – How to do

The information needed was described in steps 1 to 4. In particular step 4 is pertinent to this methodology indicating how to stratify the animals by temperature...

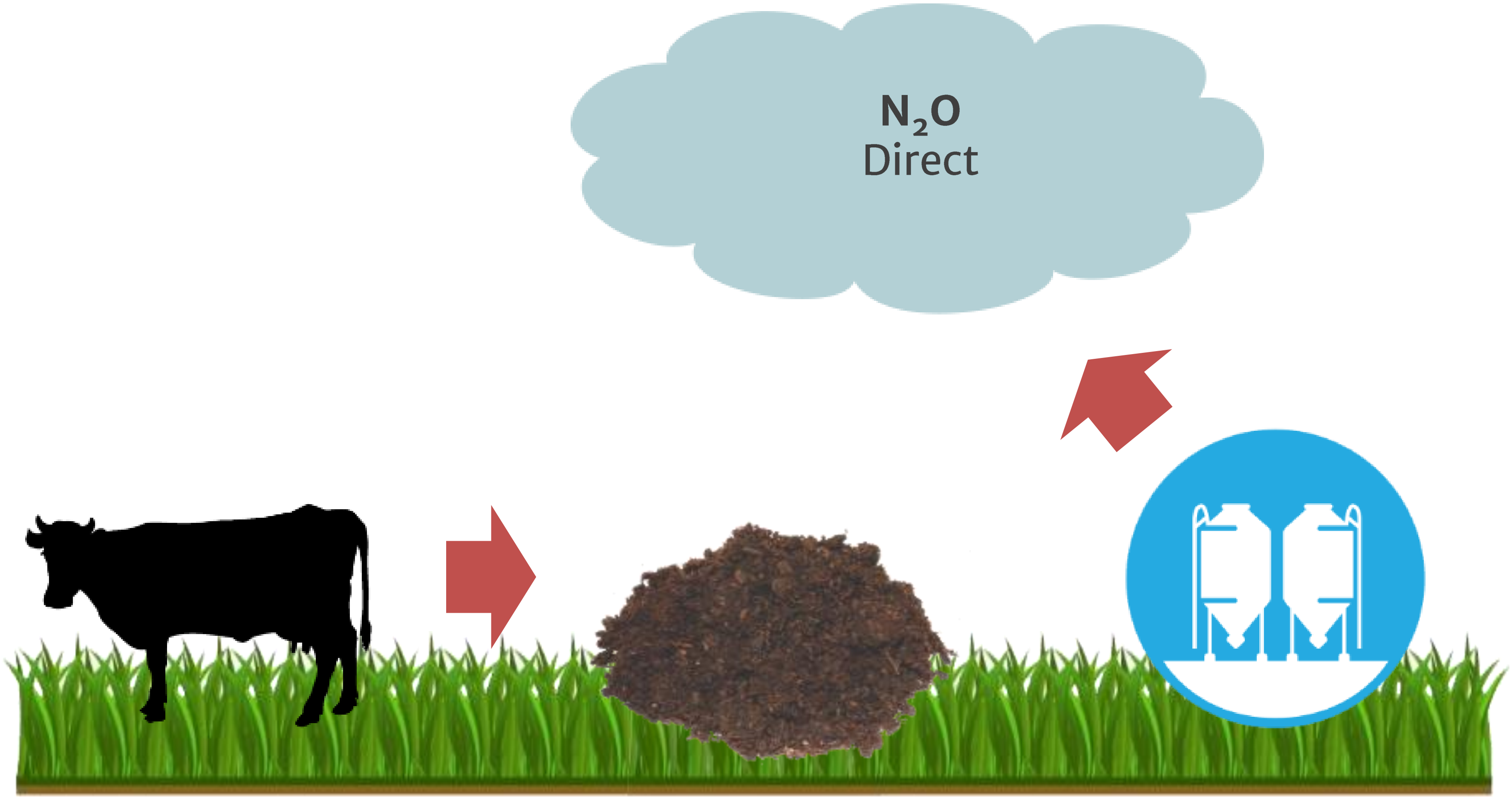
1. For each livestock category, calculate the emissions by multiplying the respective emission factor by the AAP, both stratified by AAT.
2. Then, sum emissions from all defined livestock categories to determine total national emissions.

$$CH_{4\ Manure} = \sum_{(T)} \left(\frac{EF_{(T)} \cdot N_{(T)}}{10^6} \right)$$

Equation 10.22

Direct N_2O from manure management

Let's begin with emissions directly produced by manure management.



N_2O is emitted directly into the atmosphere during the storage and treatment of manure via combined nitrification and denitrification of N contained in manure.

N_2O emissions are a function of:

- N content of manure;
- duration of storage; and
- type of treatment.

Direct N_2O from manure management – How to do

HOW TO DO?

Collect data on the fraction of manure managed within different management systems is needed.

1 For each MMS, you need to multiply the total amount of N excretion (from all livestock species/categories) managed in it by an emission factor for that type of MMS.

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \right) \right] EF_{3(S)} \right] \cdot \left(\frac{44}{28}\right)$$

Equation 10.25

2 Then, sum emissions over all MMS to obtain the total national emissions.

Direct N_2O from manure management – How to do

HOW TO DO?

$Nex_{(T)}$ Annual N excretion

TAM

Default typical animal mass (TAM) values are provided in Tables 10A-4 to 10A-9 in Annex 10A.2 of the 2006 IPCC Guidelines. However, it is preferable to collect country-specific TAM values due to the sensitivity of N excretion rates to different weight categories.

$$Nex_{(T)} = N_{rate(T)} \cdot \frac{TAM}{1.000} \cdot 365$$

Equation 10.30

N_{rate}

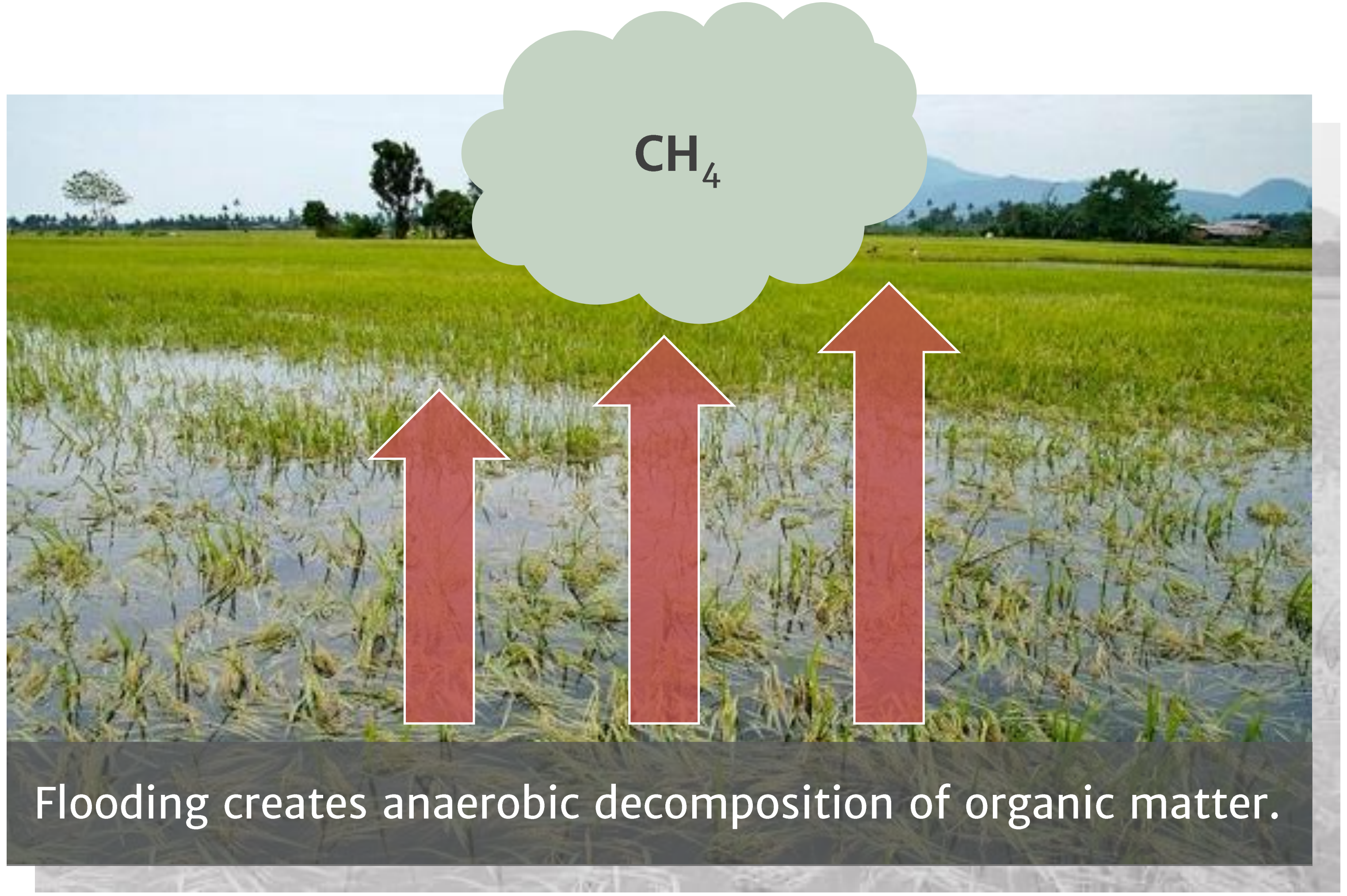
Default N_{rate} are provided in Table 10.19 of the 2006 IPCC Guidelines. These rates are presented in units of nitrogen excreted per 1 000 kg of animal per day. However, country-specific nitrogen excretion rates may be taken directly from documents or reports such as agricultural industry and scientific literature. In some situations, it may be appropriate to use excretion rates developed by other countries that have livestock with similar characteristics.

CH_4 from rice cultivation

CH_4 emissions from rice cultivation are produced by the anaerobic decomposition of organic matter in flooded lands. CH_4 is released into the atmosphere through: diffusion loss across the water surface, bubbles, and rice plants **themselves**, which is the most common.

The annual amount of CH_4 emissions from a given area of rice is a function of:

- Cultivation period (days).
- Water regimes (**before** and **during** cultivation period).
- Organic amendments applied to the soil.
- Others (soil type, temperature, rice cultivar).



Flooding creates anaerobic decomposition of organic matter.

It is important to note that upland rice fields do not produce significant quantities of CH_4.

CO_2 from rice cultivation – How to Do

This is the formula to estimate emissions from rice cultivation and the steps to follow.

$$CH_{4\ Rice} = \sum_{i,j,k} (EF_{i,j,k} \cdot t_{i,j,k} \cdot A_{i,j,k} \cdot 10^{-6})$$

Equation 5.1

1. Due to the complexity and variability of rice production management, it is good practice to disaggregate hierarchically the total harvested area into sub-units according to the ***i***, ***j*** and ***k*** conditions (ecosystems, water regimes, type and amount of organic amendments), as well as the cultivation period and the emission factor (e.g., harvested areas under different water regimes).
2. For each sub-unit, calculate the emissions by multiplying the respective emission factor by the cultivation period (t) and the annual harvested area (A).
3. Then, sum the emissions from each sub-unit of harvested area to determine the total annual national emissions in rice cultivation.

3B Land-related emissions

- listen about new terms as carbon pools, land representation
- learn the data necessary for emissions calculations; and
- identify how to apply procedures and approaches

Introduction

The land use sector accounts for…

…**GHG emissions to the atmosphere** caused by losses of organic matter from terrestrial ecosystems…

… and for carbon dioxide (CO_2) **removals from the atmosphere** as uptaken by vegetation and stored in the organic matter.

Organic matter is composed of organic compounds that are part of organisms such as plants and their remains. It has a very heterogeneous and complex chemistry, which is essentially composed of the four elements below; their average weight shares in organic matter are also provided.

Carbon (C): 45–55%	Hydrogen (H): 3–5%
Oxygen (O): 35–45%	Nitrogen (N): 1–4%

These elements are constituents of the three important GHG below, that are to be reported in the land use sector.

CO_2 Carbon dioxide

CH_4 Methane

N_2O Nitrous Oxide

Carbon pools

Since C is the most relevant component of the organic matter, the amount of organic matter in an ecosystem is regarded as a C Stock that can be stratified into six so-called C pools listed below:

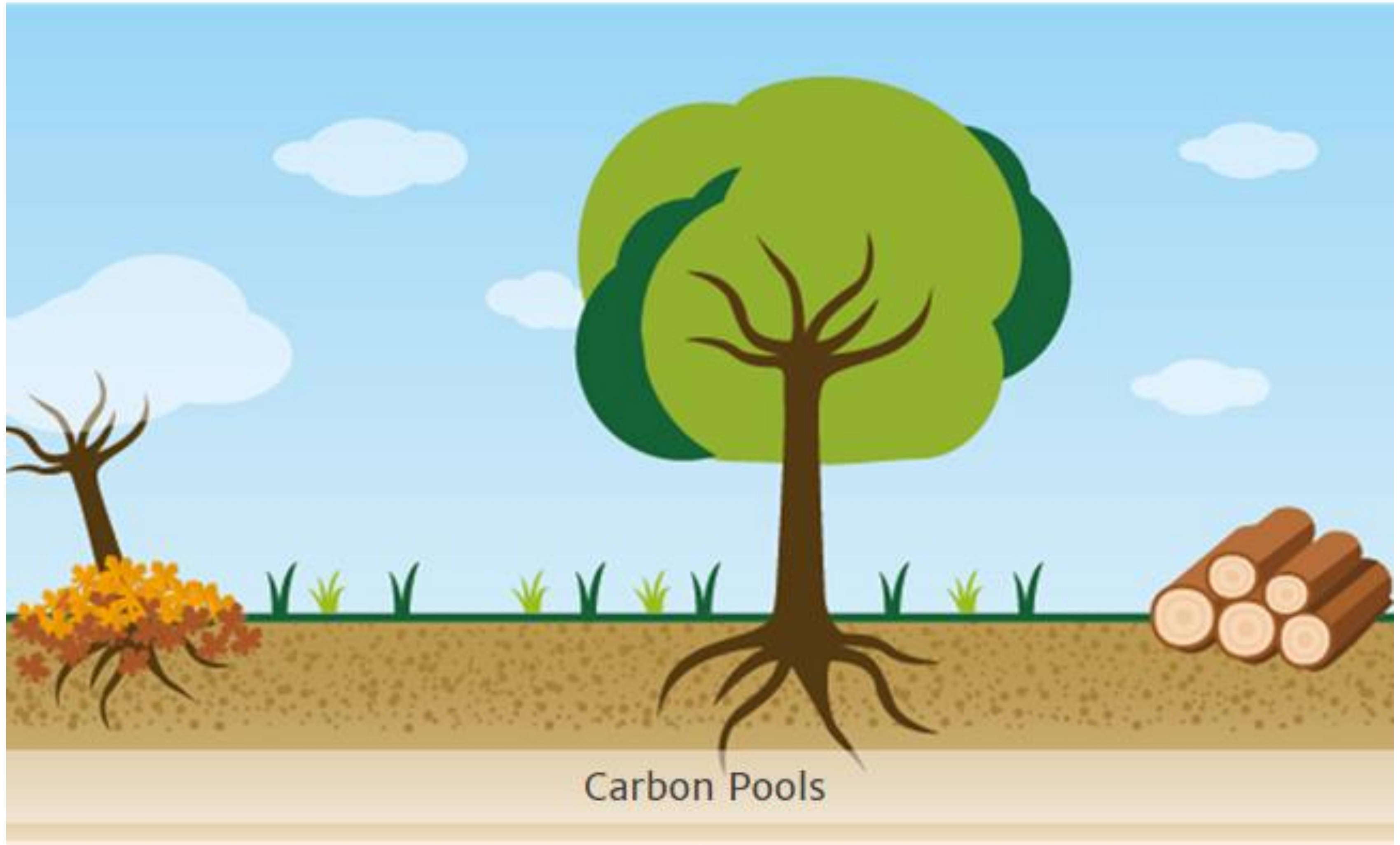
Living Biomass (LB) includes:

1. Above-Ground Biomass (AB)
2. Below-Ground Biomass (BB)

Dead Organic Matter (DOM) includes:

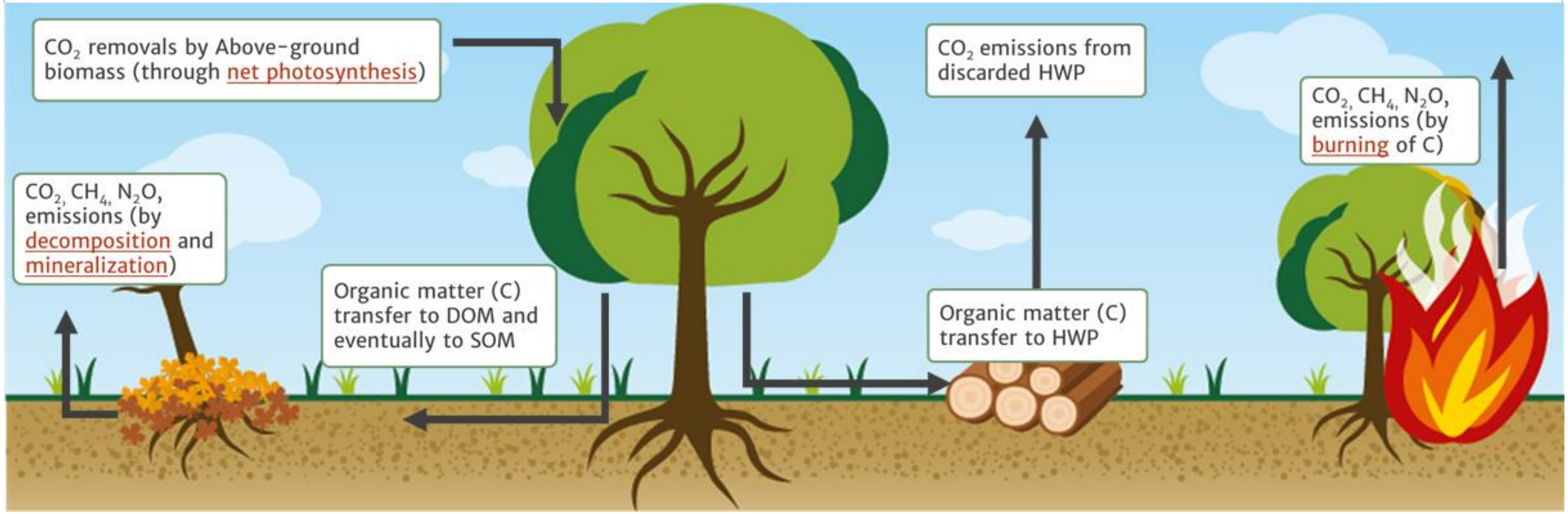
3. Dead Wood (DW)
4. Litter (LI)

5. Soil Organic Matter (SOM)
6. Harvested Wood Products (HWP)



Carbon stock transfer

Here are three examples of natural processes or human activities that generate C stock changes as a consequence of organic matter transfers between C pools. Each C stock change in a land use category is estimated in an IPCC GHG inventory category, and is associated with the corresponding CO_2, CH_4 and N_2O emission/removal.



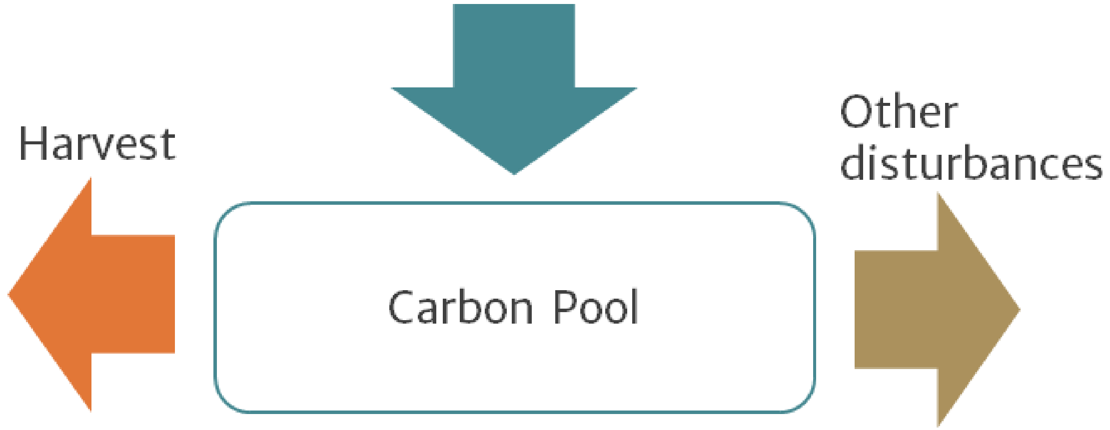
Methodological approaches to estimate C stocks

In the land use sector, carbon stock changes are estimated to derive emissions and removals of CO_2.

The C stock changes are estimated for each carbon pool by using **two generic methodological approaches.**

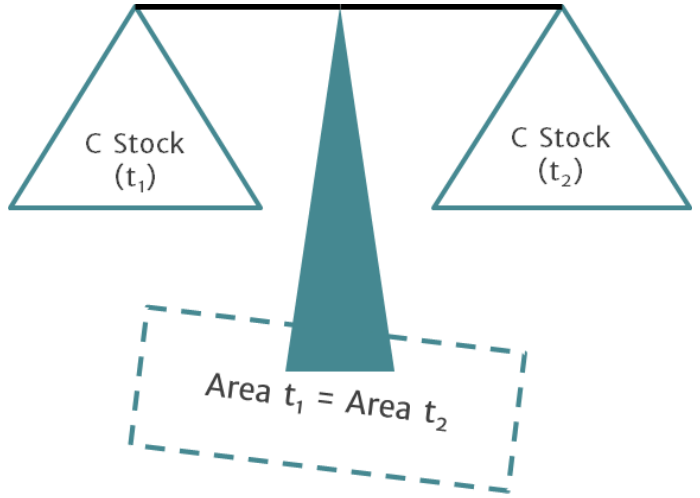
Method 1

Gain and Loss Method is a the process-based approach, which estimates the net balance of C stock additions to and removals from a carbon pool.



Method 2

Stock Difference Method is a stock-based approach, which estimates the difference in C stocks at two points in time.



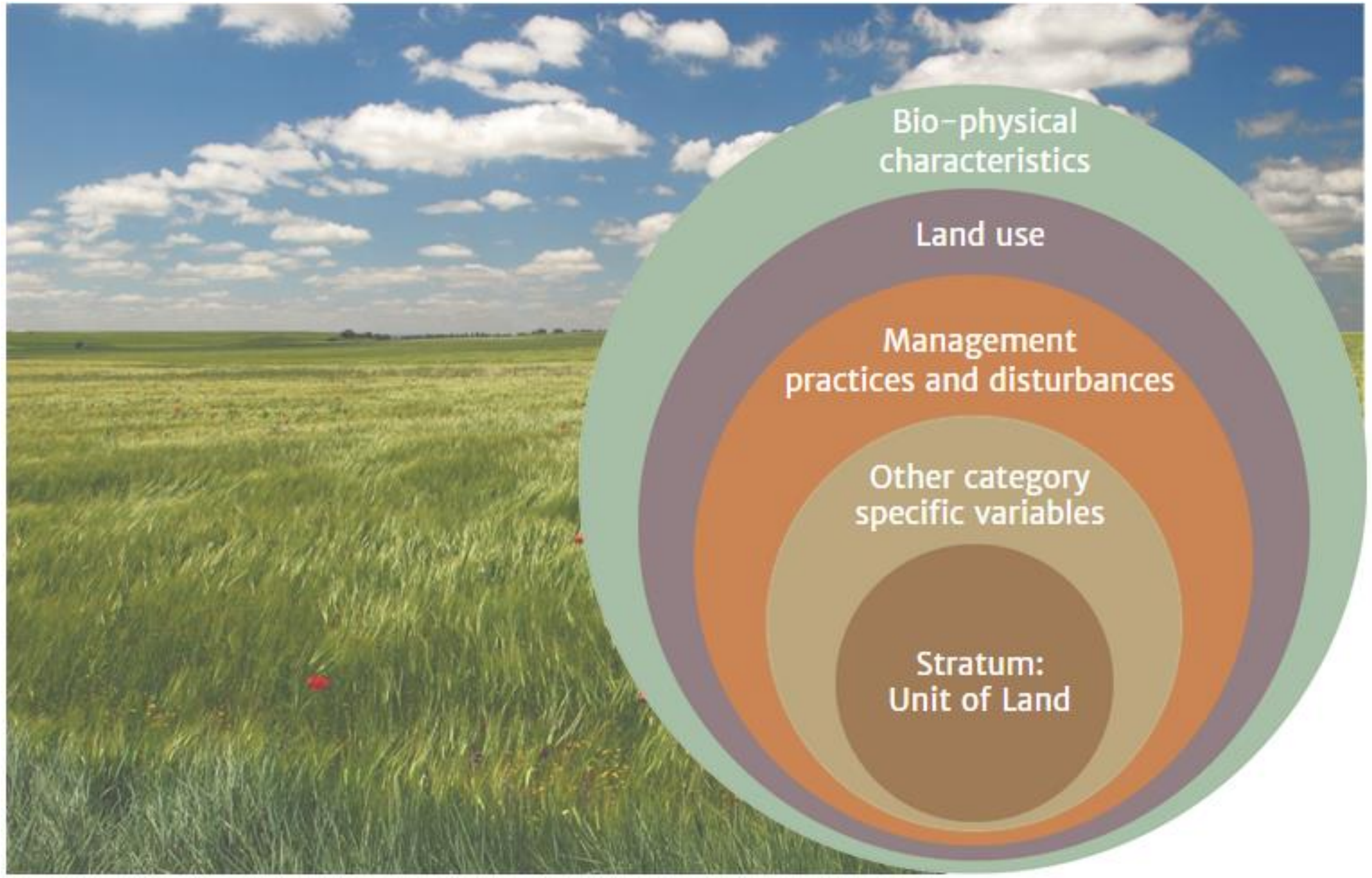
Land representation

Land representation is the analysis undertaken to identify and quantify human activities on land, as well as to track their changes over time.

The land representation results in a **stratification** of the total area of the country into **strata**, homogeneous for a number of variables, that explain the current level and dynamic of C stocks within the stratum, with the purpose of making the GHG inventory compilation practicable while enhancing accuracy of GHG estimates.

Land is characterized by bio-physical variables and various human activities.

The **variables for land stratification** are shown in this image.

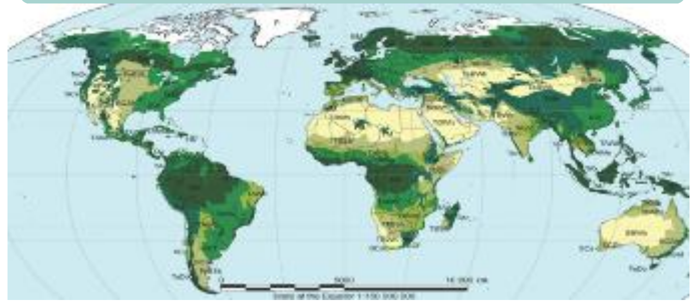


Land representation – Stratification

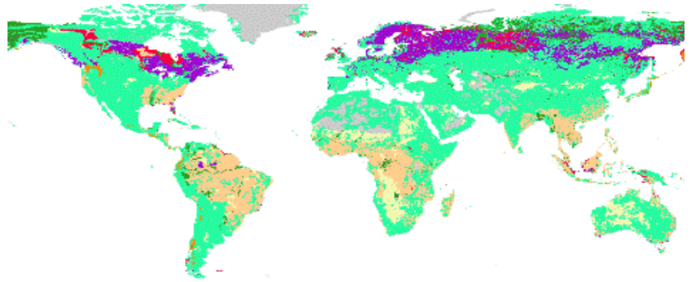
Biophysical characteristics

Climate

Ecological zones



Soil type



Land Use

Managed vs Unmanaged

Six Land Use Categories
(Forest land, Cropland, Grassland, Wetlands, Settlements, Other land)

Historical Land Use
- Land remaining in a land use category
- Land converted into a new land use category

Management practices and disturbances

Default management systems/ practices
(i.e. managed natural forest/forest plantation, improved grassland, annual/ perennial crop management, peat extraction, prescribed burning, organic fertilization)

Fires
Insects
Wind

Methodological approaches for consistent land representation

The IPCC provides three methodological approaches for land representation.

Approach 1	Data is not spatially explicit, so it does not identify land use/management changes through time.
Approach 2	Data provides spatial information on the land use/management change between 2 points in time, although this approach does not track over time the land converted.
Approach 3	Data provide fully spatially-explicit information on the use/management of each unit of land over the entire time series. So, it is capable to track over time each land converted.

The level of aggregation at which the land representation should be reported in the NGHGI is that of land use categories (the six land remaining categories and the associated thirty land-use change categories).

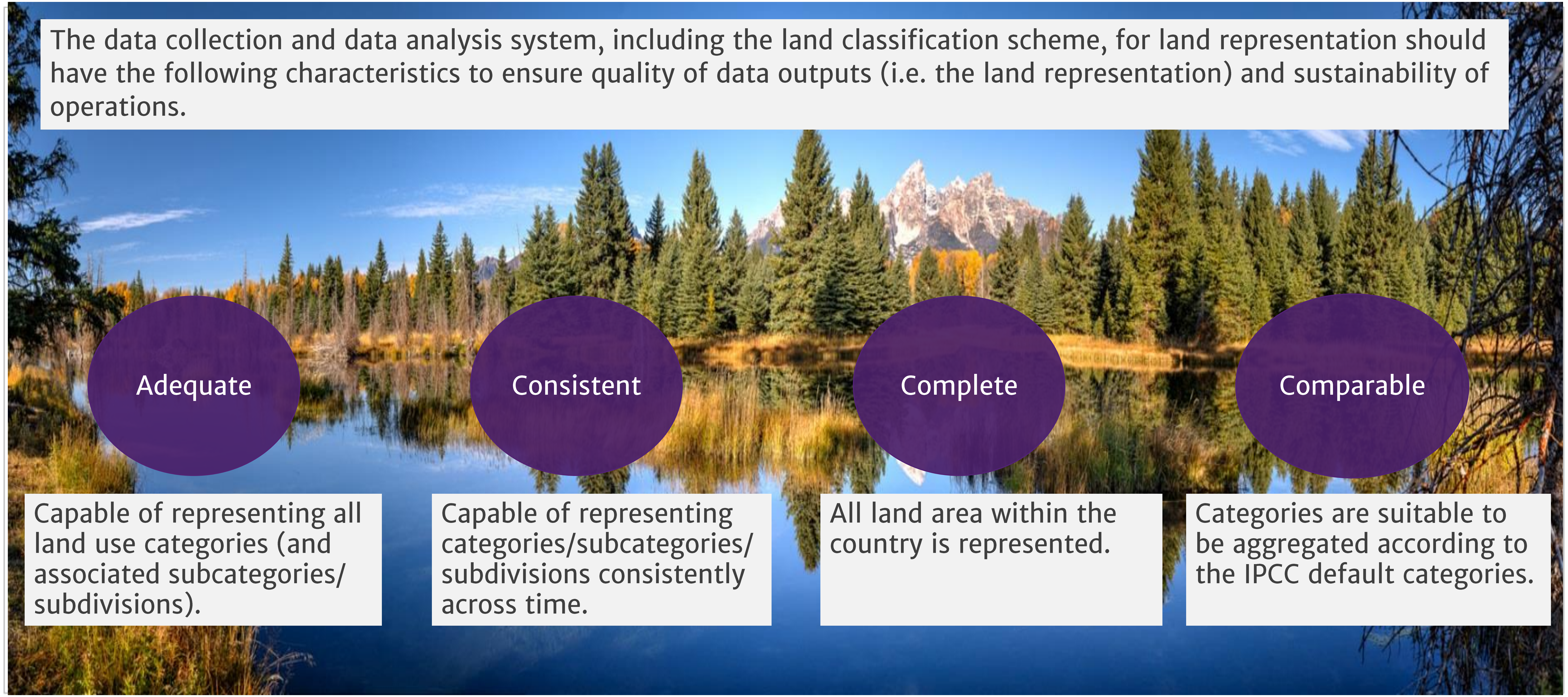
This means that units of land with homogeneous history of use are aggregated under the same land use category (although the units of land within a land use category may differ for other variables, according to the stratification scheme applied).

Annual matrices of land use and land use change

	Hectares	2004									Total
		Unmanaged Forest land	Manged Forest Land	Cropland	Unmanaged Grassland	Managed Grassland	Unmanaged Wetlands	Managed Wetlands	Settlements	Other Land	2005
2005	Unmanaged Forest land	6,308	0	0	0	0	0	0	0	0	6,308
	Manged Forest Land	0	322,330	352	0	0	0	0	0	0	322,682
	Cropland	0	130	324,480	0	260	0	0	0	0	324,870
	Unmanaged Grassland	0	0	0	1,965	0	0	0	0	0	1,965
	Managed Grassland	0	0	708	0	648,840	0	0	0	0	649,548
	Unmanaged Wetlands	0	0	0	0	0	6,254	0	0	0	6,254
	Managed Wetlands	0	0	0	0	0	0	5,191	0	0	5,191
	Settlemen										
	Other Lan										
Total 2004											

Hectares				2005															Total
				Unmanaged Forest land	Managed Forest Land								Cropland		Unmanaged Grassland	Managed Grassland	Unmanaged Wetlands	Managed Wetlands	Settlements	Other Land	2006
					conifer				broadleaves				annual	perennial							
					plantation		natural		plantation		natural										
					20 years ≤	> 20 years	20 years ≤	> 20 years	20 years ≤	> 20 years	20 years ≤	> 20 years									
2006	Unmanaged Forest land			6,178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,178
	Manged Forest Land	conifer	plantation 20 years ≤	0	14,336	0	0	0	0	0	0	0	10	3	0	0	0	0	0	0	14,349
			plantation > 20 years	0	0	7,168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,168
			natural 20 years ≤	0	0	0	17,203	0	0	0	0	0	42	10	0	0	0	0	0	0	17,255
			natural > 20 years	26	0	0	0	68,811	0	0	0	0	0	0	0	0	0	0	0	0	68,837
		broadleaves	plantation 20 years ≤	0	0	0	0	0	28,671	0	0	0	21	5	0	0	0	0	0	0	28,697
			plantation > 20 years	0	0	0	0	0	0	14,336	0	0	0	0	0	0	0	0	0	0	14,336
			natural 20 years ≤	0	0	0	0	0	0	0	34,406	0	83	21	0	0	0	0	0	0	34,510
			natural > 20 years	104	0	0	0	0	0	0	0	137,622	0	0	0	0	0	0	0	0	137,726
	Cropland (annual)			0	0	0	0	0	0	0	0	0	259,013	0	0	566	0	0	0	0	259,579
	Cropland (perennial)			0	0	0	0	0	0	0	0	0	0	64,753	0	142	0	0	0	0	64,895
	Unmanaged Grassland			0	0	0	0	0	0	0	0	0	0	0	1,900	0	0	0	0	0	1,900
	Managed Grassland			0	0	0	0	0	0	0	0	0	208	52	65	648,580	0	0	0	0	648,905
	Unmanaged Wetlands			0	0	0	0	0	0	0	0	0	0	0	0	0	6,254	0	0	0	6,254
	Managed Wetlands			0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,191	0	0	5,191
	Settlements			0	6	3	7	28	12	6	14	55	519	130	0	260	0	0	26,216	0	27,255
	Other Land			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,488	6,488
Total 2005				6,308	14,341	7,171	17,210	68,839	28,683	14,341	34,419	137,678	259,896	64,974	1,965	649,548	6,254	5,191	26,216	6,488	1,349,522

System from Land representation



The data collection and data analysis system, including the land classification scheme, for land representation should have the following characteristics to ensure quality of data outputs (i.e. the land representation) and sustainability of operations.

Adequate

Capable of representing all land use categories (and associated subcategories/ subdivisions).

Consistent

Capable of representing categories/subcategories/ subdivisions consistently across time.

Complete

All land area within the country is represented.

Comparable

Categories are suitable to be aggregated according to the IPCC default categories.

System from Land representation

When preparing a land representation of a country’s area various datasets are likely integrated. In doing so the following guidance should be applied.

Accuracy
Assess the accuracy of each dataset.

Consistency
Assess the time series consistency of each dataset.

Completeness
Assess the time series length and completeness of each dataset

Suitability
On the basis of assessed accuracy, consistency and completeness of datasets, establish a hierarchy among them. So that in case of inconsistencies among datasets the one highest in the hierarchy prevails.

Generic methodological approaches to estimate emissions/removal

To prepare a GHG estimates for a land you need to have activity data, mostly areas of strata, and emission(/removal) or C stock change factors associated to each specific stratum.

Activity Data (Areas)

Area data for at least two points in time from the inventory time series are needed.

Emission Factors (or Carbon Stock-Change Factors)

For each stratum identified, a corresponding emission or carbon-stock-change factor should be available.

IPCC default factors are built for the IPCC default stratification (to be carried out using Tier 1) that includes: climate zones, soil types, ecological zones and management system/practices; so that there is no ambiguity in the selection of IPCC default data to implement IPCC methods.

However, IPCC default factors cannot be applied as they are to country-specific strata. In such case, the availability of both area data and emission factors to be associated with each stratum must be considered when adding further level of stratification to the land representation.

Generic methodological approaches to estimate emissions/removal

The total net C stock change of a stratum is estimated using equation 2.3 shown below.

$$\Delta C_{LU_i} = \Delta \mathrm{C}_{\mathrm{AB}} + \Delta \mathrm{C}_{\mathrm{BB}} + \Delta \mathrm{C}_{\mathrm{DW}} + \Delta \mathrm{C}_{\mathrm{LI}} + \Delta \mathrm{C}_{\mathrm{SOM}} + \Delta \mathrm{C}_{\mathrm{HWP}}$$

Equation 2.3

The total C stock change of a land use category as the sum of all C stock changes estimated for the strata belonging to the category is estimated using the equation 2.2.

$$\Delta C_{LU} = \sum_i \Delta C_{LU_i}$$

Equation 2.2

Finally, the total C stock change of the entire land use sector is calculated as the sum of net C stock change of each land use category as shown in equation 2.1.

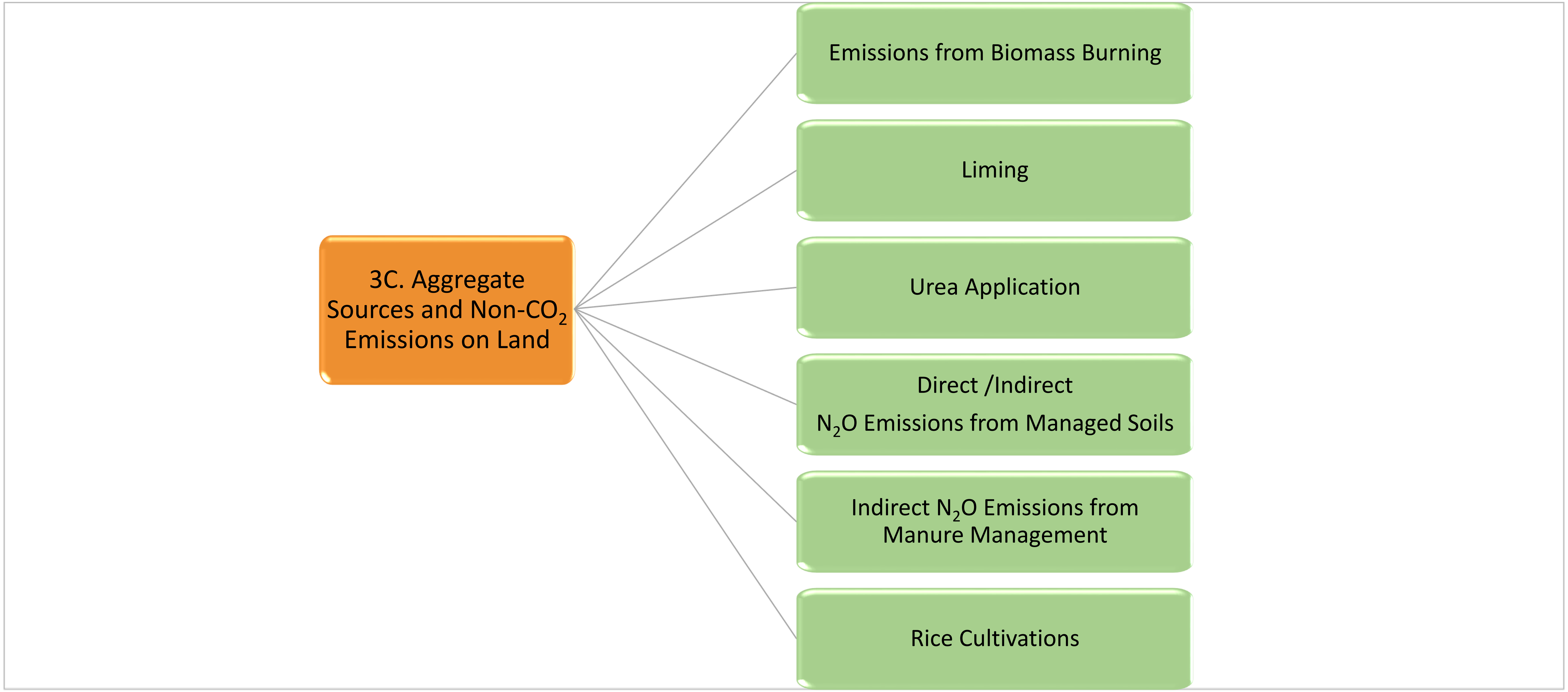
$$\Delta \mathrm{C}_{\mathrm{AFOLU}} = \Delta \mathrm{C}_{\mathrm{FL}} + \Delta \mathrm{C}_{\mathrm{CL}} + \Delta \mathrm{C}_{\mathrm{GL}} + \Delta \mathrm{C}_{\mathrm{WL}} + \Delta \mathrm{C}_{\mathrm{SL}} + \Delta \mathrm{C}_{\mathrm{OL}}$$

Equation 2.1

3C Aggregate sources and non-CO_2 emissions on land

- understand which are the sources of emissions of this category;
- learn the data necessary for emissions calculations; and
- identify how to apply procedures and approaches

Aggregate sources and non-CO2 emissions on land



Emissions from Biomass Burning

GHG emissions from on-site burning of organic matter (biomass, DOM, SOM peatlands) include CH_4, N_2O and CO_2, produced by following activities

Managed forests

Deforestation of formerly managed forest

Unmanaged forests

Deforestation of formerly unmanaged forest

Annual biomass

Savanna/Shrubland

Crop residues

Peatlands

Emissions from Biomass Burning – How to Do

The amount of emissions is a function of the following information:

- Area burnt
- Density of fuel (biomass) present on the area

- Carbon content
- Moisture content of the fuel

- Type of fire
- Completeness of combustion

This is the formula to estimate emissions from fire and these are the steps to follow...

$$L_{fire} = A \cdot M_B \cdot C_f \cdot G_{ef} \cdot 10^{-3}$$

Equation 2.27

Activity data (A) | Fuel biomass consumption ($M_B \cdot C_f$) | Emission factor (G_{ef})

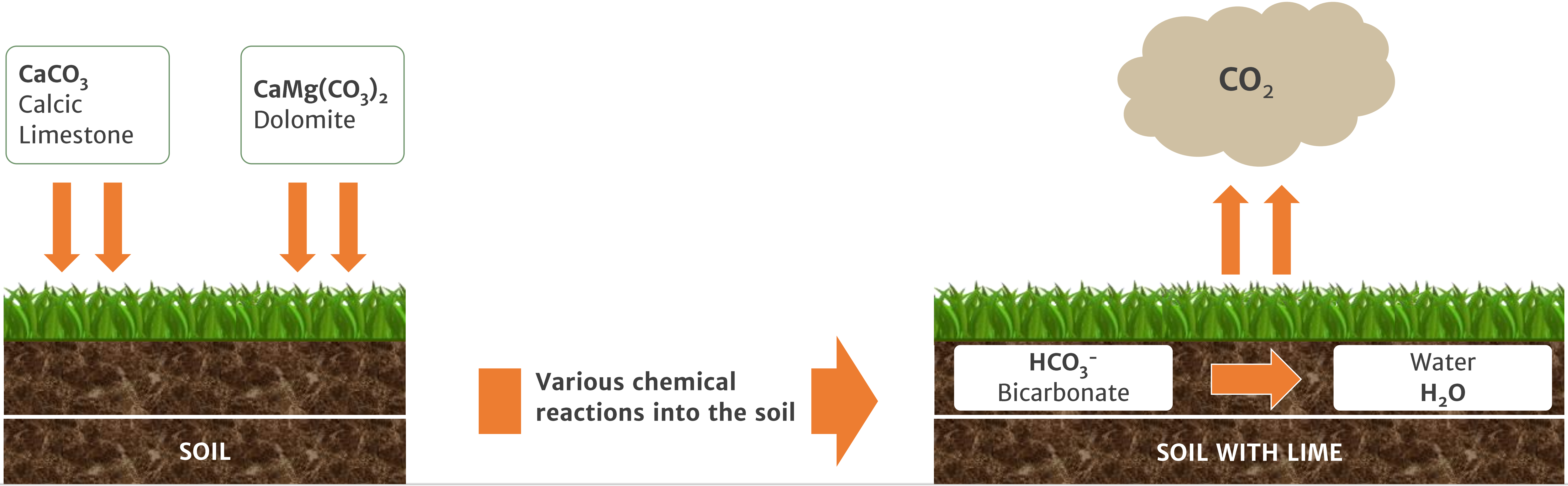
1 First, multiply the area burnt (A) by the mass of fuel available for combustion (M_B) and the combustion factor (C_f).

2 Then, multiply by the emission factor (G_{ef}), and lastly by 10^{-3} as a dimensionless conversion factor to convert kg to tonnes.

CO_2 from liming

Liming is used to reduce soil acidity and improve plant growth in agricultural lands and managed forests.

Adding carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$) leads to carbon dioxide (CO_2) emissions as the carbonate limes dissolve and release bicarbonate (**HCO_3^-**), which evolves into CO_2 and water (H_2O). Also organic materials are used as calcic amendments of soil, although IPCC default methodology considers only lime and dolomite since the organic matter is assumed to be C neutral.



CO_2 from liming – How to Do

This is the formula to estimate emissions from liming and the steps to follow.

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

Equation 11.12

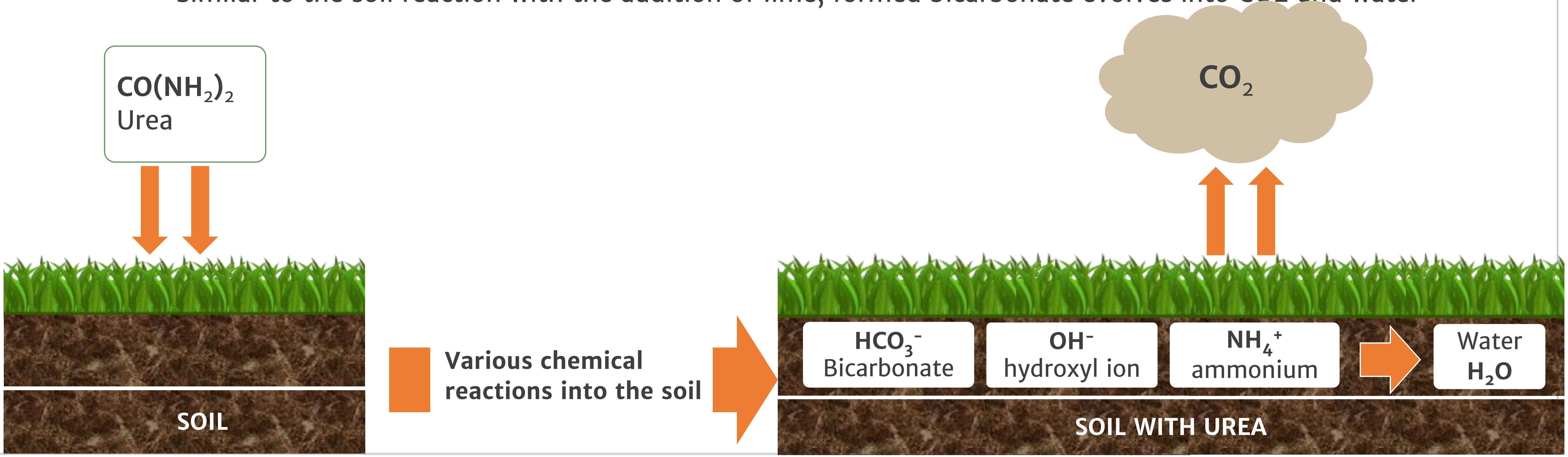
1. Find the annual amount of calcic limestone and multiply it by the respective emission factor.
2. Find annual amount of dolomite and multiply it by the respective emission factor.
3. Then, sum the two values to determine the total national emissions from liming.

CO_2 from urea application

Urea $CO(NH_2)_2$ is a fertilizer that leads to emissions of N_2O (these emissions are estimated as direct and indirect N_2O emissions in the managed soil as synthetic fertilizers) and CO_2.

Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process.

Once in the soils, urea is converted into ammonium (NH_4+), hydroxyl ion (OH−), and bicarbonate (HCO_3−). Similar to the soil reaction with the addition of lime, formed bicarbonate evolves into CO2 and water



CO_2 from urea application – How to Do

This is the formula to estimate emissions from urea application and the steps to follow.

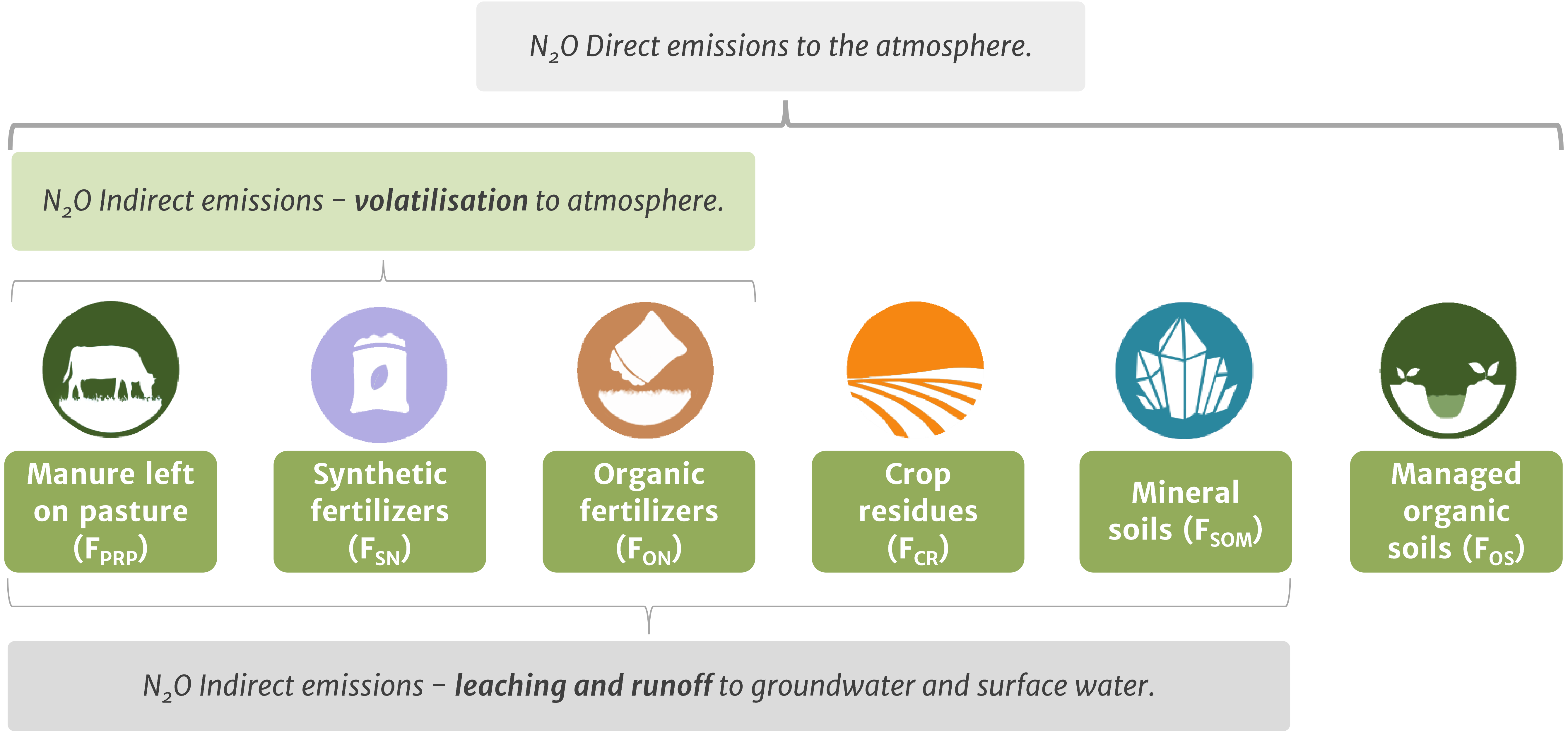
$$CO_2\text{–}C\ Emission = M \cdot EF$$

Equation 11.13

1 Find the annual amount of urea and multiply it by the respective emission factor.

Direct and Indirect N_2O from managed soils

The following scheme shows the pathway of N_2O emissions by source.



Direct N_2O from managed soil – How to do

HOW TO DO?

This is the equation to calculate direct N_2O emissions from managed soil.

As you can see, it is the sum of emissions from different activities.

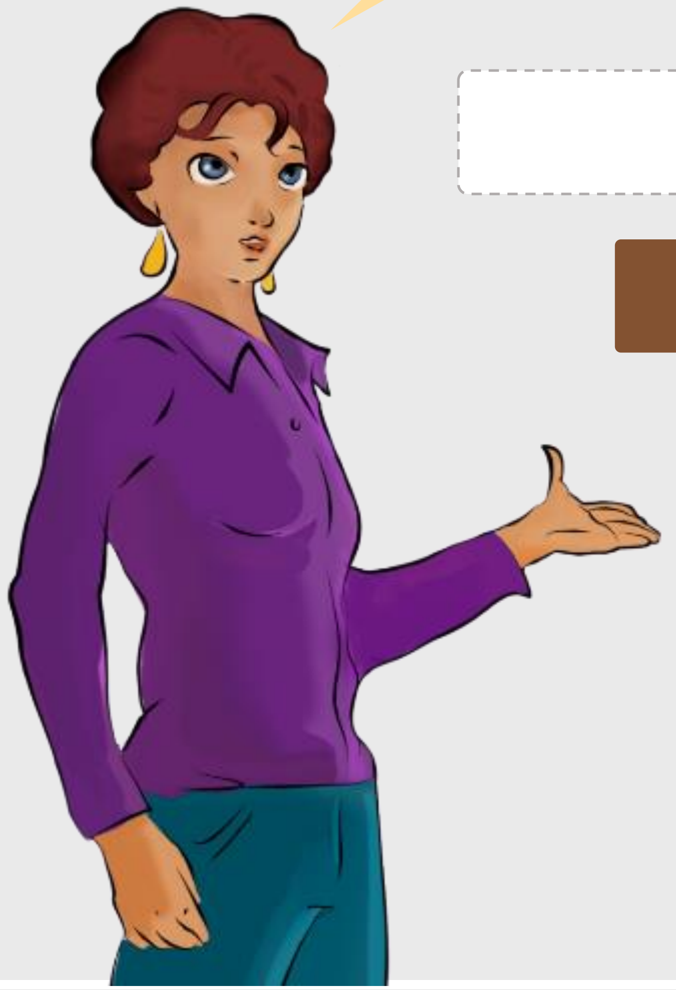
$$N_2O_{Direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Equation 11.1

- $N_2O - N_{N\ inputs}$: Emissions from N input
- $N_2O - N_{OS}$: Emissions from organic soils
- $N_2O - N_{PRP}$: Emissions from manure left on pasture

Indirect N_2O from managed soil – How to do

This is the equation to calculate indirect N_2O emissions from managed soil, associated with atmospheric deposition of N volatilised (ATD). It includes **activity data**, **volatilisation fractions** and **emission factor**.



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

Equation 11.9

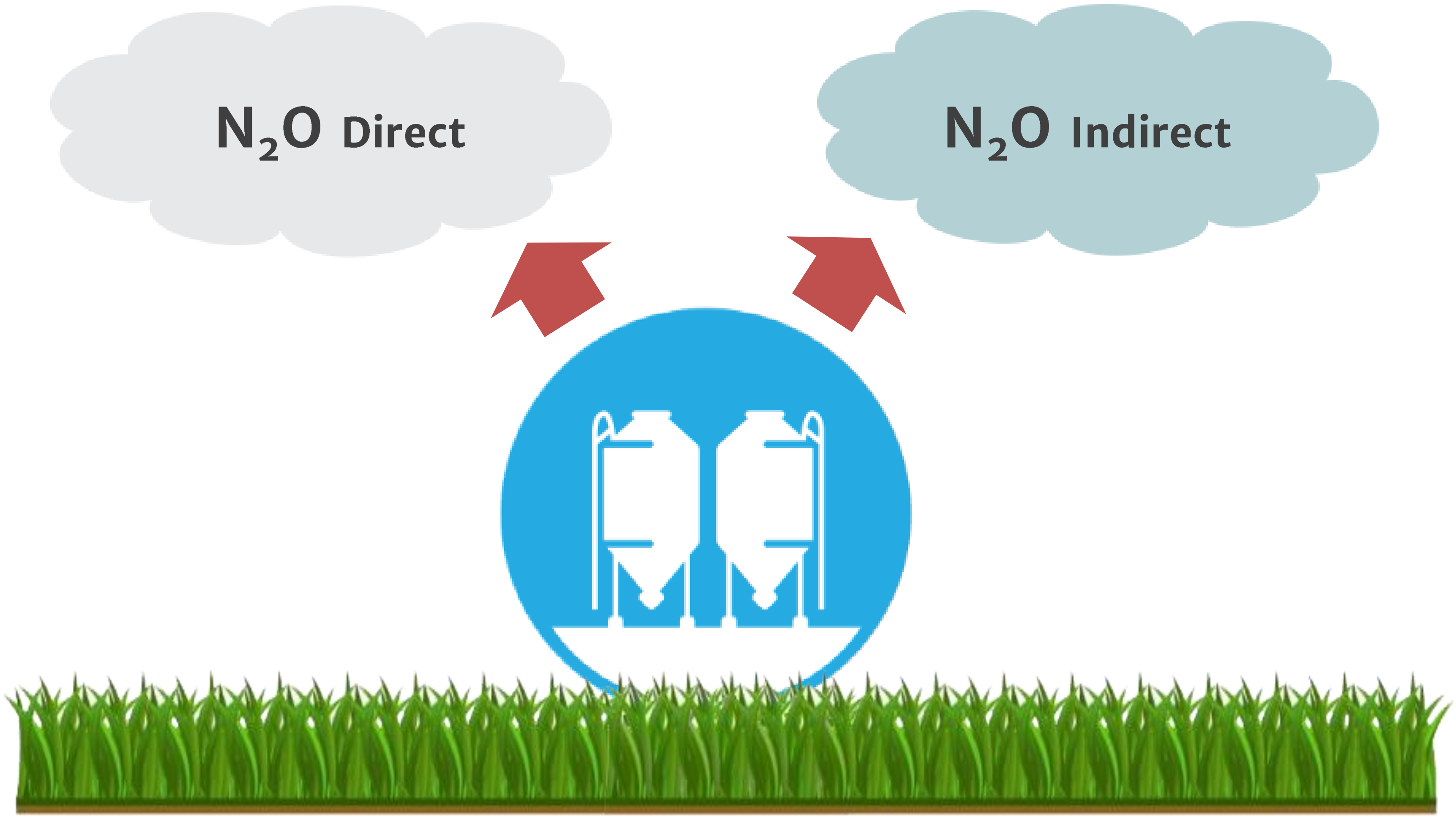
1 Multiply and sum the N amount from the sources by a volatilisation fraction. The resulting figure is multiplied by an emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces.

2 Then, perform the conversion of $N_2O_{(ATD)}$–N emissions to $N_2O_{(ATD)}$ emissions for reporting purposes by using the following equation:

$$N_2O_{(ATD)} = N_2O_{(ATD)} - N \cdot \frac{44}{28}$$

Indirect N_2O from manure management

Indirect N_2O emissions result from volatile N losses that occur primarily in the forms of ammonia and nitric oxide.



N_2O is **emitted indirectly**, as a fraction of N that **volatilises** as ammonia or nitric oxide and **deposes** afterwards on the ground. Moreover another fraction **leaches** from the system into the soil (leaching), going into the water bodies (run off).

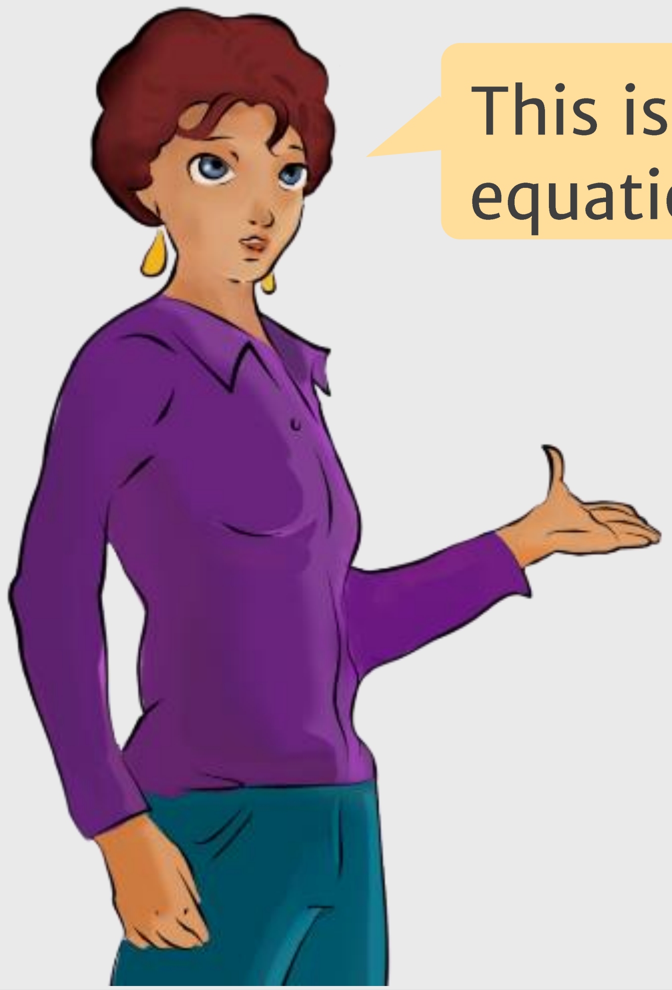
Indirect N_2O emissions are function of:

- temperature; and
- duration of storage.

Using a **Tier 1 method**, for manure management, only indirect emissions from volatilization and deposition have to be estimated.

Indirect N_2O from manure management – How to do

To calculate indirect N_2O emissions from manure management has to be applied two equations



This is the first equation...

1

For each MMS, the amount of ammonia and nitric oxide that volatilizes is estimated by multiplying the total amount of N excreted and managed (from all livestock categories) by a volatilization fraction.

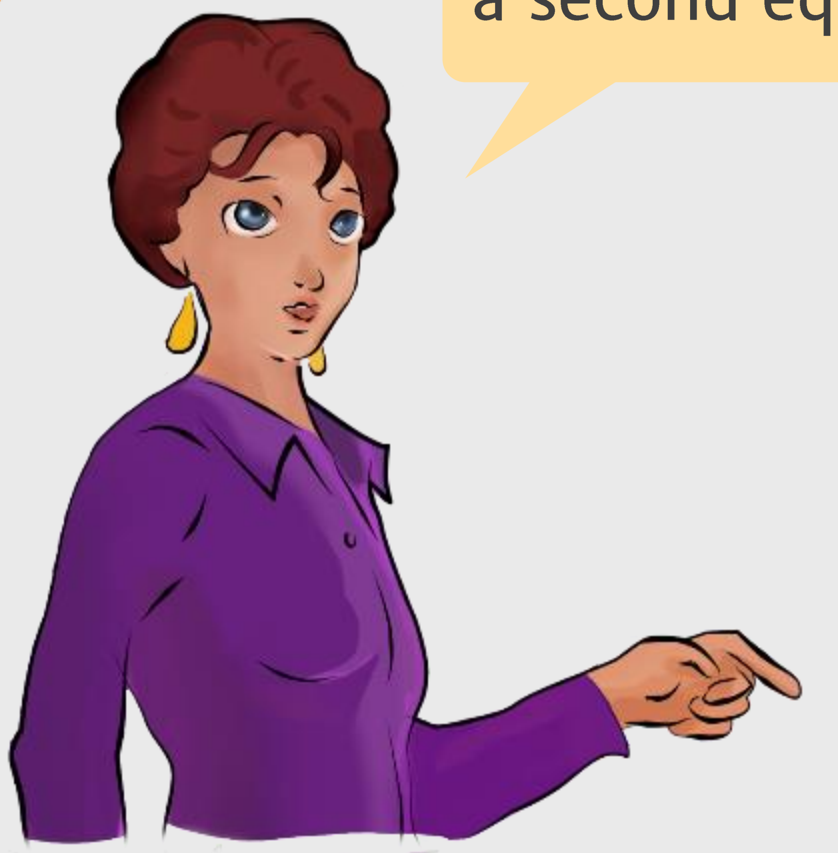
The total amount that volatilises is the sum of all MMS.

$$N_{vol-MMS} = \sum_{S} \left[\sum_{T} \left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \right) \cdot \left(\frac{Frac_{GasMS}}{100} \right)_{(T,S)} \right] \right]$$

Equation 10.26

Indirect N_2O from manure management – How to do

Then you need to apply a second equation.



2

The total amount that volatilises resulting from the previous equation is then multiplied by an emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, determining total national emissions from volatilization.

$$N_2O_{G(mm)} = \left(N_{vol-MMS} \cdot EF_4 \right) \cdot \left(\frac{44}{28}\right)$$

Equation 10.27

Estimation of N losses from leaching and runoff from manure management should be considered part of a Tier 2 or Tier 3 method.

Food and Agriculture Organization of the United Nations

THANKS FOR THE ATTENTION

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