Climate MRV for Africa – Phase 2
Development of National GHG Inventory
Methane Emissions from Rice Cultivation

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Team Leader and Key Experts
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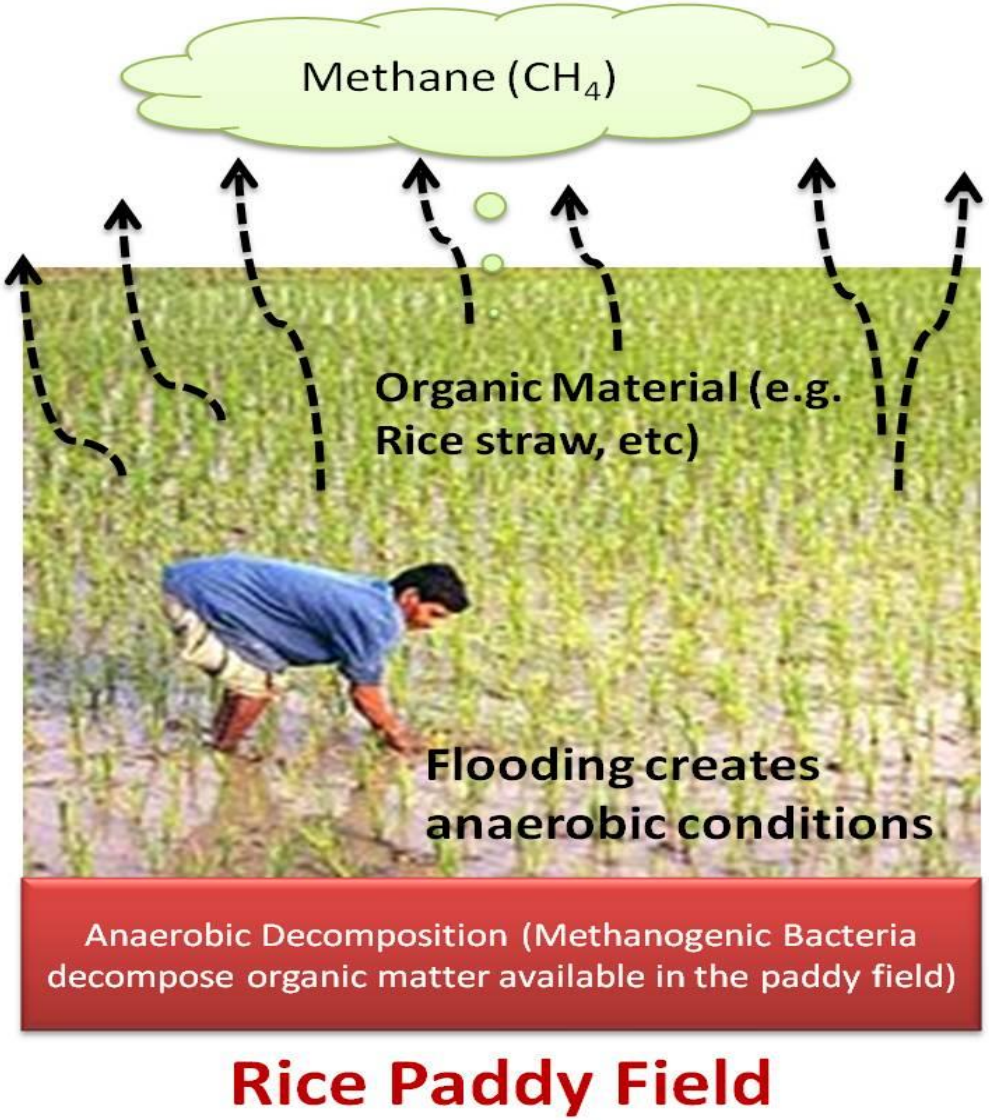
Introduction to CH_4 in Rice Cultivation IPCC Sources

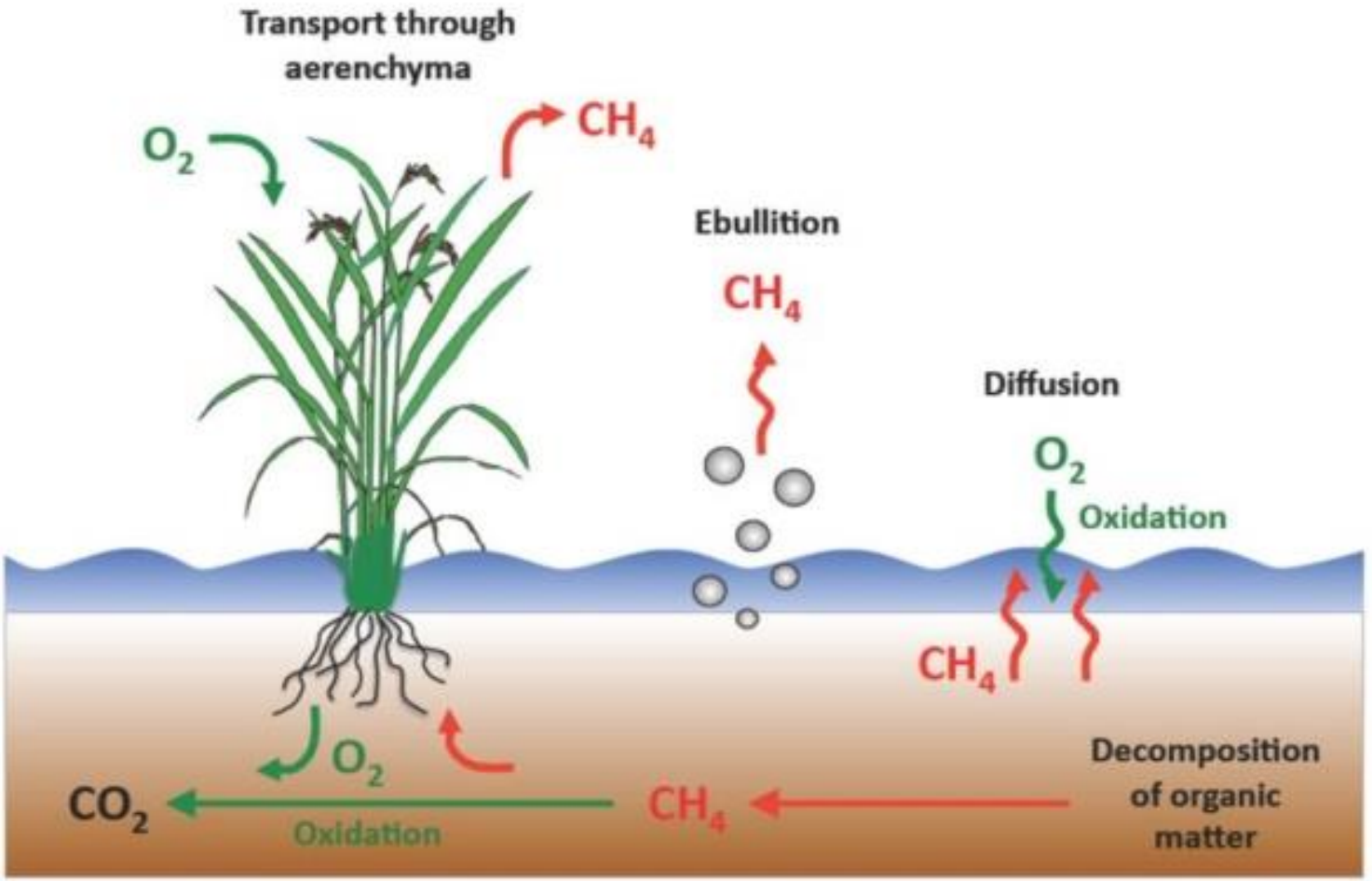
- IPCC 2006 Guidelines, Vol. 4 (AFOLU), Chapter 5, Section 5.5 "Methane Emissions from Rice Cultivation"
- IPCC 2013 Wetlands Supplement:
  - Chapter 2, methane (NH_4) from drained organic soils;
  - Chapter 5, NH_4 from inland wetlands soils.

CH_4 emissions occur from organic decomposition in organic (anaerobic) or mineral soils – paddy (wetland) rice is a major agricultural source of methane.

CH_4 from Organic Material Decomposition in Wetlands



Methanogenesis & Methane Oxidation



Methane oxidation:

$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$

Methanogenesis:

- Hydrogenotrophic: $CO_2 + 4\,H_2 \rightarrow 2\,H_2O + CH_4$
- Acetotrophic: $CH_3COOH \rightarrow CO_2 + CH_4$

Methanogenesis & Methane Oxidation

- **Methanogenesis (organic production of CH_4 by bacteria)**
  - Hydrogeotrophic:

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$

  - Acetotrophic (acetate fermentation):

$$CH_4COOH \rightarrow 2H_2O + CH_4$$

- **Methane Oxidation**

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Factors that Affect NH_4 from Rice Cultivation

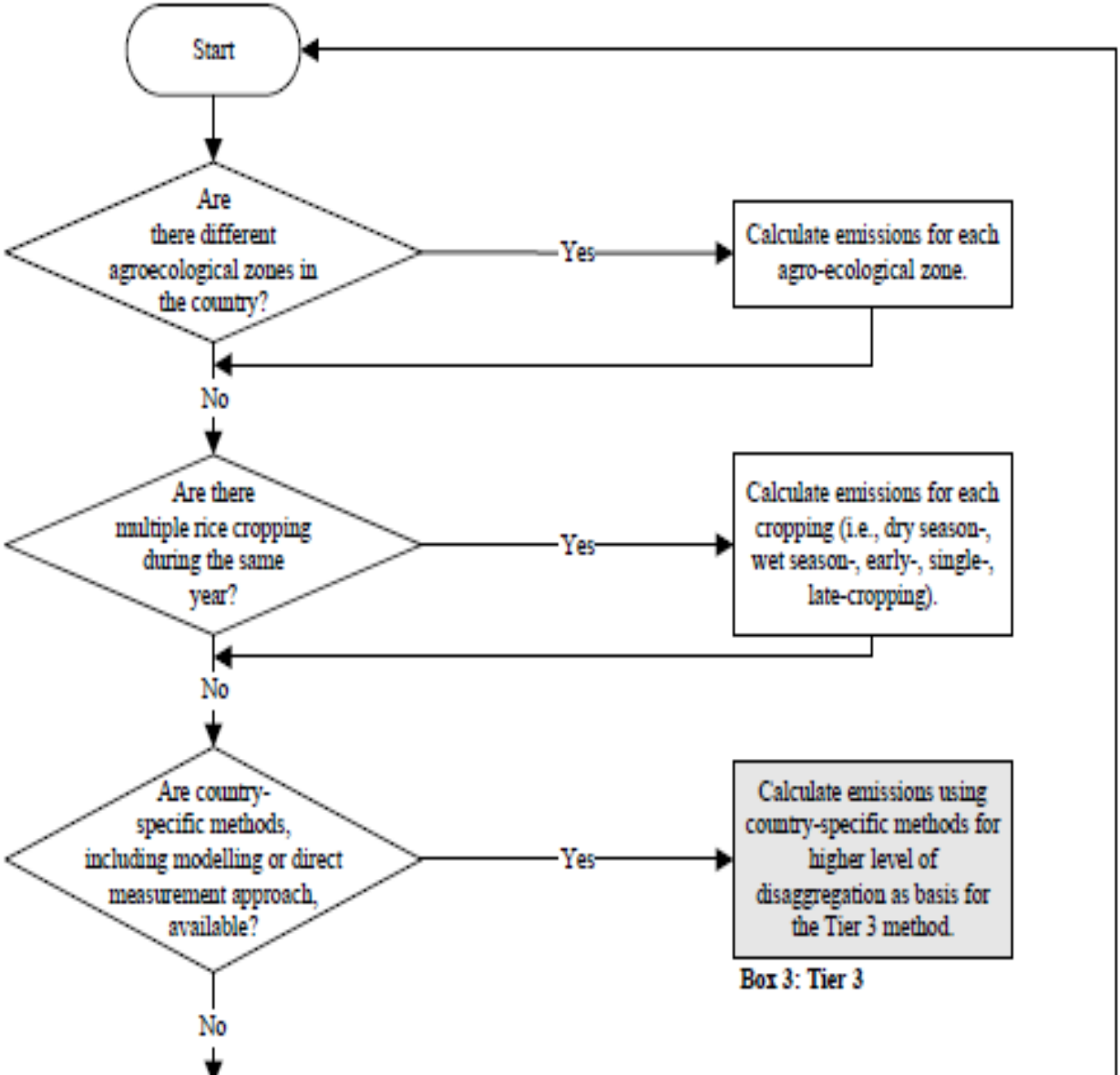
- Soil type
- Rice crop type (cultivar)
- Temperature
- Soil amendments (organic & inorganic fertilizers)
- Number of crop growing periods in a year
- Water management practices (frequency & duration of flooding)
- Other agricultural management practices

Conditions influencing CH_4 emissions from rice cultivation

- **Regional cropping systems**
- **Multiple crops**
- **Water regimes**
- **Ecosystem type for each water regime**
- **Flooding pattern**
- **Organic amendments in soils**
- **Other conditions**

CH_4 Rice Cultivation Decision Tree

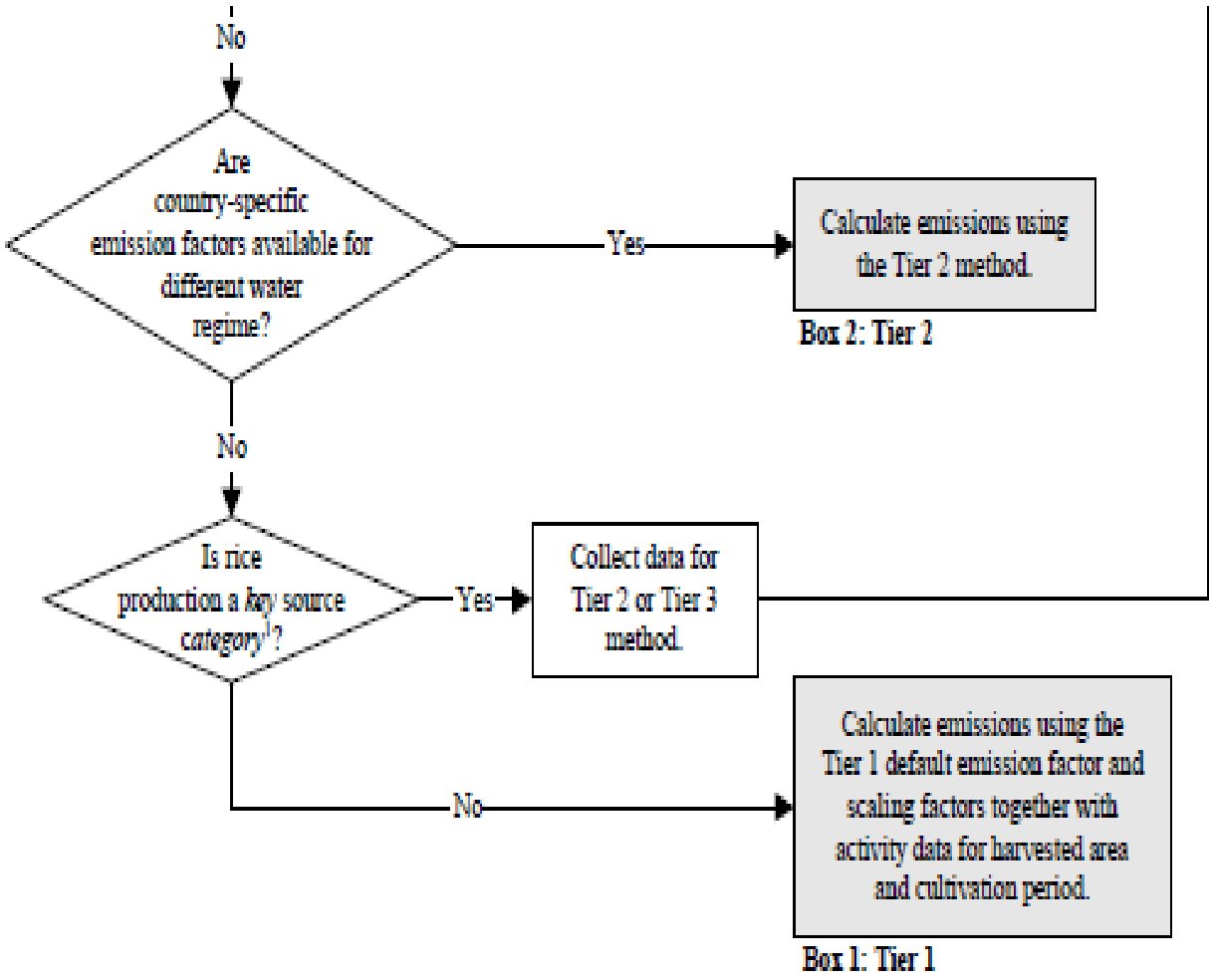
- **If 1 agro-ecological zone Then "NO"**
- **If no multiple rice cropping then "NO"**
- **If no country-specific methods, then "NO"**



Box 3: Tier 3

CH_4 Rice Cultivation Decision Tree (2)

- **If no country-specific EF for different water regime, then "NO"**
- **If key source category, then, go to Tier 2**
- **If not key source category, use Tier 1**



IPCC Key Equation: Tier 1 Formula for CH_4 Emissions from Rice Cultivation

A		B		C		D		E		F	
$CH_{4\ rice}$	=	$\sum_{(i,j,k)}$	(	$EF_{i,j,k}$	*	$t_{i,j,k}$	*	$A_{i,j,k}$	*	10^{-6}	)

A
annual methane emissions from rice cultivation = Gg CH_4 yr^{-1}

B		C		D		E
i,j,k= ecosystems, water regimes & other	*	daily emission factor for i, j, and k = kg CH4 ha^{-1} day^{-1}	*	cultivation period of rice for i, j, and k conditions	*	Rice harvested area p.a. for i, j, and k conditions, ha yr^{-1}

Emission Factor for Rice Production = EF_i

- Third NC assumes an emission factor (EF_i) of 25g of CH4 per square metre (~ 2.4 kg per ha).
  - This is based upon past research that compares Egypt Delta rice cultivation very similar to eastern Texas (USA) conditions (soils, temperature, flooding, cultivars, etc.)
- IPCC 2006 default baseline EF_i assumes 1.30 kg per ha.
  - This assumes no flooding for less than 180 days prior to rice cultivation, continuous flooding during cultivation & no use of organic amendments

Adjusted Daily Emissions Factor (EF_i)

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)

Key to gaining more accuracy in calculating methane, is "scaling" to account for variables including irrigation duration, organic amendments, etc.

Scaling Factor SFw – Water Regime

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

Scaling Factor SF_w provides sensitivities for different types of watering regimes, from flood irrigation to rainfed, & disaggregation of those regimes.

Water regime before the cultivation period (SFp)

- Non-flooded pre-season < 180 days, which often occurs under double cropping of rice;
- Non-flooded pre-season > 180 days, e.g., single rice crop following a dry fallow period; and
- Flooded pre-season in which the minimum flooding interval is set to 30 days.

Bulk of Egypt's rice cultivation is irrigated, non-flooded pre-season for greater than 180 days

IPCC 2006: Tier 2 Method

- Tier 2 applies the same methodological approach as Tier 1:
  - country-specific emission factors;
  - Country-specific scaling factors.
  - Should implement the method at the most disaggregated level the conditions (i, j, k, etc.) that influence CH_4 emissions.

IPCC 2006: Tier 3 Method

- Tier 3 includes models and monitoring networks tailored to address national circumstances of rice cultivation,
- Region-specific studies are required that cover the range of rice cultivation characteristics, particularly paying attention to organic amendments (e.g., rice straw, animal manure, etc.).

IPCC 2006 Rice CH_4 Methodology

Sector	**Agriculture, Forestry and Other Land Use**								
Category	**Rice Cultivation: Annual CH_4 emission from rice**								
Category code	**3C7**								
Sheet	**1 of 2**								
Equation	**Eq. 2.2**	**Equation 5.1**		**Equation 5.2**			**Equation 5.3**		
Rice Ecosystem	Subcate-gories for reporting year[1]	Annual harvested area	Cultivation period of rice	Baseline emission factor for continuously flooded fields without organic amendments	Scaling factor to account for the differences in water regime during the cultivation period	Scaling factor to account for the differences in water regime in the pre-season before the cultivation period	Application rate of organic amendment in fresh weight	Conversion factor for organic amendment	Scaling factor for both types and amount of organic amendment applied
		(ha yr^{-1})	(day)	kg CH_4 ha^{-1} day^{-1}	(-)	(-)	(tonnes ha^{-1})	(-)	(-)
				Table 5.11	Table 5.12	Table 5.13		Table 5.14	$SF_o = \frac{}{(1+ROA_i * CFOA_i)^{0.59}}$
		A	**t**	**EF_c**	**SF_W**	**SF_p**	**ROA_i**	**$CFOA_i$**	**SF_o**
Irrigated									
	Sub-total	650000	105	2.48	0.78	1.22			1
Rainfed and deep water									
	Sub-total								
Upland									
	Sub-total								
Total									

Sheet 1 of 2

IPCC 2006 Rice CH_4 Methodology

Sector	**Agriculture, Forestry and Other Land Use**			
Category	**Rice Cultivation: Annual CH_4 emission from rice**			
Category code	**3C7**			
Sheet	**2 of 2**	Sheet 2 of 2		
Equation	**Equation 2.2**	**Equation 5.2**		**Equation 5.1**
Rice Ecosystem	Subcategories for reporting year[1]	Scaling factor for soil type, rice cultivar, etc., if available	Adjusted daily emission factor for a particular harvested area	Annual CH_4 emission from Rice Cultivation
		(-)	(kg CH_4 ha^{-1} day^{-1})	Gg CH_4 yr^{-1}
			$EF_i = EF_c * SF_w * SF_p * SF_o * SF_{s,r}$	$CH_{4Rice} = A * t * EF_i * 10^{-6}$
		$SF_{s,r}$	**EF_i**	**CH_{4Rice}**
Irrigated				
	Sub-total		2.359968	161.067816
Rainfed and deep water				
	Sub-total			
Upland				
	Sub-total			
Total				

Thank you!

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