Methane Emission from Rice Cultivation

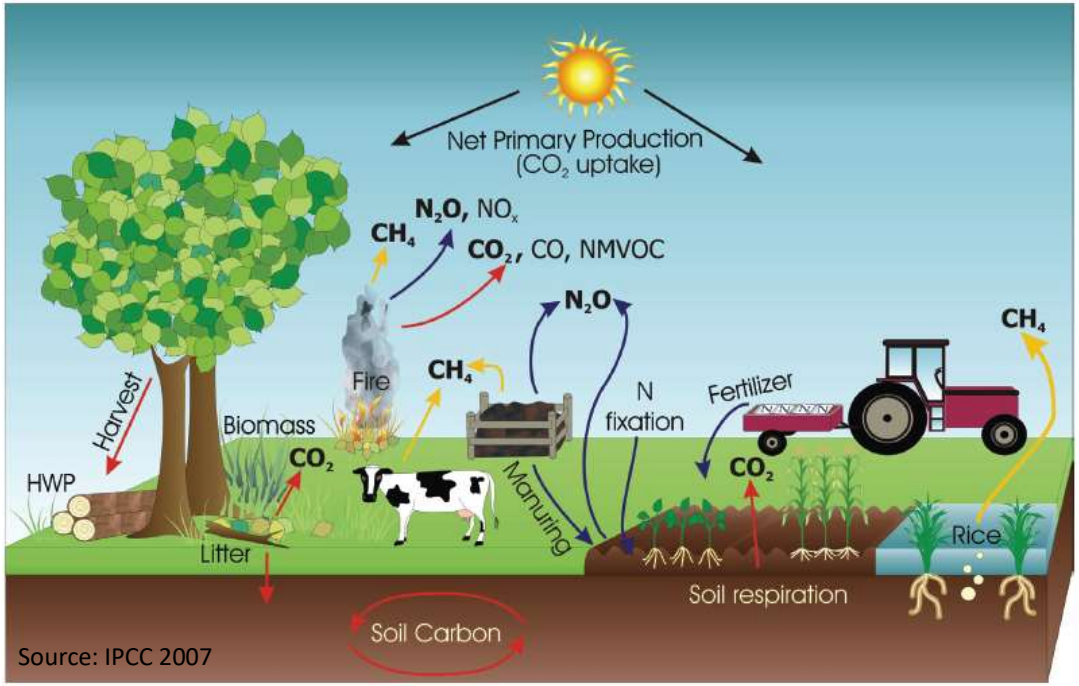
(Capacity Building Program for Indian Experts on National Greenhouse Gas Inventory Preparation as per Enhanced Transparency Framework Guidelines, 25 April 2024 – 1 May 2024, Indian Institute of Technology Gandhinagar, Gujarat, India)

Leandro Buendia, Consultant

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)

Methane (CH4) Emission from Rice Cultivation

EQUATION 5.1
CH_4 EMISSIONS FROM RICE CULTIVATION

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

Where:

$CH_{4\ Rice}$ = annual methane emissions from rice cultivation, Gg CH_4 yr^{-1}

EF_{ijk} = a daily emission factor for *i*, *j*, and *k* conditions, kg CH_4 ha^{-1} day^{-1}

t_{ijk} = cultivation period of rice for *i*, *j*, and *k* conditions, day

A_{ijk} = annual harvested area of rice for *i*, *j*, and *k* conditions, ha yr^{-1}

i, *j*, and *k* = represent different ecosystems, water regimes, type and amount of organic amendments, and other conditions under which CH_4 emissions from rice may vary

Methane (CH4) Emission from Rice Cultivation

EQUATION 5.2
ADJUSTED DAILY EMISSION FACTOR

$$EF_i = EF_c \bullet SF_w \bullet SF_p \bullet SF_o \bullet SF_{s,r}$$

Where:

EF_i = adjusted daily emission factor for a particular harvested area

EF_c = baseline emission factor for continuously flooded fields without organic amendments

SF_w = scaling factor to account for the differences in water regime during the cultivation period (from Table 5.12)

SF_p = scaling factor to account for the differences in water regime in the pre-season before the cultivation period (from Table 5.13)

SF_o = scaling factor should vary for both type and amount of organic amendment applied (from Equation 5.3 and Table 5.14)

$SF_{s,r}$ = scaling factor for soil type, rice cultivar, etc., if available

Baseline Emission Factor (EFc)

TABLE 5.11
DEFAULT CH_4 BASELINE EMISSION FACTOR ASSUMING NO FLOODING FOR LESS THAN 180 DAYS PRIOR TO RICE CULTIVATION, AND CONTINUOUSLY FLOODED DURING RICE CULTIVATION WITHOUT ORGANIC AMENDMENTS

	Emission factor	Error range
CH_4 emission (kg CH_4 ha^{-1} d^{-1})	1.30	0.80 - 2.20

Source: Yan et al., 2005

- ✓ Derived from various researches/experiments, in rice fields which are continuously flooded, and without organic amendment
- ✓ Tier 1 method uses the IPCC default EFc value
- ✓ Tier 2 method uses country-specific EFc, based on published research papers

Scaling Factor for Water Regime During Cultivation (SFw)

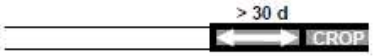
TABLE 5.12
DEFAULT CH_4 EMISSION SCALING FACTORS FOR WATER REGIMES DURING THE CULTIVATION PERIOD RELATIVE TO CONTINUOUSLY FLOODED FIELDS

Water regime		Aggregated case		Disaggregated case	
		Scaling factor (SF_w)	Error range	Scaling factor (SF_w)	Error range
Upland [a]		0	-	0	-
Irrigated [b]	Continuously flooded	0.78	0.62 - 0.98	1	0.79 - 1.26
	Intermittently flooded – single aeration			0.60	0.46 - 0.80
	Intermittently flooded – multiple aeration			0.52	0.41 - 0.66
Rainfed and deep water [c]	Regular rainfed	0.27	0.21 - 0.34	0.28	0.21 - 0.37
	Drought prone			0.25	0.18 - 0.36
	Deep water			0.31	ND

- ✓ When data on specific water regime (**Disaggregated Case**) are not available, **Aggregated Case** factors can be used
- ✓ Tier 1 uses the IPCC default SFw values; Tier 2 uses country-specific SFw based on published research papers.

Scaling Factor for Water Regime Before Cultivation (SFp)

TABLE 5.13
DEFAULT CH_4 EMISSION SCALING FACTORS FOR WATER REGIMES BEFORE THE CULTIVATION PERIOD

Water regime prior to rice cultivation (schematic presentation showing flooded periods as shaded)	Aggregated case		Disaggregated case	
	Scaling factor (SF_p)	Error range	Scaling factor (SF_p)	Error range
Non flooded pre-season <180 d 	1.22	1.07 - 1.40	1	0.88 - 1.14
Non flooded pre-season >180 d 			0.68	0.58 - 0.80
Flooded pre-season (>30 d)[a,b] 			1.90	1.65 - 2.18

[a] Short pre-season flooding periods of less than 30 d are not considered in selection of SFp

[b] For calculation of pre-season emission see below (section on completeness)

Source: Yan *et al.*, 2005

- Non-flooded pre-season < 180 days, often occurs under double cropping of rice;
- Non-flooded pre-season > 180 days, e.g., single rice crop following a dry fallow period
- Flooded pre-season, the minimum flooding interval is set to 30 days; i.e., **shorter flooding periods (usually done to prepare the soil for ploughing) will not be included in this category.**
- When activity data for the pre-season water status are not available, **aggregated case factors can be used**.
- Tier 1 uses the IPCC default SFp values; Tier 2 uses country-specific SFp based on published research papers.

Scaling Factor for Organic Amendment (SFo)

EQUATION 5.3

ADJUSTED CH_4 EMISSION SCALING FACTORS FOR ORGANIC AMENDMENTS

$$SF_o = \left(1 + \sum_i ROA_i \bullet CFOA_i\right)^{0.59}$$

Where:

SF_o = scaling factor for both type and amount of organic amendment applied

ROA_i = application rate of organic amendment i, in dry weight for straw and fresh weight for others, tonne ha^{-1}

$CFOA_i$ = conversion factor for organic amendment i (in terms of its relative effect with respect to straw applied shortly before cultivation) as shown in Table 5.14.

Scaling Factor for Organic Amendment (SFo)

TABLE 5.14
DEFAULT CONVERSION FACTOR FOR DIFFERENT TYPES OF ORGANIC AMENDMENT

Organic amendment	Conversion factor (CFOA)	Error range
Straw incorporated shortly (<30 days) before cultivation[a]	1	0.97 - 1.04
Straw incorporated long (>30 days) before cultivation[a]	0.29	0.20 - 0.40
Compost	0.05	0.01 - 0.08
Farm yard manure	0.14	0.07 - 0.20
Green manure	0.50	0.30 - 0.60

[a] Straw application means that straw is incorporated into the soil, it does not include case that straw just placed on the soil surface, nor that straw was burnt on the field.

Source: Yan *et al.*, 2005

- ✓ Tier 1 uses the IPCC default Conversion Factor for Organic Amendment (CFOA) for estimating SFo values; Tier 2 uses country-specific CFOA based on published research papers
- ✓ Note: CFOA must be derived based on a control treatment i.e. on straw incorporated shortly (<30 days before cultivation)

Other Scaling Factors

Scaling Factor for Soil type (SFs) and rice cultivar (SFr) :

- **2006 IPCC Guidelines have no default values** for SFs and SFr due to large variations in available measured data; Tier 1 is equal to 1 (no effect)
- some countries may have derived SFs and SFr, and published them; can be used as Tier 2 for SFs and SFr

Hands-on exercise …

Using available country-specific data on rice cultivation, let us use the ALU Software to:

1. Characterize rice cultivation by management system (e.g. water management, organic amendment)
2. Assign emission factor, including documentation
3. Calculate methane emission from rice cultivation, and
4. Report activity data, other related information, and estimates in CRT for BTR.