# IPCC 2019 Refinement: AFOLU

## METHANE EMISSIONS FROM RICE CULTIVATION

**Sumana Bhattacharya**

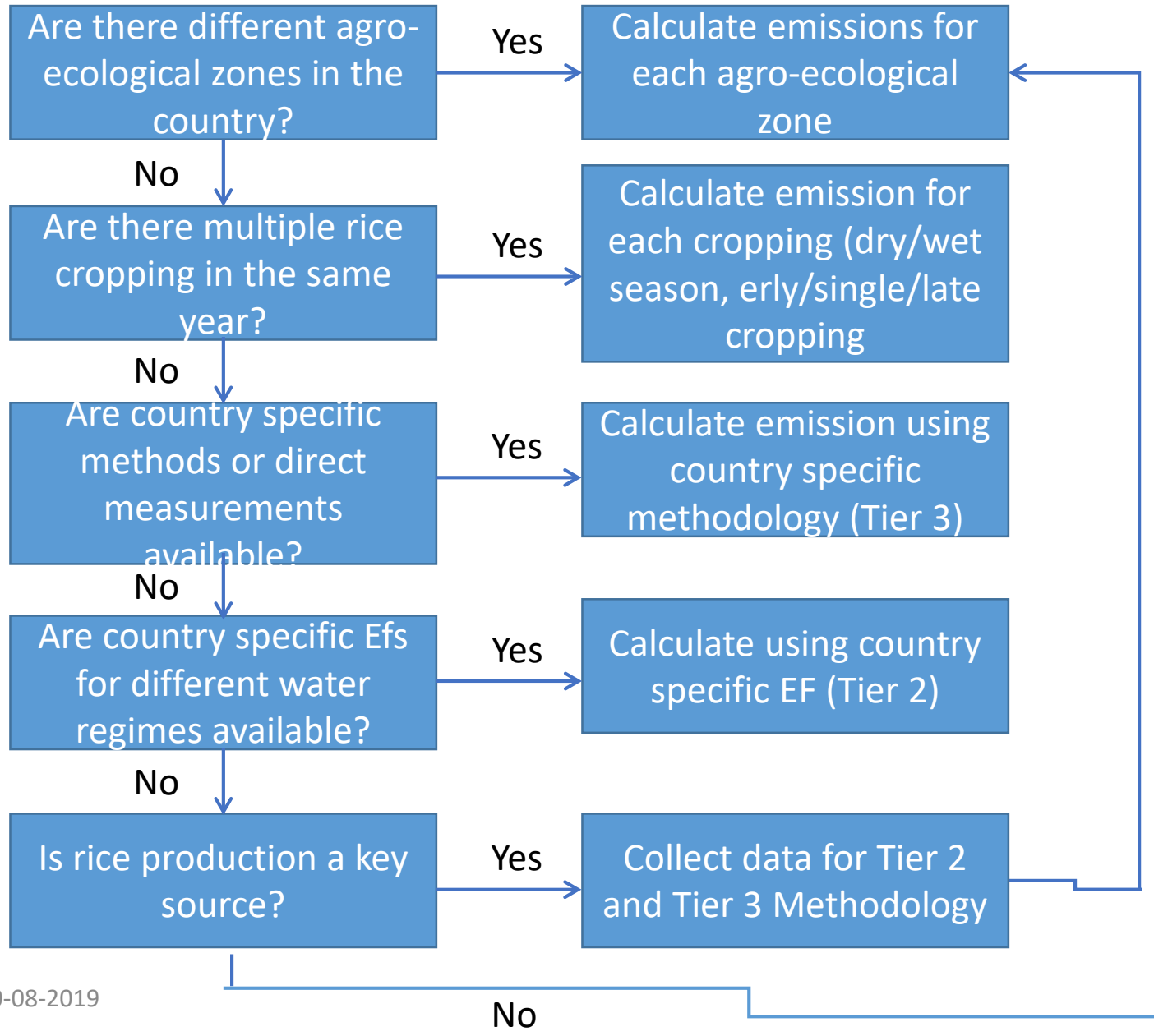
**India**

# Refinements in 2019 Update with Respect to 2006 Guidelines

- Baseline emission factor (EF) at a global scale with new default values at regional scale;
- Scaling factors for water regimes before and during the cultivation periods; and
- Default conversion factors for different types of organic amendments.
- A new table on default cultivation periods, at global and regional scales, is provided, and
- A new section showing an example of how to implement the Tier 1 method.
- Also included is a new box on good practice guidance for developing EFc.

# $CH_4$ Emission from Rice Cultivation: Influencing Condition

- Regional differences in rice cropping practices
- Multiple Crops
- Rice Ecosystems type (continuously and intermittently flooded (irrigated rice), and regular rainfed, drought prone, and deep water (rainfed), according to the flooding patterns during the cultivation period. Also, flooding pattern before cultivation period should be considered )
- Organic amendments to soils (Organic material incorporated into rice soils increases CH4 emissions and can be described by a dose response curve. Organic material incorporated into the soil can either be of endogenous (straw, green manure, etc.) or exogenous origin (compost, farmyard manure, etc.).
- Soil type
- Rice cultivar
- Sulphate containing amendments
- Any other




# Decision Tree:
## Choice of Methodology for Estimating CH4 Emission

# $CH_4$ Emission Calculation Formulae

$$CH_4 = \sum_{ijk} (Ef_{ijk} * t_{ijk} * A_{ijk} * 10^{-6})$$

**Where**

Tier 1: EF= $EFc * SFw * SFp * SFo$ (Updated)

Tier 2: EF = $EFc * SFw * SFp * SFo *$ SFs $*$ SFr (New)

Tier 3: EF is based on models and monitoring networks tailored to address national circumstances of rice cultivation, repeated over time, driven by high-resolution activity data such as satellite-based and in-situ measurement and disaggregated at sub-national level.

**Notation**

$CH_4$ *Rice* = Annual methane emissions from rice cultivation, Gg CH4 yr-1

EF*ijk* = Daily emission factor for *i*, *j*, and *k* conditions, kg CH4 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 CH4 emissions from rice may vary

**Where**

EFi = Adjusted daily emission factor for a particular harvested area

EFc = Baseline emission factor for continuously flooded fields without organic amendments

SFw = Scaling factor for differences in water regime during the cultivation period

SFp = Scaling factor for the differences in water regime in the pre-season before the cultivation period

SFo = Scaling factor for type and amount of organic amendment applied

SFs = Scaling factor for soil type

SFr = Scaling factor for rice cultivar

# 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 (UPDATED: Table 5.11)

| Emission Factor (k CH4/ha/day) | Error range (Kg CH4/ha/day) | Region | Emission factor (kg CH4/ha/day) | Error range Kg CH4/ha/day) |
|---|---|---|---|---|
| 1.19 | 0.80-1.76 | Africa* | 1.19 | 0.80-1.76 |
| | | East Asia | 1.32 | 0.89-1.96 |
| | | Southeast Asia | 1.22 | 0.83-1.81 |
| | | South Asia | 0.85 | 0.58-1.26 |
| | | Europe | 1.56 | 1.06-2.31 |
| | | North America | 0.65 | 0.44-0.96 |
| | | South America | 1.27 | 0.86-1.88 |
| | | | | |

***Note:*** Emission factors and error ranges were estimated based on 95% confidence interval, using statistical model with updated database; See Annex 5A.2 for more information.

*For Africa, the global estimate is used due to lack of data.

# Default Cultivation Period of Rice (New Guidance: Table 5.11A)

| Cultivation Period (days) | Error range (days) | Region | Cultivation Period (days) | Error range (days) |
|---|---|---|---|---|
| 113 | 74-152 | Africa* | 113 | 74-152 |
| | | East Asia | 112 | 73-147 |
| | | Southeast Asia | 102 | 78-150 |
| | | South Asia | 112 | 90-140 |
| | | Europe | 123 | 111-153 |
| | | North America | 139 | 110-165 |
| | | South America | 124 | 110-146 |
| | | | | |

***Note:*** Cultivation period was calculated from updated database, and the error range or uncertainty was based on the 2.5th percentile to 97.5th percentile of the distribution of ratios; See Annex 5A.2 for more information.

*For Africa, the global estimate is used due to lack of data.

# Table 5.12: Default $CH_4$ Emission Scaling Factors for Water Regimes During the Cultivation Period Relative to Continuously Flooded Fields (Updated)

| Water Regime | | Aggregated case | | Disaggregated Case | |
|---|---|---|---|---|---|
| | | Scaling Factor (SFw) | Error Range | Scaling Factor (SFw) | Error Range |
| Upland* | | 0 | - | 0 | - |
| Irrigated** | Continuously Flooded | 0.60 | 0.44 – 0.78 | 1.00 | 0.73-1.27 |
| | Single Drainage period | | | 0.71 | 0.53-0.94 |
| | Multiple Drainage Periods | | | 0.55 | 0.41-0.72 |
| Rainfed and Deep water*** | Regular Rainfed | 0.45 | 0.32 -0.62 | 0.54 | 0.39-0.74 |
| | Drought prone | | | 0.16 | 0.11-0.24 |
| | Deep water | 0.06 | 0.03 -0.12 | 0.06 | 0.03-0.12 |

***Source:*** Scaling factors and error ranges (based on 95% confidential interval) were determined using statistical model and updated database; see Annex 5A.2 for more information.

***Notes:***

* Fields are never flooded for a significant period of time.

** Fields are flooded for a significant period of time and the water regime is fully controlled.

- Continuously flooded: Fields have standing water throughout the rice growing season and may only dry out for harvest (end-season drainage).
- Single drainage period: Fields have a single drainage event and period during the cropping season at any growth stage, in addition to the end of season drainage.
- Multiple drainage periods: Fields have more than one drainage event and period of time without flooded conditions during the cropping season, in addition to an end of season drainage, including alternate wetting and drying (AWD).

*** Fields are flooded for a significant period of time with water regimes that depend solely on precipitation.

- Regular rainfed: The water level may rise up to 50 cm during the cropping season.
- Drought prone: Drought periods occur during every cropping season.
- Deep water rice: Water level rises to more than 50 cm above the soil for a significant period of time during the cropping season.
- Other rice ecosystem categories, like swamps and inland, saline or tidal wetlands may be discriminated within each sub-category

# Table 5.13: Default $CH_4$ Emission Scaling Factors for Water Regimes Before the Cultivation Period (Updated)

| Water regime prior to rice cultivation | Aggregated case | | Dissaggregated Case | |
|---|---|---|---|---|
| | Scaling Factor (SFp) | Error Range | Scaling Factor (SFp) | Error Range |
| Non flooded pre season (<180 days) | 1.22 | 1.08-1.37 | 1.00 | 0.88-1.12 |
| Non flooded pre season( > 180 days) | | | 0.89 | 0.80-0.99 |
| Flooded pre season (>30 days) **a,b** | | | 2.41 | 2.13-2.73 |
| Non-flooded pre season (> 365 days) **c** | | | 0.59 | 0.41-0.84 |

***Source:*** Scaling factors and error ranges (based on 95% confidential interval) were determined using statistical model and updated database; see Annex 5A.2 for more information.

**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)

**c** Refers to "upland crop - paddy rotation" or fallow without flooding in previous year.

# Organic Amendment

$$SFo = (1 + \sum i \text{ROAi} * \text{CFOAi})^{-0.59}$$

**Where**
SFo = 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
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 next table

**Table 5.14: Default Conversion Factors for Different Types of Organic Amendments** (Updated)

| Organic Amendment | Conversion Factor (CFOA) | Error Range |
|---|---|---|
| Straw incorporated shortly (<30 days) before cultivation* | 1.00 | 0.85-1.17 |
| Straw incorporated (>30 days) before cultivation* | 0.19 | 0.11-0.28 |
| Compost | 0.17 | 0.09-0.29 |
| Farm Yard Manure | 0.21 | 0.15-0.28 |
| Green manure | 0.45 | 0.36-0.57 |

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| Green manure | 0.45 | 0.36-0.57 |

Source: Conversion factors and error ranges (based on 95% confidential interval) were determined using statistical model and updated database; see Annex 5A.2 for more information.

* Straw application means that straws are incorporated into the soil. It does not include cases where straws are just placed on soil surface, and straws that were burnt on the field.

# Good Practice Guidance on Developing Baseline Emission Factors for CH4 Emissions From Rice Cultivation Using Closed Chamber Technique for Continuously Flooded Fields with Recommended Fertilizer Application and no Organic Amendment (New Guidance)

Details of

- Chamber Design
- Field Set up and Experimental Design
- Sampling Strategies
- Gas Analysis
- Data Processing
- Deriving Emission Factor
- Reference for more details refer to Minamikawa et al. (2015) and Sanders and Wassmann (2014).

# Table 5.14a: Calculation for Total Harvested Area (New Guidance)

| Rice Ecosystem | Rice Area (ha) | % of Total Area | Cropping Season (per year) | Harvested Area (ha/yr) |
|---|---|---|---|---|
| | **A** | **B** | **C** | **D = (A x C)** |
| Irrigated | | | | |
| - Irrigated Continuously Flooded | 750,000 | 25 | 2 | 1,500,000 |
| - Irrigated with Multiple drainage periods | 750,000 | 25 | 2 | 1,50,000 |
| Rainfed | 900,000 | 30 | 1 | 900,000 |
| Upland | 450,000 | 15 | 1 | 450,000 |
| Deep Water | 150,000 | 5 | 1 | 150,000 |
| **Total** | **3000,000** | **100** | | **4,500,000** |

# Table 5.14 b &C: Calculation for Total Harvested Area (New Guidance)

| Rice Ecosystem- | Baseline Emission Factor (EFc) (kg CH4 ha-1 d-1) [from Table 5.11] | Scaling Factor for Water Regime during Cultivation (SFw) [from Table 5.12] | Scaling Factor for Pre-season Water Regime (SFp) [from Table 5.13] | Scaling Factor for Organic Amendment (SFo) [using Equation 5.4 and Table 5.14] | Adjusted Daily Emission Factor (EFi) [kg CH4 ha-1 d-1] | Cultivation Period (days) | Methane Emissions (Gg CH4 y-1) |
|---|---|---|---|---|---|---|---|
| | **E** | **F** | **G** | **H** | **I** | **J** | **K=(D x I x J)x10 $^{-6}$** |
| Irrigated | | | | | | | |
| - Irrigated Continuously Flooded | 1.22 | 1.00 | 1.00 | 1.21 | 1.48 | 102 | 226.4 |
| - Irrigated with Multiple drainage periods | 1.22 | 0.55 | 1.00 | 1.21 | 0.81 | 102 | 123.93 |
| Rainfed | 1.22 | 0.54 | 0.89 | 1.00 | 0.59 | 102 | 54.16 |
| Upland | 1.22 | 0 | 0.89 | 1.00 | 0.00 | 102 | - |
| Deep Water | 1.22 | 0.06 | 2.41 | 1.00 | 0.18 | 220 | 5.94 |
| TOTAL | | | | | | | 410.47 |