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Emission reduction through improved management practices in rice cultivation

INDIAN Carbon MARKET

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Sectoral scope(s): Agriculture

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1. Introduction

1. This methodology is adopted and refers to the latest approved version of the UNFCCC Clean Development Mechanism Methodology AMS-III.AU (as valid from 28 November 2014).

2. It shall be the responsibility of the non-obligated entity and Accredited Carbon Verification Agency (ACVA) to note of any subsequent changes or revisions in the above-mentioned methodology while developing projects and performing validation and/or verification activity respectively.

3. The following table describes the key elements of the methodology.

Table 1. Methodology key elements

Typical project(s)	**(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; and **(c)** Rice farms that change their rice cultivation practice from transplanted to direct seeded rice (DSR)
Type of GHG emissions mitigation action	Greenhouse gas (GHG) emission avoidance: Reduced anaerobic decomposition of organic matter in rice cropping soils

2. Definitions

4. For the purpose of this methodology the following definitions[1] apply:

(a) **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;

(b) **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;

(c) **IPCC approach** - the most recent version of the applicable IPCC guidance on methane emission from rice cultivation. The applicable version at the time of approval of the methodology is Chapter 5.5, Methane Emissions from Rice Cultivation, Volume 4 of the 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;

(d) **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;

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

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[1] IPCC approach provides for the definitions (e) to (h) (see volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for further details).

(f) **Upland** - a type of water regime in which fields are never flooded for a significant period of time;

(g) **Irrigated** - a type of water regime in which fields are flooded for a significant period of time and water regime is fully controlled;

(h) **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.

5. For the purpose of defining reference field conditions for baseline and project emission measurements and their comparison with project fields, classify each project field with its specific pattern of cultivation conditions, applying the following parameters under Table 2:

Table 2. Parameters for the definition of cultivation patterns

Nr.	Parameter	Type[a]	Values/categories	Element	Source/method[b]
1	Water regime – on-season[c]	Dynamic	Continuously flooded	w1	Baseline: Farmer's information Project: Monitoring
			Single Drainage	w2	
			Multiple Drainage	w3	
2	Water regime – pre-season	Dynamic	Flooded	p1	Baseline: Farmer's information Project: Monitoring
			Short drainage (<180d)	p2	
			Long drainage (>180d)	p3	
3	Organic Amendment	Dynamic	Straw on-season[d]	o1	Baseline: Farmer's information Project: Monitoring
			Straw off-season[d]	o2	
			Green manure	o3	
			Farm yard manure	o4	
			Compost	o5	
			No organic amendment (low stubbles are left after harvesting or straw is burnt in the field)	o6	
4	Soil pH	Static	< 7	s1	ISRIC-WISE soil property database[e] or national data
			7-8	s2	
			> 8	s3	
5	Soil Organic Carbon	Static	< 1%	c1	ISRIC-WISE soil property database[e] or national data
			1 – 3 %	c2	
			> 3%	c3	
6	Climate	Static	[AEZ][f]		Rice Almanac, HarvestChoice[f]
7	Duration of the crop with variety	Dynamic	Long	t1	Baseline: Farmer's information Project: Monitoring
			Medium	t2	
			Short	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 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.

6. With the help of this field characterization, project fields can be grouped according to their cultivation pattern. All fields with the same cultivation pattern form one group.

3. Scope & applicability

3.1. Scope

7. 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 (see <http://www.knowledgebank.irri.org/watermanagement>);

(c) Rice farms that change their rice cultivation practice from transplanted to direct seeded rice.[2]

3.2. Applicability

8. 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 2 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;

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[2] 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").

(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 5.1.2 “Emission reductions using IPCC tier 1 approach or default values” is chosen for emission reductions calculations, project proponents have access to infrastructure to measure CH_4 emissions from reference fields using closed chamber method and laboratory analysis;

3.3. Methodology Approval Date

9. The date of adoption of this document shall be effective from XX/XX 2025.

3.4. Applicability of sectoral scopes

9. For validation and verification of ICM projects by a designated ACVA using this methodology, the application of Sectoral Scope 04:Agriculture is mandatory.

3.5. Applicability of approved adopted tools

10. This methodology also refers to the latest approved versions of the following adopted ICM tools:

a) “BM-T-001: Combined tool to identify the baseline scenario and demonstrate additionality” (hereinafter referred as “BM-T-001”);

4. Methodology: Baseline Component

4.1. Project boundary

11. 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.

4.2. Baseline

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

4.3. Baseline emissions

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

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

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

Where:

BE_y	=	Baseline emissions in year *y* (t CO_2e)
BE_s	=	Baseline emissions from project fields in season *s* (t CO_2e)
$EF_{BL,s,g}$	=	Baseline emission factor of group *g* in season *s* (kgCH_4/ha per season)
$A_{s,g}$	=	Area of project fields of group *g* in season *s* (ha)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4):28.0
g	=	Group *g*, covers all project fields with the same cultivation pattern as determined with the help of Table 2 (*G* = total number of groups)

4.4. Determination of baseline emission factor on reference fields

14. 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 2, 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 kgCH_4/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).

4.5. Leakage

15. 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.

4.6. Project emissions

16. Project emissions consist of the CH_4 emissions, which will still be emitted under the changed cultivation practice. Due to the optimized *N* fertilization practice (cf. applicability criteria in paragraph 3(d), *N* fertilizer control), N_2O emissions should be accounted if it significantly increases from the baseline. The project should not lead to an increased application of fertiliser in the baseline, which shall be ascertained through interviews, purchase records, fertiliser application log books, interviews with experts, etc. In the project scenario, fertiliser application shall be recorded in the log books or farm records. If there is an increase in the application rate of fertilisers, then emissions from N_2O shall be accounted as project emissions. Emissions from land preparation should also be ascertained if they are significant.

17. Project emissions from project fields are calculated on a seasonal basis as follows:

$$PE_y = \sum_s PE_s + PE_n + PE_l$$

Equation (3)

Where:

PE_y	=	Project emissions in year *y* (t CO_2e)
PE_s	=	Project emissions from project fields in season *s* (t CO_2e)
PE_n	=	Project emissions (N_2O) from N-inputs in the project fields (tCO2e)

PE_l	=	Project emissions (CO_2) from fields preparations (tCO_2e)

18. **CH_4 project emissions:**CH_4 emissions from project fields are calculated on a seasonal basis as follows:

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

Where:

PE_s	=	Project emissions from project fields in season *s* (t CO_2e)
$EF_{P,s,g}$	=	Project emission factor of group *g* in season *s* (kgCH_4/ha per season)
$A_{s,g}$	=	Area of project fields of group *g* in season *s* (ha)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4):28.0
g	=	Group *g*, covers all project fields with the same cultivation pattern as determined with the help of Table 2 (*G* = total number of groups)

19. The seasonally integrated project emission factor 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. Project emissions is the average of the measurement results from the three reference fields.

20. N_2O emission: The increment in N_2O emission associated with AWD is calculated by assuming that there is no increase in N input and that there may be an expected increase in emissions associated with AWD systems in comparison to continuously flooded rice systems. The increment in N_2O emission associated with AWD is calculated for the application of N fertiliser in the project. The N_2O emission is calculated as per the equation below.

$$PE_n = \sum_{g=1}^{G} (Q_{n,Pg} \times A_g) \times (EF_{N2O,B,g} - EF_{N2O,P,g}) \times 10^{-3} \times GWP_{N2O}$$

Where:

PE_n	=	Project emissions from project fields in season *s* (t CO_2e)
$Q_{n,Pg}$	=	Application rate of N-input in the project scenario where the application rate doesn't exceed that of baseline (kg inputs per Hectare)
$A_{g,s}$	=	Area of project fields of group *g* in season *s* (ha)
$EF_{N2O,P,g}$	=	Emission factor for single and multiple drainage:0.005 kgN_2O-n/kgN input
$EF_{N2O,B,g}$	=	Emission factor for continuously flooded:0.003 kgN_2O-n/kgN input

GWP_{N2O}	=	Global warming potential of N_2O (t CO_2e/t N_2O):265.0
g	=	Group *g*, covers all project fields with the same cultivation pattern as determined with the help of Table 2 (*G* = total number of groups)

21. CO_2 Emission: Project emissions arising from using mechanical devices (PE_l), farm equipment and specialised vehicles for land preparation shall be accounted. This can be in lieu of water management mechanisms being put in place. If the total emissions resulting from land preparation exceed 5% of the total emission reductions in year y, they shall be considered as project emissions and accounted for accordingly. In case it exceeds more than 5%, CDM Tool03 shall be used for the calculation of CO_2 emission.

22. Reduction in N_2O emissions arising from decrease in fertiliser usage rate cannot be claimed under this methodology.

4.7. Emission reductions

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

$$ER_y = (BE_y - PE_y) \times (1 - U_d)$$

Equation (5)

Where:

ER_y	=	Emission reductions in year (t CO_2e)
U_d	=	Uncertainty Deduction (%)

4.7.1. Ex ante estimation of emission reductions

24. 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.

4.7.2. Emission reductions using IPCC tier 1 approach or default values

25. As an alternative to the reference field approach indicated in above paragraphs 4.4 , project participants may calculate emission reductions using the simplified approaches :

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

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

$$EF_{ER} = EF_{BL} - EF_P \times (1 - U_d)$$ Equation (7)

$$EF_{BL} = EF_{BL,c} \ x \ SF_{BL,w} \ x \ SF_{BL,p} \ x \ SF_{BL,o}$$ Equation (8)

$$EF_P = EF_{BL,c} \ x \ SF_{P,w} \ x \ SF_{P,p} \ x \ SF_{P,o}$$ Equation (9)

Where:

ER_y	=	Emission reductions in year *y* (t CO_2e)

EF_{ER}	=	Adjusted daily emission factor ($kgCH_4$/ha/day). Alternatively, seasonal emission factor ($kgCH_4$/ha/season) may be determined[3]
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 CH_4 (t CO_2e/t CH_4)
EF_{BL}	=	Baseline emission factor ($kgCH_4$/ha/day) or ($kgCH_4$/ha/season)
EF_P	=	Project emission factor ($kgCH_4$/ha/day) or ($kgCH_4$/ha/season)
$EF_{BL,c}$	=	Baseline emission factor for continuously flooded fields without organic amendments ($kgCH_4$/ha/day) or ($kgCH_4$/ha/season)
$SF_{BL,w}$ or $SF_{P,w}$	=	Baseline or project scaling factors[4] 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
Ud	=	Uncertainty deductions: Apply default value of 15% for IPCC default values (global, regional or country specific).

27. 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.

28. 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.

29. IPCC default for $SF_{BL,w}$ or $SF_{P,w}$ is as follows:

Table 3. 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

[3] 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.

[4] For all scaling factors used in the methodology, the average values in 2006 IPCC Guidelines for National Greenhouse Gas Inventories are chosen. Uncertainties related to scaling factors may be considered in the future revision of the methodology.

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

[(a)] 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).

30. 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 4. IPCC default values for $SF_{BL,p}$ or $SF_{P,p}$

Water regime prior to rice cultivation	$SF_{BL,p}$ 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

[(a)] Source: IPCC 2006, volume 4, chapter 5.5, Table 5.13.

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

$$SF_o = \left(1 + \sum_i ROA_i \; x \; CFOA_i\right)^{0.59}$$ 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[5]

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

Table 5. IPCC default values for $SF_{BL,o}$ *or* $SF_{P,o}$

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

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

33. The above table is for rice straw only. To include other organic amendments following IPCC 2019, Chapter5.5, 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 farm yard 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, farm yard manure, and green manure, respectively.

34. The calculation of specific emission factor for the baseline (EF_{BL}) and for the project activity (EF_P) ($kgCH_4$/ha/day) is summarized in the table below.

[5] 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, 0.29 is used.

On the contrary, when rice straw is incorporated for a duration < 30 days before the cultivation (a double crop situation), the rice straw is not mineralized and the readily fermentable C contents of the rice straw results in the formation of higher quantity of methane production, therefore, 1.0 is used. Moreover, the soil characteristics when a second crop follows an earlier one favour larger methane production.

Table 6. Specific emission factors for baseline, project and emission reductions ($kgCH_4$/ha/day) or($kgCH_4$/ha/season)

	$EF_{BL,c}$	**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

35. **Using India default values derived from IPCC tier 2 approach**.

36. Emission reductions using IPCC tier 2 approach: In Tier 2 approach, country-specific emission factors and/or scaling factors shall be used. The country-specific factors are necessary to consider the local impact of the condition that influence CH4 emissions. Peer-reviewed scientific literature on methane emission in rice fields may be used that represents similar agroclimatic conditions and cultural practices. These conditions include different ecosystems, water regimes, type and amount of organic amendments, and other conditions that may cause CH4 emissions to vary. Ideally, country-specific emission factors shall be developed through collection of field data such as effects of soil type and rice cultivar. It is encouraged to implement the method at the most disaggregated level and to incorporate the multitude of conditions that influence CH_4 emissions. Project emission would be calculated as per section 4.6 of this methodology. The emission reduction will be calculated as per section 4.7.

5. Methodology: Monitoring Component

5.1. Monitoring of baseline and project emissions

37. The following parameters shall be monitored as per the below. The applicable requirements specified in the "General guidelines for SSC CDM methodologies" (e.g. calibration requirements, sampling requirements) shall be taken into account by the project participants.

Data / Parameter table 1.

Data / Parameter:	**$EF_{BL,s,g}$**
Data unit:	$kgCH_4$/ha per season
Description:	Baseline emission factor
Source of data:	-
Measurement procedures (if any):	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Monitoring frequency:	Regular measurements as per closed chamber method guidance, seasonally integrated
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	**$EF_{BL,c}$**
Data unit:	$kgCH_4$/ha/day or $kgCH_4$/ha/season
Description:	Baseline emission factor for continuously flooded fields without organic amendments
Source of data:	-
Measurement procedures (if any):	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.

Monitoring frequency:	Determined ex ante prior to the start of the project activity (in this case, the ex ante value should be used to calculate emissions reduction during the crediting period) or monitored annually
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 3.

Data / Parameter:	$\mathbf{EF_{P,\ s,\ g}}$
Data unit:	$kgCH_4$/ha per season
Description:	Project emission factor
Source of data:	-
Measurement procedures (if any):	As per the instructions in the appendix (Guidelines for measuring methane emissions from rice fields) and IPCC 2019, volume 4, chapter 5.5.
Monitoring frequency:	Regular measurements as per closed chamber method guidance, seasonally integrated
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 4.

Data / Parameter:	$\mathbf{A_{s.\ g}}$
Data unit:	ha
Description:	Aggregated project area in a given season *s*
Source of data:	-
Measurement procedures (if any):	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
Monitoring frequency:	Every season
QA/QC procedures:	-
Any comment:	Only compliant farms are considered

Data / Parameter table 5.

Data / Parameter:	$\mathbf{A_y}$
Data unit:	ha
Description:	Aggregated project area in year *y*.
Source of data:	-
Measurement procedures (if any):	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
Monitoring frequency:	Every year

QA/QC procedures:	-
Any comment:	This parameter is only required to monitor if approach mentioned under IPCC Tier 1 and Tier 2 is used. Only compliant farms are considered

Data / Parameter table 6.

Data / Parameter:	**Ly**
Data unit:	days/year
Description:	Cultivation period of rice in year *y*
Source of data:	-
Measurement procedures (if any):	To be determined using cultivation logbooks
Monitoring frequency:	Every year
QA/QC procedures:	-
Any comment:	This parameter is only required to monitor if approach mentioned under IPCC Tier 1 and Tier 2 is used. Only compliant farms are considered

Data / Parameter table 7.

Data/Parameter:	Organic amendment
Data unit:	kg
Description:	Organic amendment can be categorised Straw on-season, Green manure, Straw off-season, Farm yard manure, Compost, No organic amendment
Source of data:	For baseline: Can be based on studies that are relevant to the area, information from official sources or reputed research bodies, interviews with farmers, or other such records of applications in the baseline. Sampling is allowed. For project scenario: Information recorded by a farmer in log books during the application or in a digital database, compiled into a spreadsheet for the entire project.
Monitoring frequency:	Annual
QA/QC procedures:	Quantity of organic amendments to be recorded category wise for items provided in ‘description’ above.
Any comment:	-

Data / Parameter table 8.

Data/Parameter:	Synthetic fertilizer
Data unit:	kg
Description:	Quantity of synthetic fertiliser applied in the project fields.

Source of data:	For baseline: Can be based on studies that are relevant to the area, information from official sources or reputed research bodies, interviews with farmers, or other such records of applications in the baseline. Sampling is allowed. The information recorded by farmers in log books during the application, compiled into a spreadsheet for the entire project.
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Data / Parameter table 9.

Data/Parameter:	$Q_{F,i}$
Data unit:	Liter
Description:	Quantity of fossil fuel consumed by farming equipment and specialised vehicles (tractors, land movers, etc.) during land preparation for implementing the project. The same will be used to calculate project emissions from land preparation.
Source of data:	Records of the type of equipment used, type of fuel and time operated can be estimated using operational records.
Monitoring frequency:	Only year 1 of field operation of respective project fields
QA/QC procedures:	IPCC default values to be applied for emission calculation. Efficiency of equipment (if required) shall follow manufacturer's manual or details of comparable devices.
Any comment:	To be monitored only for the first year of field operation. Emissions from land preparation beyond the first year of field operation are deemed to be insignificant.

Data / Parameter table 10.

Data / Parameter:	$Q_{N,Proj,g}$
Data unit:	kg N-input per hectare
Description:	Application rate of N-inputs in the project scenario in area group g where it exceeds the baseline application rate
Source of data:	Fertiliser application log books from farmers, surveys among farmers.
Monitoring frequency	Annual
QA/QC procedures	Consolidated purchase receipts could be considered to check the N-inputs.
Any comment:	-

5.2. Monitoring of farmers' compliance with project cultivation practice

38. 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) Land preparation operations, 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.

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

40. 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.

41. Reporting and verification shall be done on the basis of samples of the log-books from the farmers, according to the latest version of the "Standard for sampling and surveys for CDM project activities and programme of activities".

42. 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.

43. Projects applying the project methodology a default uncertainty deduction factor of 15% is to be applied on the emission reductions.

Guidelines for measuring methane emissions from rice fields

1. 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. They rather set minimum requirements that serve for standardizing the conditions under which methane emissions are measured for projects under this methodology.

2. 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.

3. 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 1. 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

Feature	Conditions	
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 2. On the field – air sampling

Feature	Conditions
Replicate chambers per plot	Minimum requirement: Three replicate chambers per plot
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. After fertilizer or irrigation event, increase the frequency of gas sampling. For example, gas samples need to be collected 2, 3, and 5 days after application of fertilizer.
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 the syringe; • Storage > 24 h: transfer air samples into evacuated vial, store with slight overpressure

Table 3. 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

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

4. For each gas analysis, calculate the mass of CH_4 emissions with the help of the following formula:

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

Where:

$m_{CH4,t}$	=	Mass of CH_4 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)
$c_{CH4,t}$	=	CH_4 concentration in chamber at time *t*, from gas analysis (ppm)
$V_{Chamber}$	=	Chamber volume (L)
M_{CH4}	=	Molar mass of CH_4: 16 g/mol
$1atm$	=	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)

5. 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 (2)

Where:

S	=	Slope of line of best fit (mg/min)

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

$$RE_{ch} = s \times 60min / A_{Chamber}$$

Equation (3)

Where:

RE_{ch}	=	Emission rate of chamber *ch* (mg/h $\times$ m²)
Ch	=	Index for replicate chamber on a plot
$A_{Chamber}$	=	Chamber area (m²)

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

$$RE_{plot} = \frac{\sum_{ch=1}^{Ch} RE_{ch}}{Ch}$$

Equation (4)

Where:

RE_{plot}	=	Average emission rate of a plot (mg/h $\times$ m²)
Ch	=	Number of replicate chambers per plot

8. 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.

Revision/Changes in the Document

Version	*Date*	*Description*
1.0	Month & Year	Section / Annexure Revision to