SCM0002 - Methane emission reduction by adjusted water management practice in rice cultivation

Document Prepared by the Social Carbon Foundation

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Contents

Methodology Details

1. Sources

The methodology uses the following sources:

- SOCIALCARBON Standard Definitions
- AMS-III.AU, "Methane emission reduction by adjusted water management practice in rice cultivation".

A full list of the scientific literature used to develop this methodology can be found in section 10. References.

2. Summary description of the Methodology

Rice is the nutritious staple crop for more than half of the world's people, but growing rice produces methane, a greenhouse gas more than 28 times as potent as carbon dioxide. Methane from rice contributes around 1.5 percent of total global greenhouse gas emissions and could grow substantially.[1]

The methodology comprises technology/measures that result in reduced anaerobic decomposition of organic matter in rice cropping soils and thus reduced generation of methane. The methodology includes projects such as:

(a) Rice farms that change the water regime during the cultivation period from continuously to intermittent flooded conditions and/or a shortened period of flooded conditions;

(b) Alternate wetting and drying method and aerobic rice cultivation methods[2];

(c) Rice farms that change their rice cultivation practice from transplanted to direct seeded rice.[3]

Additionality and Crediting Method	
Additionality	Project Method
Crediting Baseline	Project Method

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[1] Searchinger & Waite (2014)

[2] Saving water with alternative wetting drying (AWD). Source

[3] A switch from transplanted rice with continuously flooded fields to DSR leads to a reduced flooding period since DSR requires non-flooded conditions after sowing until the seed has fully germinated and developed into a viable, young plantlet (at the "2 to 4 leaf stage").

The methodology is focused on GHG emission avoidance, through reduced anaerobic decomposition of organic matter in rice cropping soils.

3. Definitions

In addition to the definitions set out in the latest version of the SOCIALCARBON Standard Definitions, the following definitions apply to this methodology revision:

Direct seeded rice (DSR)
A system of cultivating rice in which seeds, either pre-germinated or dry, are broadcast or sown directly in the field under dry- or wetland condition; no transplanting process is involved.

IPCC approach
The most recent version of the applicable IPCC guidance on methane emission from rice cultivation - Chapter 5.5, Methane Emissions from Rice Cultivation, Volume 4 of the 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;

Irrigated
A type of water regime in which fields are flooded for a significant period of time and water regime is fully controlled.

Project cultivation practice
A set of elements of a cultivation practice which is adopted under the CDM project activity. This mainly consists of the adjusted irrigation method. Field preparation, fertilization and weed and pest control may also be included.

Rainfed and deep water
A type of water regime in which fields are flooded for a significant period of time and water regime depends solely on precipitation.

Transplanted rice
A system of planting rice where seeds are raised in a nursery bed for some 20 to 30 days. The young seedlings are then directly transplanted into the flooded rice field.

Upland
A type of water regime in which fields are never flooded for a significant period of time.

Water regime
A combination of rice ecosystem type (e.g. irrigated, rainfed and deep water) and flooding pattern (e.g. continuously flooded, intermittently flooded).

To define reference field conditions for baseline and project emission measurements and their comparison with project fields, each project field shall be classified according to its specific pattern of cultivation conditions. The reference fields should be as close as possible to the project fields, with no lateral water movement, and with the appropriate justification of ecological attributes for all the reference fields.

It is mandatory to consider water regime (on-season and pre-season) and organic amendments for stratification. Using this classification, the project area can be stratified, with all areas having the same cultivation pattern forming a stratum.

In addition, parameters provided in Table 1: Parameters for the definition of cultivation patterns may be considered for stratification. The list of parameters provided is indicative and can be amended as per local conditions.

Table 1: Parameters for the definition of cultivation patterns

No.	Parameter	Type [a]	Values/categories	Source/Method [b]	Stratum element
1	Water regime – on-season [c]	Dynamic	Continuously flooded	Baseline: Farmer's information / Remote sensing Project: Monitoring	w1
			Single Drainage		w1
			Multiple Drainage		w1
2	Water regime – pre-season	Dynamic	Flooded	Baseline: Farmer's information / Remote sensing Project: Monitoring	p1
			Short drainage (<180d)		p2
			Long drainage (>180d)		p3
3	Organic Amendment	Dynamic	Straw on-season [d]	Baseline: Farmer's information / Remote sensing Project: Monitoring	o1
			Green manure		o2
			Straw off-season [e]		o3
			Farmyard manure		o4
			Compost		o5
			No organic amendment		o6
4	Soil pH	Static	<4.5	ISRIC-WISE soil property database [e] or national data	s1
			4.5 – 5.5		s2
			>5.5		s3
5		Static	<1%		c1

	Soil Organic Carbon		1 – 3%	ISRIC-WISE soil property database [e] or national data	c2
			>3%		c3
6	Climate	Static	AEZ [f]	Rice Almanac, HarvestChoice [f]	w1 to wn (where n is the types of climatic conditions)
7	Input number of days until maturity as per the rice variety	Dynamic	May be categorized as high, medium and low duration based on the varieties	Farmer’s information / national data	t1 to t3

Comments:

(a) Dynamic conditions are those that are connected to the management practice of a field, thus can change over time (no matter whether intended by the project activity or due to other reasons) and shall be monitored in the project fields. Static conditions are site-specific parameters that characterize a soil and do not (relevantly) change over time and thus do in principle only have to be determined once for a project and the corresponding fields;

(b) Source/method of data acquisition to determine the applicable value for each parameter;

(c) The values ‘upland’, ‘regular rainfed’, ‘drought prone’ and ‘deep water’, which are regularly used to differentiate the on-season water regime (see latest IPCC guidelines), are not mentioned here, because these categories are excluded from a project activity under this methodology (cf. applicability criteria);

(d) Straw on-season means straw applied just before rice season, and straw off-season means straw applied in the previous season. Rice straw that was left on the surface and incorporated into soil just before the rice season is classified as straw on-season;

(e) For these static parameters, refer to appropriate global or national data. The database from ISRIC provides soil data which can be used for this purpose;

(f) Climate zone: use agroecological zones as shown in the Rice Almanac (Third Edition, 2002), or by HarvestChoice.

4. Applicability Conditions

This methodology is applicable under the following conditions:

a) Rice cultivation in the project area is predominantly characterized by irrigated, flooded fields for an extended period of time during the growing season, i.e., farms whose water regimes can be classified as *upland* or *rainfed and deep water* are not eligible to apply this methodology. This shall be shown from a representative survey conducted in the geographical region of the proposed project or by using national data. This project area characterization shall also include information on pre-season water regime and applied organic amendments, so that all dynamic parameters as shown in Table 1 are covered by the baseline study;

b) The project rice fields are equipped with controlled irrigation and drainage facilities such that both during dry and wet season, appropriate dry/flooded conditions can be established on the fields;

c) The project activity does not lead to a decrease in rice yield. Likewise, it does not require the farm to switch to a cultivar that has not been grown before;

d) Training and technical support during the cropping season that delivers appropriate knowledge in field preparation, irrigation, drainage and use of fertilizer to the farmer is part of the project activity and is to be documented in a verifiable manner (e.g. protocol of trainings, documentation of on-site visits). In particular the project proponent is able to ensure that the farmer by himself or through experienced assistance is able to determine the crop's supplemental N fertilization need. The applied method shall assess the fertiliser needs using for example a leaf colour chart or photo sensor or testing stripes. Alternatively, a procedure to ensure efficient fertilization considering the specific cultivation conditions in the project area backed by scientific literature or official recommendations shall be used;

e) Project proponents shall assure that the introduced cultivation practice, including the specific cultivation elements, technologies and use of crop protection products, is not subject to any local regulatory restrictions;

f) Except the case where the default value approach indicated in section 6.1.2 "Emission reductions using IPCC tier 1 approach or default values" is chosen for emission reductions calculations, project proponents have access to infrastructure to measure CH4 emissions from reference fields using closed chamber method and laboratory analysis;

g) Where suitable project proponents are permitted to switch to organic manures that do not reduce yield and reduce emissions[4].

Example of how classification can be represented is given below in Table 2. Scaling factors and other relevant values that will be used in the equations to estimate emission reductions in this methodology depends on the stratum elements selected.

Table 2: Example of assigning strata using stratum elements

Cultivation Pattern	Stratum name	Assigned stratum code
• Single drainage, • Non flooded pre-season >180 days, • No organic amendment, • Medium duration variety	w2, p3, q1, t2	1

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[4] Win et al., (2021); Yean et al., (2005); Ladha et al., (1988); Oo et al., (2016)

• Continuous Flooding, • Non flooded pre-season <180 days, • Straw-on season, • Medium duration variety	w1, p2, o1, t2	2
• ...		

5. Project Boundary

The geographic boundary encompasses the rice fields where the cultivation method and water regime are changed. The spatial extent of the project boundary includes all fields that change the cultivation method in the context of the project activity.

Table 3: GHG Sources included in or excluded from the Project Boundary

Source		Gas	Included?	Explanation
Baseline	Emissions from Rice cultivation	CO_2	No	Negligible under applicability conditions
		CH_4	Yes	Major pool considered in the baseline scenario
		N_2O	No	Negligible under applicability conditions
Project	Emissions from Rice cultivation	CO_2	No	Negligible under applicability conditions
		CH_4	Yes	Major pool considered in the project scenario
		N_2O	No	Negligible under applicability conditions[5]

6. Baseline Scenario

The baseline scenario is the continuation of the current practice e.g., transplanted and continuously flooded rice cultivation in the project fields.

Projects must demonstrate historical trends of the current practice. Project proponents must obtain at least 3 years of historical data (remote sensing imagery) prior to the project start date. The resolution of the historical data must be at least weekly, and with no less than 52 images per year to ensure a trend can be accurately determined.

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[5] Islam et al., (2022); Islam et al., (2020); Islam et al., (2018); Akiyama et al., (2005); Bouwman et al., (2002); Yan et al., (2003).

The project must demonstrate that in at least 2 out of the past three years, the current practice has been implemented. The most recent year must align with the current practice documented by the project proponent.

The data source and evidence of the baseline analysis must be documented in the Project Description Document.

7. Additionality

This methodology uses a project method for the demonstration of additionality.

Step 1: Regulatory Surplus

Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the SOCIALCARBON Methodology Requirements.

Step 2: Project Method

The project activity shall apply the additionality analysis method set out in the latest version of the *SOCIALCARBON Tool for the Demonstration and Assessment of Additionality for AFOLU project activities (SCT0001)* to determine that the proposed project activity is additional.

The common practice threshold accepted by this methodology is 20%.

8. Quantification of GHG Emission Reductions

8.1 Baseline Emissions

The baseline emissions shall be calculated on a seasonal basis using the following formula:

$$BE_y = \sum_s BE_s \qquad \text{(Equation 1)}$$

$$BE_s = \sum_{g=1}^{G} EF_{BL,s,g} \times A_{s,g} \times 10^{-3} \times GWP_{CH4} \qquad \text{(Equation 2)}$$

Where:

BE_y = Baseline emissions in year y; tCO2e

BE_s = Baseline emissions from project fields in season s; tCO2e

$EF_{BL,s,g}$ = Baseline emissions factor of group g in season s; kgCH4/ha per season

$A_{s,g}$ = Area of project fields of group g in season s; ha

GWP_{CH4} = Global Warming Potential of CH4; tCO2e/tCH4

g = Group g, covers all project fields with the same cultivation pattern as determined with the help of Table 1 (G = total number of groups)

Determination of baseline emission factor on reference fields

Baseline reference fields shall be set up in a way that they are representative of baseline emissions in the project rice fields. For each group of fields with the same cultivation pattern, as defined with the help of Table 1, at least three reference fields with the same pattern shall be determined in the project area. On these fields, measurements using the closed chamber method shall be carried out, each resulting in an emission factor expressed as kgCH4/ha per season. The seasonally integrated baseline emission factor $EF_{BL,s,g}$ shall be derived as average value from the three measurements for each group (see the appendix for guidelines on methane measurement).

8.2 Project Emissions

Project emissions consist of the CH4 emissions, which will still be emitted under the changed cultivation practice. Due to the optimized N fertilization practice, N2O emissions do not significantly deviate from the baseline emissions and hence are not considered.

CH4 emissions from project fields are calculated on a seasonal basis as follows:

$$PE_y = \sum_{s} PE_s \qquad \text{(Equation 3)}$$

$$PE_s = \sum_{g=1}^{G} EF_{P,s,g} \times A_{s,g} \times 10^{-3} \times GWP_{CH4} \qquad \text{(Equation 4)}$$

Where:

PE_y = Project emissions in year y; tCO2e

PE_s = Project emissions from project fields in season s; tCO2e

$EF_{P,s,g}$ = Project emissions factor of group g in season s; kgCH4/ha per season

Determination of project emission factor on reference fields

The seasonally integrated project emission factor $EF_{P,s,g}$ shall be determined using measurements on at least three project reference fields that fulfil the same conditions as the baseline reference fields, with the difference that they are cultivated according to the defined project cultivation practice. Project reference fields shall be established close to the baseline reference fields and begin with the growing season at the same time. $EF_{P,s,g}$ is the average of the measurement results from the three reference fields.

8.3 Leakage

Any effects of the project activity on GHG emissions outside the project boundary are deemed to be negligible and do not have to be considered under this methodology.

8.4 Net GHG Emission Reductions

The emission reductions achieved by the project activity shall be calculated as the difference between the baseline and the project emissions.

$$NER_y = BE_y - PE_y \qquad \text{(Equation 5)}$$

Where:

NER_y = Net emission reductions during year y; tCO2e

Ex ante estimation of emission reductions

For the ex-ante estimation of emission reductions within the project design document (PDD), project participants shall either refer to own field experiments or estimate baseline and project emissions with the help of national data or IPCC tier 1 default values for emission and scaling factors. The approach shall be explained and justified in the PDD.

Emission reductions using IPCC tier 1 approach or default values

As an alternative to the reference field approach, project participants may calculate emission reductions using one of the following two simplified approaches (i.e. **Option 1** or **Option 2**):

Option 1: Using the IPCC tier 1 approach but undertaking measurements to determine baseline emission factors for continuously flooded fields, as per the following formula:

$$ER_y = (EF_{ER} \times A_y \times L_y \times 10^{-3} \times GWP_{CH4}) \times (1 - U_d) \tag{Equation 6}$$

$$ER_{ER} = EF_{BL} - EF_p \tag{Equation 7}$$

$$ER_{BL} = EF_{BL,c} \times SF_{BL,w} \times SF_{BL,p} \times SF_{BL,o} \tag{Equation 8}$$

$$ER_P = EF_{BL,c} \times SF_{P,w} \times SF_{P,p} \times SF_{P,o} \tag{Equation 9}$$

Where:

ER_y = Emission reductions during year y; tCO2e

EF_{ER} = Adjusted daily emission factor; kgCH4/ha/day. Alternatively, seasonal emission factor (kgCH4/ha/season) may be determined[6]

A_y = Area of project fields in year y; ha

L_y = Cultivation period of rice in year y; days/year. This is not applicable when seasonal emission factor is determined

GWP_{CH4} = Global warming potential of CH4; tCO2e/tCH4

EF_{BL} = Baseline emission factor; kgCH4/ha/day or kgCH4/ha/season

EF_P = Project emission factor; kgCH4/ha/day or kgCH4/ha/season

$EF_{BL,c}$ = Baseline emission factor for continuously flooded fields without organic amendments; kgCH4/ha/day or kgCH4/ha/season

$SF_{BL,w}$ or $SF_{P,w}$ = Baseline or project scaling factors[7] to account for the differences in water regime during the cultivation period

$SF_{BL,p}$ or $SF_{P,p}$ = Baseline or project scaling factors to account for the differences in water regime in the pre-season before the cultivation period

$SF_{BL,o}$ or $SF_{P,o}$ = Baseline or project scaling factors should vary for both type and amount of organic amendment applied

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[6] In this methodology, "season" means an entire cropping season (from land preparation until harvest or post season drainage). If a seasonal emission factor is opted, it should be based on measurements over the entire period of flooding, and should account for fluxes of soil-entrapped methane that typically occur upon drainage.

[7] For all scaling factors used in the methodology, the average values in 2019 IPCC Guidelines for National Greenhouse Gas Inventories are chosen. Uncertainties related to scaling factors may be considered in the future revision of the methodology.

U_d = Uncertainty deductions: Apply default value of 15% for IPCC default values (global, regional or country specific)

The baseline emission factor for continuously flooded fields without organic amendments ($EF_{BL,c}$) shall be either determined ex ante prior to the start of the project activity (in this case the ex ante value should be used to calculate emission reduction during the crediting period) or monitored annually (in this case, the ex post values should be used to calculate emissions reduction during the crediting period). At least three reference fields shall be chosen in the project area. On these fields, measurements shall be carried out using the closed chamber method in accordance with the guidance on methane measurement in the appendix.

Alternatively, the baseline emission factor for continuously flooded fields with organic amendments may be determined. In this case, scaling factors to account for organic amendments ($SF_{BL,o}$ or $SF_{P,o}$) shall not be applied in the equations (8) and (9) above.

Table 4: IPCC default values for $SF_{BL,w}$ or $SF_{P,w}$

Water regime during the cultivation period		$SF_{BL,w}$ or $SF_{P,w}$
Irrigated	Continuously flooded	1
	Intermittently flooded – single aeration	0.71
	Intermittently flooded – multiple aeration	0.55

Source: IPCC 2019, volume 4, chapter 5.5, Table 5.12

1. Continuously flooded: Fields have standing water throughout the rice growing season and may only dry out for harvest (end-season drainage).
2. Intermittently flooded: fields have at least one aeration period of more than three days during the cropping season;
    a. Single aeration: fields have a single aeration during the cropping season at any growth stage (except for end-season drainage);
    b. Multiple aeration: fields have more than one aeration period during the cropping season (except for end-season drainage).

IPCC default for $SF_{BL,p}$ or $SF_{P,p}$ is provided in the following table. For regions/countries where it can be demonstrated by official government data or peer-reviewed literature that double cropping is practiced, a default value of 1.0 is used. Otherwise, 0.89 is used.

Table 5: IPCC default values for SFBL,p or SFP,p

Water regime prior to cultivation period	$SF_{BL,p}$ or $SF_{P,p}$
Non flooded pre-season < 180 days (indicating double cropping)	1
Non flooded pre-season < 180 days (indicating single cropping)	0.89

Source: IPCC 2019, volume 4, chapter 5.5, Table 5.13

IPCC default for $SF_{BL,o}$ or $SF_{P,o}$ is calculated as follows:

$$SF_o = (1 + \sum_i ROA_i \times CFOA_i)^{0.59}$$ (Equation 10)

Where:

ROA_i = Application rate of organic amendment type i, in dry weight for straw and fresh weight for others, tonne ha^{-1}.
5 tonne/ha of straw is assumed as the baseline quantity of organic amendment, because the value of leftover straw after harvest is in the range of 3 tonne/ha (when harvested manually to the ground level, leaving very little stubble and the root residues) to 7 tonne/ha (harvested mechanically leaving behind large amount of crop residues on the field)

$CFOA_i$ = Conversion factor for organic amendment type i (in terms of its relative effect with respect to straw applied shortly before cultivation.
0.19 is used for a single crop and 1.0 for a double crop[8]

Accordingly, default for $SF_{BL,o}$ or $SF_{P,o}$ is provided in the following table.

Table 6: IPCC default values for $SF_{BL,o}$ or $SF_{P,o}$

Water regime prior to cultivation period	$SF_{BL,o}$ *or* $SF_{P,o}$	
Non flooded pre-season < 180 days (indicating double cropping)	2.88	$SF_{BL,o}$ or $SF_{P,o} = (1 + 5 \text{ x } 1)^{0.59} = 2.88$
Non flooded pre-season > 180 days (indicating single cropping)	1.48	$SF_{BL,o}$ or $SF_{P,o} = (1 + 5 \text{ x } 0.19)^{0.59} = 1.48$

Source: calculated using equation (10) above with default values from IPCC 2019, volume 4, chapter 5.5, Table 5.14.

The above table is for rice straw only. To include other organic amendments following IPCC 2019 Table 5.14, the data will be:

(a) For compost, the $SF_{BL,o}$ or $SF_{P,o}$ will be $(1 + C \times 0.17)^{0.59}$;
(b) For farmyard manure, the $SF_{BL,o}$ or $SF_{P,o}$ will be $(1 + YM \times 0.21)^{0.59}$;
(c) For green manure, the $SF_{BL,o}$ or $SF_{P,o}$ will be $(1 + GM \times 0.45)^{0.59}$;
(d) C, YM, GM are application rate (tonne ha^{-1}) of compost, farmyard manure, and green manure, respectively.

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[8] For a single crop, where the rice straw is usually ploughed back to the soil after the harvest of the crop and left for long period of time (i.e. rice straw is incorporated for a duration of > 30 days before cultivation), the straw is already mineralized being left in the dry field. Therefore the readily fermentable C component of the rice straw is less at flooding. This gives rise to lesser methane production when the soil is flooded for cultivation, therefore, 0.19 is used.

The calculation of specific emission factor for the baseline (EF_{BL}) and for the project activity (EF_P) (kgCH4/ha/day) is summarized in the table below.

Table 7: Specific emission factors for baseline, project and emission reductions (kgCH4/ha/day) or (kgCH4/ha/season)

		Baseline				**Project Scenarios**	**Project**				**Emission Reduction Factor** (EF$_{ER}$)
		SF$_{BL,w}$	SF$_{BL,p}$	SF$_{BL,o}$	**Emission Factor** (EF$_{BL}$)		SF$_{P,w}$	SF$_{P,p}$	SF$_{P,o}$	**Emission Factor** (EF$_{P}$)	
For regions/ countries where double cropping is practiced	EF$_{BL,c}$	1.00	1.00	2.88	EF$_{BL,c}$ x 2.88	**Scenario 1:** change the water regime from continuously to intermittent flooded conditions (single aeration)	0.71	1.00	2.88	EF$_{BL,c}$ x 2.04	EF$_{BL,c}$ x 0.84
						Scenario 2: change the water regime from continuously to intermittent flooded conditions (multiple aeration)	0.55	1.00	2.88	EF$_{BL,c}$ x 1.58	EF$_{BL,c}$ x 1.30
For regions/ countries where single cropping is practiced	EF$_{BL,c}$	1.00	0.89	1.48	EF$_{BL,c}$ x 1.32	**Scenario 1:** change the water regime from continuously to intermittent flooded conditions (single aeration)	0.71	0.89	1.48	EF$_{BL,c}$ x 0.94	EF$_{BL,c}$ x 0.38
						Scenario 2: change the water regime from continuously to intermittent flooded conditions (multiple aeration)	0.55	0.89	1.48	EF$_{BL,c}$ x 0.72	EF$_{BL,c}$ x 0.60

Option 2: using global default values derived from IPCC tier 1 approach.

In cases where country specific or regional default values are not available, the project developer may use global default values from IPCC tier 1 approach. Emission reductions shall be calculated, as per the equation (6), using default values of adjusted daily emission factor EF_{ER} (kgCH4/ha/day) given below in different project scenarios:[9]

(a) For regions/countries where double cropping is practiced:
  (i) Use 1.00 (kgCH4/ha/day) for project activities that shift to intermittent flooding (single aeration);
  (ii) Use 1.55 (kgCH4/ha/day) for project activities that shift to intermittent flooding (multiple aeration);

(b) For regions/countries where single cropping is practiced:
  (i) Use 0.45 (kgCH4/ha/day) for project activities that shift to intermittent flooding (single aeration);
  (ii) Use 0.71 (kgCH4/ha/day) for project activities that shift to intermittent flooding (multiple aeration).

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[9] Under this option, $EFBL$,= 1.19 (kgCH4/ha/day) as an example of the world emission factor from IPCC guidelines (2019), volume 4, chapter 5.5, Table 5.11. is used in Table 8 to derive at $EFER$. Note that 2019 Refinement to the 2006 IPCC Guidelines for National Gas Inventories includes different emission factors for East Asia, Southeast Asia, South Asia, Europe, North America, South America and Africa. That data should be used instead of the global mean as good practice.

The default values above consider the rice straw on field as the only organic amendment inputs. Other organic amendments such as compost, farmyard manure and green manure, which have been used in the pre-project scenario, may continue to be applied at the same or a lower rate during the crediting period, but do not affect the emission reductions estimated using the default values.

Global, regional and country specific default values are provided in Table 7 below and can be applied in Equation 8 and 9 as applicable.

Table 8: Global, regional and country specific default emission factors

Region	**Emission factor ($EF_{BL,C}$)** (kg CH4/ha/d)
Global	1.19
Regional Values	
Africa	1.19
East Asia	1.32
Southeast Asia	1.22
South Asia	0.85
Europe	1.56
North America	0.65
South America	1.27
Country specific[10]	
Bangladesh	0.97
Brazil	1.62
China	1.30
India	0.85
Indonesia	1.18
Italy	1.66
Japan	1.06
Philippines	0.60
South Korea	1.83
Spain	1.13
Uruguay	0.80
USA	0.65
Vietnam	1.13

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[10] Wang, J., Akiyama, H., Yagi, K., & Yan, X. (2018). Controlling variables and emission factors of methane from global rice fields. *Atmospheric Chemistry and Physics*, *18*(14), 10419-10431.

Uncertainty

Where global, regional or country specific default values are applied, a default uncertainty deduction factor of 15% is to be applied on the emission reductions.

All projects applying direct measurement will be subjected to the assessment of uncertainty as per the following requirements.

a) If the uncertainty of estimated value is equal to or less than 10% of the mean change value then the project owner may use the estimated value without any deduction for uncertainty, i.e. UD = 0.
b) If the uncertainty is greater than 10% of the mean value, then the project owner shall either increase the sampling effort to achieve this target or the project owner shall use the estimated value subject to an Uncertainty Deduction (UD) in Table 9 below.

Table 9: Uncertainty discount factors

Uncertainty Range	Discount (% of Uncertainty)	How applied
U ≤ 10%	0%	**Example:** Estimated mean = 60±9 t d.m ha^{-1} i.e. U=9/60x100 = 15% Discount = 25% x 9 = 2.25 t d.m ha^{-1} Discounted conservative mean: In baseline = 60+2.25 = 62.25 t d.m ha^{-1} In project = 60-2.25 = 57.75 t d.m ha^{-1}
10 < U ≤ 15	25%	
15 < U ≤ 20	50%	
20 < U ≤ 30	75%	
U > 30	100%	

9. Monitoring

9.1 Data and Parameters Available at Validation

Data / Parameter	$EF_{BL,s,g}$
Data unit	kgCH4/ha per season
Description	Baseline emission factor.
Equations	2

Source of data	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of baseline emissions.
Comments	Regular measurements as per closed chamber method guidance, seasonally integrated.

Data / Parameter	Historical water regime data
Data unit	Dimensionless
Description	Remote sensing data used to verify the historical baseline scenario of the project fields and their water regime.
Equations	N/A
Source of data	Remote sensing (either satellite imagery or drone)
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Projects must demonstrate historical trends of the current practice. Project proponents must obtain at least 3 years of historical data (remote sensing imagery) prior to the project start date. The resolution of the historical data must be at least weekly, and with no less than 52 images per year to ensure a trend can be accurately determined. The project must demonstrate that in at least 2 out of the past three years, the current practice has been implemented. The most recent year must align with the current practice documented by the project proponent.
Purpose of Data	Verify baseline scenario
Comments	All data must be timestamped, and the data source provided to facilitate verification.

9.2 Data and Parameters Monitored

Data / Parameter:	$EF_{BLs,g}$
Data unit:	kgCH4/ha per season
Description:	Baseline emission factor.
Equations	2
Source of data:	IPCC 2019
Description of measurement methods and procedures to be applied:	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Frequency of monitoring/recording:	Seasonally
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of baseline emissions
Calculation method:	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Comments:	N/A

Data / Parameter:	$EF_{P,s,g}$
Data unit:	kgCH4/ha per season
Description:	Project emission factor.
Equations	4
Source of data:	IPCC 2019
Description of measurement methods and procedures to be applied:	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.

Frequency of monitoring/recording:	Seasonally. Monitoring frequency dependent on measuring approach. If a closed chamber method is used, regular measurements should be conducted, seasonally integrated.
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of project emissions
Calculation method:	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Comments:	N/A

Data / Parameter:	$A_{s,g}$
Data unit:	hectares
Description:	Aggregated project area in a given season s
Equations	2 and 4
Source of data:	IPCC 2019
Description of measurement methods and procedures to be applied:	To be determined by collecting the project field sizes in a project database. The size of project fields shall be determined by GPS or satellite data. Should such technologies not be available, established field size measurement approaches shall be used provided that uncertainties are taken into account in a conservative manner.
Frequency of monitoring/recording:	Seasonally
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of project emissions
Calculation method:	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Comments:	N/A

Data / Parameter:	A_y
Data unit:	hectares
Description:	Aggregated project area in year y
Equations	6
Source of data:	IPCC 2019
Description of measurement methods and procedures to be applied:	To be determined by collecting the project field sizes in a project database. The size of project fields shall be determined by GPS or satellite data. Should such technologies not be available, established field size measurement approaches shall be used provided that uncertainties are taken into account in a conservative manner.
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	This parameter is only required to monitor if approach mentioned under option 1 or option 2 is used. Only compliant farms are considered. See section 9.3.

Data / Parameter:	L_y
Data unit:	Days/years
Description:	Cultivation period of rice in year y
Equations	6
Source of data:	To be determined using cultivation logbooks / remote sensing
Description of measurement methods and procedures to be applied:	To be determined using cultivation logbooks. Remote sensing imagery can be used to provide additional evidence on the cultivation period and is recommended to provide additional transparency of the project.

Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	N/A
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	This parameter is only required to monitor if approach mentioned under option 1 or option 2 is used. Only compliant farms are considered. Also, this parameter is not monitored when seasonal emission factor is applied.

Data / Parameter:	Remote sensing data for water regime
Data unit:	Dimensionless
Description:	Remote sensing data used to verify the project activities of the project fields and their water regime.
Equations	N/A
Source of data:	Remote sensing (Satellite imagery or drone)
Description of measurement methods and procedures to be applied:	Remote sensing (e.g., Satellite Imagery) must be used to evidence the water regime of the field. The resolution of the remote sensing data must be at least weekly, and with no less than 52 images per year. Each dataset / image must be supported with a timestamp and data source to facilitate replicability.
Frequency of monitoring/recording:	Every monitoring period, as per the data frequency outlined above.
QA/QC procedures to be applied:	If satellite imagery is not used, the project proponent shall take a drone image of the field at the same time and day.
Purpose of data:	Evidence water regime activities implemented by the project.
Calculation method:	Remote sensing (Satellite imagery or drone)
Comments:	N/A

9.3 Description of the Monitoring Plan

In order to determine whether the project fields are cultivated according to the project cultivation practice as defined by the project activity, and thus assure that measurements on the reference fields are representative for the emissions from the project fields, a cultivation logbook shall be maintained for all project fields. With the help of the logbook, all parameters that are part of the project cultivation practice, and at least the following, shall be documented by the farmers:

a) Sowing (date);

b) Fertilizer, organic amendments, and crop protection application (date and amount);

c) Water regime on the field (e.g. "dry/moist/flooded") and dates where the water regime is changed from one status to another;

d) Yield.

Where possible, remote sensing can be used to collect and document relevant parameters that are part of the project cultivation practice.

Remote sensing (e.g., Satellite Imagery) must be used to evidence the water regime of the field. The resolution of the remote sensing data must be at least weekly, and with no less than 52 images per year. Each dataset / image must be supported with a timestamp and data source to facilitate replicability.

In addition, farmers shall state whether they have followed fertilization recommendations provided with the introduction of the adjusted water management practice.

Project proponents shall assure that the project reference fields are cultivated in a way that they represent the ranges of cultivation practice elements on the project fields in a conservative manner with respect to methane emissions. Should farmers relevantly deviate from the defined project cultivation practice, so that their fields cannot be deemed to be represented by the reference fields any more, those fields shall not be taken into account for the determination of the aggregated project area $A_{s,g}$ of that season. This requirement shall assure that only those farms are considered for the calculation of emission reductions which comply with the project cultivation practice.

Reporting and verification shall be done on the basis of samples of the log-books from the farmers, remote sensing data and align with the latest version of the "Standard for sampling and surveys for CDM project activities and programme of activities".

Project proponents shall set up a database which holds data and information that allow an unambiguous identification of participating rice farms, including name and address of the rice farmer, size of the field and, if applicable, additional farm specific information as defined above.

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Appendix 1: Version Control

Version	Date	Comment
V1.0	29/04/2022	Initial version released
V1.1	01/12/2022	Revision to the Additionality Section to use the *SOCIALCARBON Tool for the Demonstration and Assessment of Additionality for AFOLU project activities (SCT0001)* to determine that the proposed project activity is additional rather than CDM tool.
V1.2	14/02/2023	• Requirement to demonstrate baseline scenario and project activities (re water management) using satellite imagery • Alignment of the methodology to the latest scientific literature • References updated
V1.3	26/07/2023	• Alignment to IPCC 2019 values • Additional clarification regarding uncertainty & remote sensing requirements

Appendix 2: Guidelines for measuring methane emissions from rice fields

Remote sensing

Project Proponents are permitted to utilise emerging technology (e.g. remote sensing) with known uncertainty to measure methane emissions. If this approach is taken, methane emissions must be measured both in the baseline and project scenario for the length of the project crediting period using this method. These emerging technology approaches must be supported by peer-reviewed literature[11] which validates their accuracy and uncertainty. Justification for the chosen approach should be documented in the Project Description Document supplemented with appropriate evidence. Any uncertainty in the approach used must be discounted for. Models must at a minimum:

- be publicly available from a reputable and recognized source (e.g., the model developer's website, IPCC, or government agency); and
- have been appropriately reviewed and tested under similar ecosystemic conditions by a recognized, competent organization, or an appropriate peer review group; and
- have comprehensive and appropriate requirements for estimating uncertainty in keeping with IPCC or other appropriate guidance, and the model shall be calibrated by parameters such as geographic location and local climate data; and
- apply conservative factors to discount for model uncertainty and shall use conservative assumptions and parameters that are likely to underestimate, rather than overestimate, the GHG emission reductions or removals.

All parameters, data sources and assumptions applied by the emerging technology, alongside evidence of compliance with the minimum requirements outlined above, must be documented in the Project Description Document.

Field measurements

The implementation of methane measurement in rice fields requires the involvement of experts in this field or at least experienced staff trained by experts (i.e. from research institutions). These guidelines cannot replace expertise in setting up chamber measurements[12]. They rather set minimum requirements that serve for standardizing the conditions under which methane emissions are measured for projects under this methodology.

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[11] The literature must be in a journal indexed in the Web of Science: Science Citation Index (SCI: available at https://mjl.clarivate.com).

[12] For example, procedures such as "Guidelines for Measuring CH4 and N2O Emissions from Rice Paddies by a Manually Operated Closed Chamber Method" and the "Handbook of Monitoring, Reporting, and Verification for a Greenhouse Gas Mitigation Project with Water Management in Irrigated Rice Paddies" may be employed. See also: GHG Mitigation in Rice - Manual chamber method (irri.org).

Project proponents shall prepare a detailed plan for the seasonal methane measurements before the start of the season. The plan shall include the schedule for the field and laboratory measurements, the logistics that are necessary to get the gas samples to the laboratory and a cropping calendar. The plan shall also include all reference field specific information regarding location and climate, soil, water management, plant characteristics, fertilizer treatment and organic amendments.

The following guidance is structured according to the steps from field measurement to emission factor calculation. Project proponents shall make sure that the measurements on project and baseline reference fields are carried out in an equal manner and simultaneously.

Table 10: On the field - technical options for the chamber design

Feature	Conditions	
Chamber material	Option 1: Non-transparent • Commercially available PVC containers or manufactured chambers (e.g. using galvanized iron); • Painted white or covered with reflective material (to prevent increasing inside temperature); • Only suitable for short-term exposure (typically 30 min) followed by immediate removal from the field	Option 2: Transparent • Manufactured chambers using acrylic glass; • Advantage of transparent chambers: could be placed for longer time spans on the field if equipped with a lid that remains open between measurements and is only closed during measurements
Placement in soil	Option 1: Fixed base • Base made of non-corrosive material and remains in the field for the whole season; • Base should allow tight sealing of the chamber; • Base should have bores in the submerged section to allow water exchange between inside and outside; • Base should be installed at least 24 hours before the first sampling	Option 2: Without base • Chamber have to be placed on the soil with open lid to allow escape of eventual ebullition
Auxiliaries of chamber	• Thermometer for measuring the temperature inside the chamber; • Fan (battery operated) inside the chamber for mix the inside air during sampling; • Sampling port (rubber stopper placed in a bore of the chamber)	
Basal area	Rectangular or rounded, but has to cover minimum of four rice hills (ca. 0.1 m^2 minimum)	
Height	Option 1: Fixed height • Total height (protruding base + chamber) should exceed plant height	Option 2: Flexible height • Adjustable to plant height; • Chambers with different heights or modular design

Table 11: On the field – air sampling

Feature	Conditions
Replicate chambers per plot	Minimum requirement: Three replicate chambers per plo
Number of air samples per exposure / data points per measurement	Minimum requirement: Three samples per exposure
Exposure time	30 minutes
Daytime of measurement	Morning
Measurement interval	Minimum requirement: once per week
Syringe	• Suitability test (leak proof) before measurement • Preferably equipped with a lock for ease of handling
Sample storage until analysis	• Storage < 24 h: air samples can remain in syringe; • Storage > 24 h: transfer air samples into evacuated vial, store with slight overpressure

Table 12: Laboratory analysis

Feature	Conditions
Method	Gas Chromatograph with flame ionization detector (FID)
Injection	Direct injection or with multi-port valve and sample loop
Column	Packed (e.g. molecular sieve) or capillary column
Calibration	With certified standard gas each day of analysis before and after the analyses are done

Calculation of the emission rate for a plot (reference field)

1. For each gas analysis, calculate the mass of CH4 emissions with the help of the following formula:

$$m_{CH4,t} = c_{CH4,t} \times V_{Chamber} \times M_{CH4} \times \frac{1_{atm}}{R \times T_t \times 1000}$$ (Equation 11)

Where:

$m_{CH4,t}$ = Mass of CH4 in chamber at time t; mg

t = Point of time of sample (e.g. 0, 15, 30 in case of three samples within 30 minutes)

$c_{CH4,t}$ = CH4 concentration in chamber at time t, from gas analysis; ppm

$V_{Chamber}$ = Chamber volume; L

M_{CH4} = Molar mass of CH4; 16 g/mol

1_{atm} = Assume constant pressure of 1atm, unless pressure measurement is installed

R = Universal gas constant; 0,08206 L atm K-1 mol-1

T_t = Temperature at time t; K

2. Determine the slope of the line of best fit for the values of over time with the help of software (e.g. Excel):

$$s = \frac{\Delta m_{CH4}}{\Delta t}$$ (Equation 12)

Where:

s = Slope of line of best fit; mg/min

3. Calculate the emission rate per hour for one chamber measurement:

$$RE_{ch} = s \times 60min \, / \, A_{Chamber}$$ (Equation 13)

Where:

RE_{ch} = Emission rate of chamber ch; mg/h x m^2

ch = Index for replicate chamber on a plot

$A_{Chamber}$ = Chamber area; m^2

4. Calculate the average emission rate of a chamber measurement per plot:

$$RE_{plot} = \frac{\sum_{ch=1}^{Ch} RE_{ch}}{Ch}$$ (Equation 14)

Where:

RE_{plot} = Average emission rate of a plot; mg/h x m^2

Ch = Number of replicate chambers per plot

Further procedure: from the average emission rates per plot of each chamber measurement, derive the seasonally integrated emission factor by integration of the measurement results over the season length. The simplest way of integration is multiplying the emission rate with the number of hours of the measurement interval (e.g. one week) and accumulating the results of every measurement interval over the season. Convert from mg/m² to kg/ha by multiplying with 0.01.