Gold Standard
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METHODOLOGY

METHODOLOGY FOR METHANE EMISSION REDUCTION BY ADJUSTED WATER MANAGEMENT PRACTICE IN RICE CULTIVATION

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SUMMARY

The methodology is applicable to measures that reduce anaerobic decomposition of organic matter in rice-cropping soils. Such measures include changing the water regime during the cultivation period from continuously to intermittently flooded conditions and/or a shortened period of flooded conditions, using the alternate wetting and drying method, adopting aerobic rice cultivation methods, and switching from transplanted to direct-seeded rice (DSR). This methodology can be applied to large and small-scale or micro-scale projects or PoAs.

The methodology is adapted from the small-scale CDM methodology AMS-III.AU - Methane emission reduction by adjusted water management practice in rice cultivation - Version 4.0. This methodology has been revised in accordance with the recent IPCC guidelines (Chapter 5.5 of IPCC Guidelines (2019)). It has introduced options for determining country-specific baselines using Tier-2 approaches, as well

as additional guidelines on baselines and methane measurements, and simplified approach for small scale and micro scale projects.

ACKNOWLEDGEMENT

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1| Definition

1.1.1 | For the purpose of this methodology the following definitions[1] apply:

a. **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;

b. **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;

c. **Project cultivation pattern** – a set of elements of a cultivation practice which is adopted under the project activity. This mainly consists of the adjusted irrigation method. Field preparation, fertilisation and weed and pest control may also be included;

d. **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;

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

f. **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;

g. **Upland** - a type of water regime in which fields are never flooded for a significant period of time;

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

2| Scope, Applicability, and entry into force

2.1 | Scope

2.1.1 | 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:

[1] IPCC approach provides for the definitions (e) to (h) (see volume 4 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as IPCC guidelines (2019)) or further details). Please refer Table 5.12 (updated) https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf

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

2.2 | Applicability

2.2.1 | This methodology is applicable globally, under the following conditions:

a. Rice cultivation in the project area is predominantly characterised 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 characterisation 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;
d. If a project activity introduces a new cultivar(s) that has not been used before in the project region, it should be demonstrated that the new cultivar(s) does not require any changes in the land management practices;
e. Training and technical support during the cropping season that delivers appropriate knowledge in field preparation, irrigation, drainage and use of fertiliser 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 developer is able to ensure that the farmer by himself or through experienced assistance is able to determine the crop's supplemental N fertilisation 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 fertilisation considering the specific cultivation conditions in

[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").

the project area backed by scientific literature or official recommendations shall be used;

f. Project developer(s) shall assure that the introduced cultivation practice, including the specific cultivation elements, technologies and use of crop protection products, is in compliance with any local regulatory restrictions, if applicable;

g. Except the case where the IPCC default value approach indicated in this methodology is chosen for emission reductions calculations, project developers have access to infrastructure to measure CH_4 emissions from reference fields using closed chamber method and laboratory analysis.

2.2.2 | The methodology can be applied to any scale i.e., large, small or micro of project activity, Programme of Activities (PoA) and VPAs.

2.2.3 | Small or micro scale projects/VPAs[3] applying simplified approach (paragraph 3.8.5 |) shall demonstrate that there is no project/VPA by the same project developer which is design certified or under design review using this methodology within 1 km of the project boundary of the proposed project at the closest point.

2.3 | Entry into force

2.3.1 | The date of entry into force of this methodology is the date of its publication. GS Approved small scale CDM methodology AMS-III.AU will become inactive after 30 days of publication of this methodology.

3| Baseline Methodology

3.1 | Project Boundary

3.1.1 | 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.

3.1.2 | The GHG emission sources included in or excluded from the project boundary are listed in the Table 1. below.

Table 1. Emissions sources included in or excluded from the project boundary

[3] Small Scale project (emission reductions not more than 60K tCO_2e/year) and Microscale (emission reduction not more than 10K tCO_2e/year, and project area not more than 500 ha). Smallholder, small scale and microscale definitions and requirements for Land-Use and Forestry (LUF) projects – Gold Standard for the Global Goals

Scenario	Source	Gas	Included	Justification/Explanation
Baseline scenario	Emissions from continuously flooded rice fields	CO_2	No	Not relevant to the project activity
		CH_4	Yes	Major source of emissions
		N_2O	No	Not relevant to the project activity
Project scenario	Emissions from fields with single or multiple drainage	CO_2	Yes	To be accounted if significant
		CH_4	Yes	Major source of emissions
		N_2O	Yes	To be accounted if significant

3.2 | Demonstration of additionality

3.2.1 | The regulatory surplus shall be demonstrated by all the projects, irrespective of scale. The project shall demonstrate that proposed activity is neither directly mandated by law nor otherwise triggered by legal requirements (e.g., legally binding agreements, covenants, consent decrees, or contracts (with government agencies or private parties). If such legal requirements are identified, then crediting for the activity shall only be allowed until the date the legal requirements would take effect.

3.2.2 | The project developer shall demonstrate that the project could not or would not take place without carbon finance. The project developer shall demonstrate additionality by conforming to additionality requirements of one of the options below,

a. Applicable GS4GG Activity Requirements;
b. CDM Tool 01 - Tool for the Demonstration and Assessment of Additionality;
c. CDM Tool 19 - Demonstration of additionality of microscale project activities; (not applicable to Gold Standard microscale projects)
d. CDM Tool 21 – Demonstration of additionality of small-scale project activities; (applicable to small-scale projects only)
e. An approved Gold Standard VER additionality tool

3.3 | Baseline scenario determination

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

3.4 | Stratification

3.4.1 | 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.

3.4.2 | 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.

3.4.3 | In addition, parameters provided Table 2 may be considered for stratification. The list of parameters provided is indicative and can be amended as per local conditions.

Table 2. Parameters for the definition of cultivation patterns

No.	Parameters	Type[a]	Values/categories[b]	Stratum element
1	Water regime – on-season[c]	Dynamic	Continuously flooded	w1
			Single Drainage	w2
			Multiple Drainage	w3
2	Water regime – pre-season	Dynamic	Flooded	p1
			Short drainage (<180d)	p2
			Long drainage (>180d)	p3
3	Organic amendment (Application rate)	Dynamic	No organic amendment	q1
			Low, medium to high organic amendment	q2 to q4
4	Organic amendment (Type)	Dynamic	Straw on-season[d]	o1
			Green manure	o2
			Straw off-season[d]	o3
			Farm yard manure	o4
			Compost	o5
			No organic amendment	q1
4	Soil pH[e]	Static	< 4.5	s1
			4.5 – 5.5	s2
			> 5.5	s3
5	Soil Organic Carbon[e]	Static	< 1%	c1
			1 – 3 %	c2
			> 3%	c3
6	Climate[f]	Static	[AEZ][f]	w1 to wn (where n is the types of climatic conditions)
7	Input number of days until maturity as	Dynamic	May be categorised as high, medium and low duration based on the varieties.	t1 to t3

per the rice variety

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 characterise 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; for example information from the farmers' or project monitoring.*

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 (2019)), 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]().

3.4.4 | Example of how classification can be represented is given below in Table 3. 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 3: 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
• Continuous Flooding, • Non flooded pre-season < 180 days, • Straw-on season, • Medium duration variety.	w1,p2,o1,t2	2
• …		

3.5 | Baseline emissions

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

$$BE_y = \sum_{s}^{S} BE_s \qquad \text{Eq. 1}$$

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

Where:

BE_y	=	Baseline emissions in year y (tCO_2e)
BE_s	=	Baseline emissions from project fields in season s (tCO_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 (tCO_2e/t CH_4)
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)
s	=	Single season
S	=	Seasons in a year considered in the project activity

3.5.2 | 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 Appendix A for guidelines on methane measurement).

3.6 | Project emissions

3.6.1 | Project emissions consist of CH_4 emissions, which will still be emitted under the changed cultivation practice. Due to the optimised *N* fertilisation practice (cf. applicability criteria paragraph 2.2.1 | aboved above, *N* fertiliser control), N_2O emissions should be accounted if it significantly increases from the baseline. Emissions from land preparation should also be considered, if significant. The estimation of project emissions, and whether they are significant are to be ascertained during verification. Therefore, project shall design and implement the monitoring plan to ensure that all necessary information is monitored and available for verification purposes.

$$PE_y = \sum_{s}^{n} PE_s + PE_N + PE_p \qquad \textit{Eq. 3}$$

PE_y = Project emissions (CH_4) in year y (tCO_2e)

PE_s = Project emissions (CH_4) from project fields in season s (tCO_2e)

PE_N = Project emissions (N_2O) from N-inputs in the project fields (tCO_2e)

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

3.6.2 | **CH_4 project emissions**: Project emissions (CH_4 from project fields on a seasonal basis are calculated as follows.

$$PE_s = \sum_{g=1}^{G} \left(EF_{P,s,g} \times A_{s,g}\right) \times 10^{-3} \times GWP_{CH4} \qquad \textit{Eq. 4}$$

Where:

$EF_{P,s,g}$ = Project emission factor of group g in season s ($kgCH_4$/ha per season)

3.6.3 | The seasonally integrated project emission factor $EF_{P,s,g}$ shall be determined using measurements on at least three project reference fields per stratum 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. Records from these reference fields will be used to arrive at emission factors.

3.6.4 | **N_2O project emissions**: N_2O emissions from fertiliser application shall be considered as project emissions. Project emissions from N-inputs shall be calculated using the formula below.

$$PE_N = PE_{N,Proj} + PE_{N,AWD} \qquad \textit{Eq. 5}$$

Where:

PE_N = Project emissions (N_2O) from N-inputs in the project fields (tCO_2e)

$PE_{N,Proj}$ = Project emissions (N_2O) from N-inputs in the project fields (tCO_2e) where application rate of N-input in the project exceeds the baseline.

$PE_{N,AWD}$ = Project emissions (N_2O) from N-inputs in the project fields (tCO_2e) where application rate of N-input in the project does not exceed the baseline.

3.6.5 | Application of fertiliser in the baseline shall be ascertained through interviews, purchase records, fertiliser application log books, interview 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. If the N_2O emissions are less than 5% of the emission reductions (after considering all emission sources in the project scenario in year Y), these N_2O emissions can be considered as *de minimis*, and maybe ignored. The project emissions from application of N-inputs shall be estimated using the equation below.

$$PE_{N,Proj} = \sum_{g}^{G} \left(\left(Q_{N,Proj,g} \times A_g \right) \times EF_N \right) \times 10^{-3} \times GWP_{N2O} \quad \text{Eq. 6}$$

Where:

$PE_{N,Proj}$	=	Project emissions (N_2O) from N-inputs in the project fields (tCO_2e) where application rate of N-input in the project exceeds the baseline.
$Q_{N,Proj,g}$	=	Application rate of N-inputs in the project scenario in area group g where it exceeds the baseline application rate (kg N input per hectare)
EF_N	=	Emission factor calculated from Table 11.1, Chapter 11, Volume 4, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2019) (tCO_2e) For single and multiple drainage: 0.00786 kg N_2O/kg N input
A_g	=	Area of project fields of group g (ha)
GWP_{N2O}	=	Global warming potential of N_2O

3.6.6 | In Area of project fields of group g, where the application rate of N-input in the project does not exceed that of baseline, an N_2O correction factor shall be applied due to the expected increase in N_2O emissions in AWD systems in comparison to continuously flooded rice field systems. The N_2O emission is calculated as per the equation below.

$$PE_{N,AWD} = \sum_{g}^{G} \left(Q_{N,g} \times A_g, i \right) \times CF_{N2O} \times 10^{-3} \times GWP_{N2O} \quad \text{Eq. 7}$$

Where:

$PE_{N,AWD}$	=	Project emissions (N_2O) from N-inputs in the project fields (tCO_2e) where application rate of N-input in the project does not exceed the baseline.
$Q_{N,g}$	=	Application rate of N-input in the project scenario where the application rate does not exceed that of baseline (kg N inputs per hectare)
CF_{N2O}	=	N_2O correction factor based on IPCC guidelines (2019). Apply 0.00314 kg N_2O/kg N input.

Correction factor has been derived by considering the difference in the emission factor (kgN_2O–N / t N) in continuously flooded rice fields and rice fields with single or multiple drainage, and the converting N_2O-N into N_2O emissions.

A_g, i = Area of project fields of group g, where the application rate of N-input in the project does not exceed that of baseline

3.6.7 | **CO_2 project emissions**: Project emissions arising from using mechanical devices, 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. The project emissions shall be estimated based on equipment usage for land preparation, fuel consumption and resulting emissions. Emissions from land preparation will be ascertained during the first year of field operation. The emissions from land preparation in the subsequent years is considered insignificant.

$$PE_p = \sum_{i}^{n} \left(EF_{fuel,i} \times Q_{F,i}\right) \quad \textit{Eq. 8}$$

Where:

$Q_{F,i}$ = Quantity of fuel of type i (quantified as energy input) (TJ)

$EF_{fuel,i}$ = Emission factor of fuel type i based on IPCC guidelines (tCO_2e/TJ)

Default emission factor may be sourced from IPCC or other comparable sources. The most conservative values for fuel efficiency shall be considered, either from the manufacturer's manual or other comparable sources.

3.6.8 | Reduction in N_2O emissions arising from decrease in fertiliser usage rate cannot be claimed under this methodology. Additional approaches to account and claim reductions in N_2O emissions in AWD systems may be published by Gold Standard in future.

3.7 | Leakage emissions

3.7.1 | 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.

3.8 | Emissions reductions

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

$$ER_y = (BE_y - PE_y) \times (1 - U_d) \quad \textit{Eq. 9}$$

Where:

ER_y	=	Emission reductions in year y (tCO_2e)
U_d	=	Uncertainty deduction (%)

3.8.2 | For the *ex ante* estimation of emission reductions within the project design document (PDD), project developer 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. The justification shall include the appropriateness of the option/tier selected. A conservative approach is to be considered.

3.8.3 | In case of small scale and micro scale projects, this methodology provides flexibility of applying default IPCC emission factors for *ex-post* estimation in the place of direct measurement as stipulated in sections 3.5 |and 3.6 |. This methodology follows the principle of no-backsliding i.e. the *ex-post* approach in monitoring report shall either be a higher tier or be the same tier as applied in the PDD.

3.8.4 | The options for estimation of emission reductions are provided in the figure below. If IPCC default values are applied, the preference shall be country specific default value, regional default value and global default value, in that order of preference.

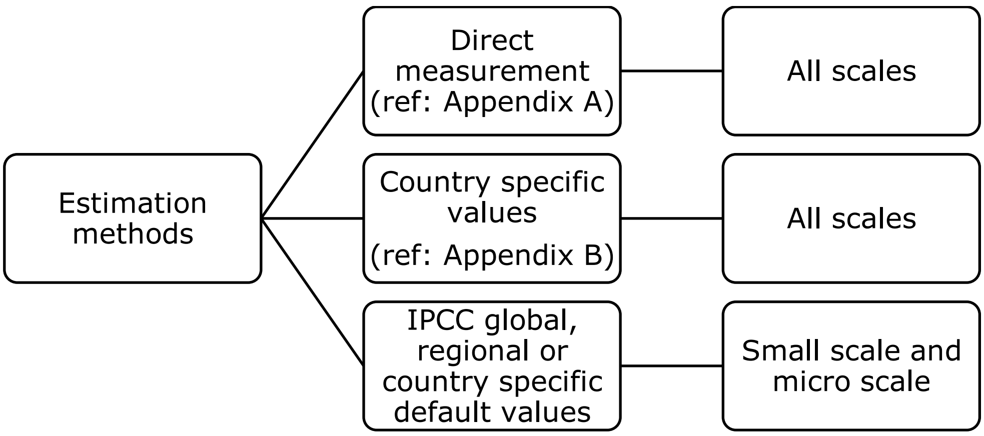

Figure 1: Estimation methods

3.8.5 | **Emission reductions using simplified approach:** As an alternative to the reference field approach indicated in paragraphs 3.3.1 |, project developer may calculate emission reductions using a simplified approach, explained in paragraphs 3.8.6 |to 3.8.17 | below.

3.8.6 | This simplified approach relies on IPCC default emission factors and can only be applied for micro or small-scale projects and the annual emission reductions shall be capped during periodic verification as per applicable project scale requirements.

3.8.7 | Emission reductions under the simplified approach shall be estimated using the following equations:

$$ER_y = \left(EF_{ER} \times A_y \times L_y \times 10^{-3} \times GWP_{CH4}\right) \times (1 - U_d) \quad \textit{Eq. 9}$$

$$EF_{ER} = EF_{BL} - EF_P \quad \textit{Eq. 11}$$

$$EF_{BL} = EF_{BL,c} \times SF_{BL,w} \times SF_{BL,p} \times SF_{BL,o} \quad \textit{Eq. 12}$$

$$EF_P = EF_{BL,c} \times SF_{P,w} \times SF_{P,p} \times SF_{P,o} \quad \textit{Eq.13}$$

Where:

ER_y	=	Emission reductions in year *y* (tCO_2e)
EF_{ER}	=	Adjusted daily emission reduction factor ($kgCH_4$/ha/day). Alternatively, seasonal emission factor ($kgCH_4$/ha/season) may be determined
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
U_d	=	Uncertainty deductions: Apply default value of 15% for IPCC default values (global, regional or country specific).

[4] For all scaling factors used in the methodology, the average values in 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories are chosen.

3.8.8 | While applying the simplified approach, the baseline emission factor for continuously flooded fields without organic amendments ($EF_{BL,c}$) shall be fixed *ex-ante* prior to the start of the project activity and should be used to calculate emission reduction during the crediting period. Country specific, regional and global default values shall be applied in that order of preference.

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

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
	Single drainage period	0.71
	Multiple drainage periods	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. *Single drainage period: fields have a single drainage event and during the cropping season, in addition to an end of season drainage.*
3. *Multiple drainage periods: fields have more than one drainage event and period of time without flooded conditions during the cropping season, in addition to an end of season drainage, including alternate wetting and drying (AWD).*

3.8.10 | 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 $SF_{BL,P}$ 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

Source: *IPCC 2019, volume 4, Chapter 5.5, Table 5.13.*

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

$$SF_O = \left(1 + \sum_{i}^{I} ROA_i \times CFOA_i\right)^{0.59} \qquad \textit{Eq. 14}$$

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]

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

Source: Calculated using equation (14) above with default values from *IPCC 2019, Volume 4, chapter 5.5, Table 5.14*.

3.8.13 | Table 6: IPCC default values for $SF_{BL,o}$ or **Table 6** above is for rice straw only. To include other organic amendments following *IPCC 2019, Volume 4, Chapter 5.5, 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 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 $(1 + GM \times 0.45)^{0.59}$;

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[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 mineralised 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 (IPCC guidelines (2019)) 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 mineralised 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.

d. C, YM, GM are application rate (tonne ha-1) of compost, farm yard manure, and green manure, respectively.

3.8.14 | Emission reduction factors may be calculated based on baseline (EF_{BL}) and project activity (EF_P) emission factors as summarised in Table 7 below. These emission reduction factors can be applied directly to equation 10.

Table 7: Specific emission factors for baseline, project and emission reductions

	$EF_{BL,c}$	Baseline				Project scenarios	Project				Emission reduction factor (EF_{ER}) ($kgCH_4$/ha/day) or ($kgCH_4$/ha/season)
		$SF_{BL,w}$	$SF_{BL,p}$	$SF_{BL,o}$	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 drainage)	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 drainage)	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 drainage)	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 drainage)	0.55	0.89	1.48	$EF_{BL,c}$ x 0.72	$EF_{BL,c}$ x 0.60

3.8.15 | 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 equation (10), using both, default emission factor values from *IPCC 2019, Volume 4, chapter 5.5, Table 5.11* and scaling factors, as summarised in **Table 8** Adjusted daily emission reduction factor EF_{ER} (kgCH_4/ha/day) given below in different project scenarios:[6]

Table 8: Emission Reduction Factors to be considered while applying global default value

Cropping Pattern	Emission Reduction Factors to be applied in Equation (10) EF_{ER} (kgCH_4/ha/day)	
	Project activities that shift to intermittent flooding (single drainage)	Project activities that shift to intermittent flooding (multiple drainage)
Double cropping regions	1.00	1.55
Single cropping regions	0.45	0.71

3.8.16 | 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.

3.8.17 | Global, regional and country specific default values are provided in Table 9 below, and can be applied in Equation 12 and 13 as applicable.

[6] Under this option, $EF_{BL,c}$= 1.19 (kgCH_4/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 EF_{ER}. 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.

Table 9: 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	
Bangladesh	0.97
Brazil	1.62
China	1.3
India	0.85
Indonesia	1.18
Italy	1.66
Japan	1.06
Philippines	0.6
South Korea	1.83
Spain	1.13
Uruguay	0.8
USA	0.65
Vietnam	1.13

3.8.18 | **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 CH_4 emissions. These conditions include different ecosystems, water regimes, type and amount of organic amendments, and other conditions that may cause CH_4 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.

3.8.19 | While applying Tier-2 approach baseline emission factor will be derived from country specific emission factor using equation 15.

$$EF_i = EF_c \times SF_w \times SF_P \times SF_o \times SF_s \times SF_r \qquad \textit{Eq. 15}$$

Where:

EF_i	=	Adjusted daily emission factor for a particular harvested area (Kg CH_4 ha^{-1} day^{-1})
EF_c	=	Baseline emission factor for continuously flooded fields without organic amendments (Kg CH_4 ha^{-1} day^{-1})
SF_w	=	Scaling factor to account for the differences in water regime during the cultivation period
SF_P	=	Scaling factor to account for the differences in water regime in the pre-season before the cultivation period
SF_o	=	Scaling factor should vary for both type and amount of organic amendment applied
SF_s	=	Scaling factor should vary for both type and amount for soil type, wherever available
SF_r	=	Scaling factor should vary for both type and amount for rice cultivar, wherever available

3.8.20 | This methodology (Appendix B) gives an example of determination of country specific emission factor for Spain and also provides guidelines for development of new country specific emission factors.

3.8.21 | Project emissions would include CH_4, N_2O and CO_2 emissions from the project as per section 3.6 | of this methodology. Country specific scaling factors for the project scenario may be applied to calculate CH_4 emissions in lieu of the direct measurement of methane from project fields.

3.8.22 | Emission reductions will be calculated as per equation 9 or equation 10 as applicable.

3.9 | Changes required for methodology implementation in 2*nd* and 3*rd* crediting periods

3.9.1 | When the project developers apply for a renewal of crediting period, the baseline shall be reassessed, as well as other relevant methodological parameters according to the latest version of the methodology available at the time submission in accordance with GS4GG crediting period renewal requirements.

3.10 | General requirements for data and information sources

3.10.1 | In the following tables of data and parameters monitored and not monitored, there are cases where a variety of source documents or studies may be applied to determine a parameter, or to cross-check a parameter.

3.10.2 | When multiple sources are available and fulfil the requirements for defining or cross-checking a parameter, the most relevant source should be chosen. Criteria for relevance include geographical (e.g. more specific to the project boundary location), temporal (e.g. more recent), and others. The VVB shall assess the relevance of the source applied compared to the other sources available. While conservativeness is a guiding principle for selecting data, the source applied to define or cross-check the parameter may not be the most conservative, if it can be shown to be the most relevant.

3.10.3 | When sampling or surveys are utilised to define parameters (e.g. N-input in the baseline, rice yield etc.) the sampling and surveys must be undertaken with reference values from other relevant data sources in mind, and project-specific survey and sampling results are expected to correlate with results from other relevant data sources. Where project specific results differ from relevant data sources in a way that is statistically significant, and the difference leads to less conservative results in the emission reduction calculations, then the project shall provide justification for the differences. Further, the project may be required to substitute more conservative results from other data sources if the justification is not accepted by the VVB or certifier.

3.11 | Data and parameters not monitored

Data/parameter ID	**AWD.1**
Data/Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Global warming potential of CH_4 ($t\ CO_2e/t\ CH_4$) Value to be applied based on the latest IPCC guidelines. For this methodology the value to be considered is: 28; as per the latest notification on the same by the Gold Standard.
Source of data:	IPCC AR5
Any comment:	

Data/parameter ID	**AWD.2**
Data / Parameter:	GWP_{N2O}
Data unit:	$tCO_{2e}/t\ N_2O$
Description:	Global warming potential of N_2O Value to be applied based on the latest IPCC guidelines. For this methodology the value to be considered is: 265; as per the latest notification on the same by the Gold Standard.
Source of data:	IPCC AR5
Any comment:	

Data/parameter ID	**AWD.3**
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. Refer Table 9 for the values.
Source of data:	IPCC guidelines (2019)
Any comment:	Country specific default values, regional values and global values are to be considered in that order of preference.

Data/parameter ID	**AWD.4**
Data / Parameter:	EF_N
Data unit:	t CO_{2e}/t N-input
Description:	N_2O Emission factor per unit of N-input in rice fields. The value to be used in case of single and multiple drainage: 0.00786 kg N_2O/kg N input. The value is to be applied in cases where there is an increase in N-input in the project scenario as compared to the baseline.
Source of data:	Emission factor calculated from Table 11.1, Chapter 11, Volume 4, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (tCO_{2e})
Any comment:	

Data/parameter ID	**AWD.5**
Data / Parameter:	CF_{N2O}
Data unit:	kg N_2O/kg N input
Description:	N_2O-factor[1] based on IPCC guidelines (2019). Apply value 0.00314 kg N_2O/kg N input. This is to be applied to compensate for increase in N_2O emissions in AWD rice fields as compared to continuously flooded rice fields.
Source of data:	IPCC guidelines (2019)
Any comment:	

<table>
<tr><th>Data/parameter ID</th><th>AWD.6</th></tr>
<tr><td>Data / Parameter:</td><td>$SF_{BL,w}$ or $SF_{P,w}$</td></tr>
<tr><td>Data unit:</td><td></td></tr>
<tr><td>Description:</td><td>Baseline or project scaling factors to account for the differences in water regime during the cultivation period. Values given below can be applied.
<table>
<tr><th colspan="2">Water regime during the cultivation period</th><th>$SF_{BL,w}$ or $SF_{P,w}$</th></tr>
<tr><td rowspan="3">Irrigated</td><td>Continuously flooded</td><td>1</td></tr>
<tr><td>Single drainage period</td><td>0.71</td></tr>
<tr><td>Multiple drainage periods</td><td>0.55</td></tr>
</table></td></tr>
<tr><td>Source of data:</td><td>The average values in 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Data/parameter ID	**AWD.7**
Data / Parameter:	$SF_{BL,p}$ or $SF_{P,p}$
Data unit:	-

Description:	Baseline or project scaling factors to account for the differences in water regime in the pre-season before the cultivation period. Use the following values: <table><tr><th>Water regime prior to rice cultivation</th><th>$SF_{BL,p}$ or $SF_{P,p}$</th></tr><tr><td>Non flooded pre-season < 180 days (indicating double cropping)</td><td>1</td></tr><tr><td>Non flooded pre-season > 180 days (indicating single cropping)</td><td>0.89</td></tr></table>
Source of data:	IPCC guidelines (2019), volume 4, Chapter 5.5, Table 5.13.
Any comment:	

Data/parameter ID	**AWD.8**
Data / Parameter:	$SF_{BL,o}$ or $SF_{P,o}$
Data unit:	-
Description:	Baseline or project scaling factors should vary for both type and amount of organic amendment applied
Source of data:	from IPCC 2019, volume 4, chapter 5.5, Table 5.14. <table><tr><th>Water regime prior to rice cultivation</th><th>$SF_{BL,o}$ or $SF_{P,o}$</th></tr><tr><td>Non flooded pre-season < 180 days (indicating double cropping)</td><td>$(1 + 5 \times 1)^{0.59}$ = **2.88**</td></tr><tr><td>Non flooded pre-season > 180 days (indicating single cropping)</td><td>$(1 + 5 \times 0.19)^{0.59}$ = **1.48**</td></tr></table>
Any comment:	.

Data/parameter ID	**AWD.9**
Data / Parameter:	EF_{ER}
Data unit:	$kgCH_4$/ha/day
Description:	Methane emission factor to be considered where there is a shift from continuously flooded rice fields. <table><tr><th rowspan="2">Cropping Pattern</th><th colspan="2">Emission Factors to be applied in Equation (10) EF_{ER} ($kgCH_4$/ha/day)</th></tr><tr><th>Project activities that shift to intermittent flooding (single drainage)</th><th>Project activities that shift to intermittent flooding (multiple drainage)</th></tr><tr><td>Double cropping regions</td><td>1.00</td><td>1.55</td></tr><tr><td>Single cropping regions</td><td>0.45</td><td>0.71</td></tr></table>
Source of data:	IPCC guidelines (2019)
Any comment:	-

Data/parameter ID	AWD.10
Data / Parameter:	$EF_{fuel,i}$
Data unit:	tCO_2e/TJ
Description:	Emission factor of fuel type i based on IPCC guidelines
Source of data:	Applicable IPCC guidelines
Any comment:	To be applied for fuel type I used to prepare the fields if applicable. The value should be mentioned in the PDD.

4| Monitoring methodology

4.1 | Data and parameters monitored

4.1.1 | 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 developers.

Parameter ID	AWD.11
Data/Parameter:	$EF_{BL,s,g}$
Data unit:	$kgCH_4$/ha per season
Description:	Baseline emission factor
Source of data:	Weekly log books, consolidated into seasonal datasheets
Monitoring frequency:	Weekly measurements as per closed chamber method guidance, seasonally integrated.
QA/QC procedures:	The instructions in the Appendix A (Guidelines for measuring methane emissions from rice fields) to be followed.
Any comment:	-

Parameter ID	AWD.12
Data/Parameter:	$EF_{P,s,g}$
Data unit:	$kgCH_4$/ha per season
Description:	Project emission factor
Source of data:	Weekly log books, consolidated into seasonal datasheets
Monitoring frequency:	Weekly measurements as per closed chamber method guidance, seasonally integrated.
QA/QC procedures:	The instructions in the Appendix A (Guidelines for measuring methane emissions from rice fields) to be followed.
Any comment:	-
	-

Parameter ID	AWD.13
Data/Parameter:	$A_{s,g}$

Data unit:	ha
Description:	Aggregated project area in a given season *s*
Source of data:	Land area survey documentation of the project
Monitoring frequency:	During every season
QA/QC procedures:	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. To scale maps that show the project fields clearly will help in ascertaining the exact area. Remote Sensing images of appropriate resolution may be used to ascertain the project boundary and area under various strata and area groups with high confidence.
Any comment:	-

Parameter ID	**AWD.14**
Data/Parameter:	A_y
Data unit:	ha
Description:	Aggregated project area in year *y*.
Source of data:	Land area survey documentation of the project
Monitoring frequency:	Annual
QA/QC procedures:	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. To scale maps that show the project fields clearly will help in ascertaining the exact area. Remote Sensing images of appropriate resolution may be used to ascertain the project boundary and area under various strata and area groups with high confidence.
Any comment:	-

Parameter ID	**AWD.15**
Data/Parameter:	L_y
Data unit:	days/year
Description:	Cultivation period of rice in year *y*
Source of data:	Farm log books
Monitoring frequency:	Annual

QA/QC procedures:	Logbooks may be compiled into a project record book by the project developer. Internal checks may be done to ascertain correctness of entries at farm level.
Any comment:	-

Parameter ID	**AWD.16**
Data/Parameter:	Water regime – on -season
Data unit:	--
Description:	Water regime can be categorised as Continuously flooded, Single Drainage, Multiple Drainage
Source of data:	Information collected and recorded by farmer or project developer by appropriate means
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Parameter ID	**AWD.17**
Data/Parameter:	Water regime – pre-season
Data unit:	-
Description:	Water regime can be categorized Flooded, Short drainage <180d), Long drainage (>180d)
Source of data:	Information collected and recorded by farmer or project developer by appropriate means
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Parameter ID	**AWD.18**
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 farmer in log books during application, 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:	-

Parameter ID	**AWD.19**
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. Information recorded by farmer in log books during application, compiled into a spreadsheet for the entire project
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Parameter ID	**AWD.20**
Data/Parameter:	$Q_{F,i}$
Data unit:	Liter
Description:	Quantity of fossil fuel consumed by farming equipment, specialised vehicles (tractors, land movers etc.) during land preparation for implementing the project. The same will be used in calculating project emissions from land preparation.
Source of data:	Records of type of equipment used, type of fuel and time operated, or 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 first year of field operation is deemed to be insignificant.

Data/parameter ID	**AWD.21**
Data / Parameter:	$Q_{N,Proj,g}$
Data unit:	tonnes 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:	-

Data/parameter ID	**AWD.22**
Data / Parameter:	A_g
Data unit:	hectare
Description:	Area of project fields of group g (ha)
Source of data:	From the project stratification maps.
Monitoring frequency	Annual
QA/QC procedures	To be determined by collecting the project field sizes based on stratification 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. To scale maps that show the project fields clearly will help in ascertaining the exact area. Remote Sensing images of appropriate resolution may be used to ascertain the project boundary and area under various strata and area groups with high confidence.
Any comment:	-

Data/parameter ID	**AWD.23**
Data / Parameter:	SF_s
Data unit:	-
Description:	Scaling factor should vary for both type and amount for soil type
Source of data:	Emission data for different soil types and rice cultivar are available and can be used to derive SF_s and SF_r, respectively, for Tier 2 method. Both experiments and mechanistic knowledge confirm the importance of these factors, but large variations within the available data do not allow one to define reasonably accurate default values for Tier 1 method.
Monitoring frequency	Once at the beginning of each crediting period
QA/QC procedures	-
Any comment:	-

Data/parameter ID	**AWD.24**
Data / Parameter:	SF_r
Data unit:	-
Description:	Scaling factor based on type and amount for rice cultivar
Source of data:	Emission data for different soil types and rice cultivar are available and can be used to derive SF_s and SF_r, respectively,

	for Tier 2 method. Both experiments and mechanistic knowledge confirm the importance of these factors, but large variations within the available data do not allow one to define reasonably accurate default values for Tier 1 method
Monitoring frequency	Once at every season
QA/QC procedures	-
Any comment:	-

4.2 | Monitoring of farmers' compliance with project cultivation practice

4.2.1 | 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. Fertiliser, 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.

4.2.2 | In addition, farmers shall state whether they have followed fertilisation recommendations provided with the introduction of the adjusted water management practice. This shall include details such as whether the optimised dosage of fertilisers, frequency etc is being followed as established during the project design phase.

4.2.3 | Project developers 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 anymore, 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.

4.2.4 | 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".

4.2.5 | Project developers 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.

5| Project activity under a Programme of Activities

5.1.1 | The methodology is applicable to a programme of activities, no additional leakage estimations are necessary other than that indicated under leakage section above.

5.1.2 | Scale of the PoA will be decided at real case VPA level. VPAs opting for micro or small scale if applying tier 1 default values, shall demonstrate compliance with de-bundling criteria.

6| Uncertainties

6.1.1 | All projects applying Tier 2 approach (refer paragraph 0) and direct measurement (refer paragraphs 3.5.2 | and 3.6.3 |) will be subjected to the assessment of uncertainty as per Annex A of LUF Activity Requirements.

6.1.2 | Simplified approach 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.

APPENDIX : A. GUIDELINES FOR MEASURING METHANE EMISSIONS FROM RICE FIELDS

A.1. Appendix A details how methane emissions can be measured from rice fields. This guideline is meant as a base-template, and it is expected that the best and latest available practices will be adopted to measure methane from rice fields.

A.2. 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[7]. They rather set minimum requirements that serve for standardising the conditions under which methane emissions are measured for projects under this methodology.

A.3. Project developers 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, fertiliser treatment and organic amendments.

A.4. The following guidance is structured according to the steps from field measurement to emission factor calculation. Project developers shall make sure that the measurements on project and baseline reference fields are carried out in an equal manner and simultaneously.

Table A.1. On the field - technical options for the chamber design

Feature	Conditions	
	Option 1: Non-transparent	Option 2: Transparent
Chamber material	• Commercially available PVC containers or manufactured chambers (e.g. using galvanised 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	• 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

[7] For example, procedures such as "Guidelines for Measuring CH_4 and N_2O 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).

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 m² 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 A. 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
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 A. 3. Laboratory analysis

Feature	Conditions
Method	Gas Chromatograph with flame ionisation 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)

A.5. For each gas analysis, calculate the mass of CH4 emissions with the help of the following formula:

$$m_{CH4,t} = c_{CH4,t} \times V_{Chamber} \times M_{CH4} \times \frac{1atm}{R \times T_t \times 1000} \qquad Eq.\ 1$$

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)

A.6. Determine the slope of the line of best fit for the values of over time with the help of software (e.g. Excel):

$$s = \frac{\Delta m_{CH4}}{\Delta t} \qquad Eq.\ 2$$

Where:

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

A.7. Calculate the emission rate per hour for one chamber measurement:

$$RE_{ch} = s \times \frac{60min}{A_{Chamber}} \qquad Eq.\ 3$$

Where:

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

A.8. Calculate the average emission rate of a chamber measurement per plot:

$$RE_{plot} = \frac{\sum_{ch=1}^{Ch} RE_{ch}}{Ch}$$ *Eq. 4*

Where:

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

A.9. 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.

APPENDIX : B. GUIDELINES FOR DEVELOPING BASELINES AND SCALING FACTORS

A. Development of a new country-specific baseline: Example for Spain

B.1. According to the IPCC 2019 (Refinement to the 2006 IPCC Guidelines for national Greenhouse for national Greenhouse Gas Inventories), it is encouraged to use direct measurements to calculate country specific emission factors.

B.2. This guideline is to be used as an example of how baselines and scaling factors can be developed that are country specific. The guideline has used example of Spain, to help explain the process.

B.3. The default country specific value for Spain reported in the National Inventory[8] of 2022 (1.3 kg CH_4/ha/day) was calculated based on the $EF_{BL,c}$ and scaling factors ($SF_w, SF_p, and\ SF_o$) as used in this methodology. The scientific articles described in Table 1 could be used to calculate new baseline emission factors. These articles have determined baseline emission values ($EF_{BL,c}$) for the main cultivation areas in Spain: Andalucía, Aragón, Ebro Delta and Extremadura (see Figure 1., from Gomez de Barreda et al., 2021).

Table B.1. Description of scientific literature used to calculate the Emission Factors

Location	Year evaluated	Reference
Andalucía. MG	1982	Seiler et al., 1983
Extremadura. EX	2011, 2012, 2013	Fangueiro et al., 2017
Albufera, Valencia. VA	2013	Sanchis, MSc´s Thesis, 2014
Ebro Delta, Catalunya. DE	2015	Martinez-Eixarch et al. 2018
	2015, 2016	Martinez-Eixarch et al. 2021a
	2016, 2017	Martinez-Eixarch et al. 2021b
	2018	Belenguer Manzanedo et al., 2022
	2012	Maris et al., 2016
Aragon. AR	2012	Maris et al., 2016

B.4. These scientific articles have different experimental settings which hamper the direct calculation of mean emission values (e.g. they are not all following continuously flooded conditions without organic amendment). To consider these different experimental conditions applied it is proposed to calculate the EF_{BL} from the baseline emission factor EF_c calculated for each of the experiments (Table 2). $SF_w, SF_p, and\ SF_o$ values used in Table B.2 have been

[8] Spain Nacional Inventory (2022): Report on the National Inventory of Greenhouse Gas Emissions Ministry for the Ecological Transition and the Demographic Challenge General Technical Secretariat. Publication Center 2022 NIPO: 665-22-007-8

calculated following the information from the scientific articles described in Table B.1 and the relevant IPCC guidelines[9].

Table B.2. Calculation of EF_{BL} from the baseline EF_c[a]

Location	EF_C (kgCH_4/ha/year)	SFw	SFp	ROA[b]	CFOA	SFo	EF_{BL} (kgCH4/ha/year)
Andalucia. MG	120.00	1	0.89	0	0.19	1.00	134.83
Extremadura. EX	353.00	1	0.89	5	0.19	1.48	267.46
Albufera. Valencia. VA	557.50	1	1	8	0.19	1.73	323.16
Ebro Delta. Catalunya. DE	98.40	1	1	5	0.19	1.48	66.36
	96.60	1	1	5	0.19	1.48	65.14
	44.15	1	1	5	0.19	1.48	29.77
	141.01	1	1	5	0.19	1.48	95.09
	437.00	1	1	5	0.19	1.48	294.69
Aragon. AR	157.00	1	1	5	0.19	1.48	105.87
Mean	222.74				Mean		153.60
CI - 95%	84.23				CI - 95%		68.33
	361.25						238.87

[a] EF_C refers to methane emissions during the growing period in the following conditions: continuous flooding during cultivation, winter flooding, and no organic amendment included.

[b]5 tonne/ha of straw is assumed as the baseline quantity of organic ammendent.

B.5. The calculated $EF_{BL,c}$ (153.60 kgCH_4/ha/year) is within the interval calculated values estimated by the National Inventory Report of Spain (195 kgCH_4/ha/year) and the work of Wang, 2018 (128.82 kgCH_4/ha/year).

B.6. The application of $SF_w, SF_p, and\ SF_o$ prior to the calculation of the mean values has reduced the 95% Confidence Interval EF_{BL} (84.23-361.25) to $EF_{BL,c}$ (68.33-238.87), suggesting the validity of the proposed approach. The reduction of EF_{BL} (222.74) to $EF_{BL,c}$ (153.60) suggests that the direct use of EF_{BL} could have overestimated the real values by not considering the specific experimental settings of each of the studies considered.

B.7. Regarding the scaling factors, the IPCC guidelines (2019)[10] states that if no national factors are available, the default IPCC scaling factors can be used. Therefore, the default scaling factors in IPCC guidelines (2019) (Vol. 4) are used to establish the baseline.

[9] IPCC 2019: Section 5.5.2., Volume 4, Chapter 5.5

[10] IPCC 2019: Section 5.5.2., Volume 4, Chapter 5.5

B.8. As an example, in the table 3, the Emission Factor (EF_{BL}) for irrigated rice fields (kgCH_4/ha/season) has been calculated based on: scaling factor for the water regime (SF_w), scaling factor for pre-season water regime (SF_p) and for scaling factor for organic amendment (SF_o). This scaling factor values are based on the IPCC guidelines (2019)[11].

Table B.3. Calculation of emission factor (EF_{BL}) for irrigated rice fields

		EFc	Baseline*			
			SFw	SFp	SFo	Emission Factor (EF_{BL})
For single cropping	Continuously flooded	153.6	1	0.89	1.48	202.32
	Intermittent flooded-single drainage	153.6	0.71	0.89	1.48	143.65
	Intermittent flooded-multiple drainage	153.6	0.55	0.89	1.48	111.28

*Scaling factor values are based on IPCC guidelines (2019)

B. Guidelines for the development of a new country-specific baseline

B.9. The example above for Spanish conditions may be applicable for countries or regions with similar agroclimatic and cultural practices. Nonetheless, if data of methane emission is available, it is recommended that the new country-specific emission factors are developed following the example above. The data should be obtained from reputed academic institutions or scientific articles published in indexed scientific journals. Still, considering the variability among the experimental settings of the scientific articles, it is recommended to have a minimum set of 10 sites*year data, and if possible, three years. In the example above, nine experiments were selected with a total of 13 sites*year (some sites having more than one year). This strategy will help minimising the variability. In addition, the calculation of $EF_{BL,c}$ from EF_{BL} using the default values from IPCC can help reducing the variability related to the experimental settings of the scientific articles. This strategy reduces the variability in the emission factors associated to water regime prior and during to rice cultivation, and to organic amendments.

B.10. Peer-reviewed scientific literature on methane emission in rice fields may be scarce in some countries where projects are developed. In this case, a still feasible option is the use of scientific articles[12] from zones with similar agroclimatic conditions and cultural practices. The emission factors calculated

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[11] IPCC 2019: Section 5.5.2., Volume 4, Chapter 5.5 https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf

[12] Preferably from the last 10 years

using this approach may still be yielding more accurate country-specific emission factors that those proposed by statistical modelling from IPCC or national inventory values, which may not be updated (i.e. the emission factor for Spanish National Inventory in 2022 was still taken from IPCC 2006[13]).

C. Consideration of post-harvest period (fallow season) in the calculation of baseline emission factors: Example for Spain

B.11. An important finding regarding methane emissions in rice fields in temperate conditions is the high emission level during the fallow season when straw is incorporated after the growing cycle (referred as "off-season" straw incorporation in the IPCC guidelines (2019)). Martinez-Eixarch et al., (2021a,b) have shown that neglecting the fallow season can significantly underestimate annual methane emissions in Ebro Delta rice fields (Spain, temperate conditions).

B.12. Martinez-Eixarch et al. 2021a showed that 36.9% of methane was emitted during the growing season and 63.1% during the flooded fallow season, mainly in October, when temperatures remain high in most of Spanish rice culture areas. October indeed accounted for over 45% of the annual emissions. This high value is related to the favorable conditions for methanogenesis in Ebro Delta rice paddy fields in October: 1) off-season straw incorporation, 2) flooding conditions and 3) the high temperatures.

B.13. Nonetheless, most of the field analysis of methane circumvents this fact, since it is assumed that most of the CH_4 from the previous season will be emitted during the next growing season, but this is not the case (Martinez-Eixarch et al., 2021a,b). Thus, to avoid the underestimation of methane emissions, it is proposed the use of an off-season scaling factor as described in Table 4:

Table B. 4. Calculation for the scaling factor for off-season (fallow) measurements in Spanish conditions (SF_{FS}).

Location	Reference	Year evaluated	Treatment	EF ($kgCH_4$/ha/season)
Ebro Delta, Catalunya. DE	Martinez-Eixarch et al. 2021a	2015, 2016	Cultivation	96.6
Ebro Delta, Catalunya. DE	Martinez-Eixarch et al. 2021a	2015, 2016	Off-season	163.9
			Total	260.50

[13]Spanish National Inventory (2022): Report on the National Inventory of Greenhouse Gas Emissions Ministry for the Ecological Transition and the Demographic Challenge General Technical Secretariat. Publication Center 2022 NIPO: 665-22-007-8: https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/es_nir_edicion2022_tcm30-523942.pdf, https://unfccc.int/documents/228014, accessed on 18.08.2022.

Scaling factor fallow season	Winter flooding	SF_{FS}	Error range[1]
Measurements include off-season	-	1	0.73-1.27
Measurements does not include off-season	Yes	2.70	1.97-3.43
	No	1.1	0.80-1.40

[1] Error ranges are proportional to the values calculated for continuosuly flooded conditions in Annex 5.A.2 using statistical model and updated database

SF_{FS} = 1.1 is obtained combining the data from Belenguer Manzanedo et al., 2022 and Martinez-Eixarch et al. 2021b

B.14. This scaling factor is proposed to be applied to the calculation of baseline emissions when the post-harvest period has not been measured. In the case of Spain, this scaling factor would be applied to the values of $EF_{BL,c}$ given in Table B 5. The application of a scaling factor (2.7) highly increases the emission baseline, but according to the scientific literature supporting the post-harvest emission, this value should be considered. Indeed, a similar value is considered by the IPCC[14] for flooded pre-season conditions ($\boldsymbol{SF_p} = 2.41$), which may reflect the high methane emission from the decomposition of organic matter under anoxia, just before the growing period. This high value ($\boldsymbol{SF_p} = 2.41$) comes from the analysis of Wang et al., 2008, which used a dataset where subtropical and tropical rice fields are overrepresented compared to temperate fields. The different cultural practices between temperate and tropical and subtropical paddy rice fields could explain the different need of scaling factors for different regions. This would support the definition of scaling factors for regions based on scientific evidence as shown above.

D. Calculation of scaling factors for pre-season water regime (SF_p) and multiple drainage period (AWD) (SF_w): Example for Spain.

i. Pre-season water regime ($\mathrm{SF_p}$)

B.15. Recent scientific literature developed in Spain has provided a basis to quantify new scaling factors for pre-season flooding and water regime during crop cultivation.

B.16. The values of the scaling factors developed in the IPCC guidelines 2019 (Vol 4, 5.55) for the water regime -before the cultivation period to (〖SF〗 _p) may not be fully representative to the agricultural practices used in Spanish, or even, in other temperate rice areas.

[14] IPCC 2019: Table 5.13, Section 5.5.2., Volume 4, Chapter 5.5 https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf

B.17. Belenguer-Manzanedo et al., (2022) showed that removing the pre-season flooding (referred as "winter flooding" in their manuscript; that is from end of September—after harvest- to end of December) significantly reduced the methane emissions. In this way, and according to the data from Belenguer-Manzanedo et al., (2022), a post-harvest (or, as defined in terms of Table 5.13 of IPCC guidelines (2019), pre-season flooding) scaling factor for water regime can be proposed, as shown in Table B.5:

Table B. 5. Calculation of a post-harvest water regime scaling factor (SF_p)

Location	Scientific reference	Year evaluated	Treatment	EF (kgCH4/ha/season)
Ebro Delta, Catalunya. DE	BelenguerManzanedo et al., 2022	2018	winter fooding and early straw incorporation	258.90
Ebro Delta, Catalunya. DE	BelenguerManzanedo et al., 2022	2018	winter fooding and late straw incorporation	294.30
			Mean	**276.60**
Ebro Delta, Catalunya. DE	BelenguerManzanedo et al., 2022	2018	non-winter fooding and early straw incorporation	153.20
Ebro Delta, Catalunya. DE	BelenguerManzanedo et al., 2022	2018	non-winter fooding and late straw incorporation	155.80
			Mean	**154.50**
Scaling factor for pre-season flooding (SF_p) = (Σ Non-off-season flooding) / (Σ Off-season flooding)				=**0.56**
			Error range[1]	0.49-0.63

[1]Error range is proportional to the values calculated in Annex 5.A.2 of IPCC guidelines (2019) refinement, using statistical model and updated database.

ii. Multiple drainage period (AWD) (SF_w)

B.18. Regarding the water regime during the cultivation period, Martinez Eixarch et al., (2021b) have shown that alternate wetting and drying (AWD) treatments can reduce the CH_4 emissions from 44.15 to 2.45 kgCH_4/ha/season. The large CH_4 mitigation capacity of AWD shown by Martinez Eixarch et al., (2021b) is comparable to that reported by other authors Linquist et al. (2015) and Peyron et al. (2016), in other regions. Therefore, a new scaling factor (SF_w = 0.06 instead of 0.55 as used in the IPCC guidelines (2019)) is suggested for multiple drained periods in the Spanish conditions as shown in table B.6.

Table B.6. Calculation for the scaling factor for multiple drainage periods in Spanish conditions (SF_w)

Location	Scientific reference	Year evaluated	Treatment	EF (kgCH_4/ha/season)

Ebro Delta, Catalunya. DE	Martinez-Eixarch et al. 2021b	2016	Continuously flooded	18.5
Ebro Delta, Catalunya. DE	Martinez-Eixarch et al. 2021b	2017	Continuously flooded	69.8
			Mean	**44.15**
Ebro Delta, Catalunya. DE	Martinez-Eixarch et al. 2021b	2016	AWD	1.7
Ebro Delta, Catalunya. DE	Martinez-Eixarch et al. 2021b	2017	AWD	3.2
			Mean	**2.45**
Scaling factor for winter flooding (SF_w) = (Σ AWD) / (Σ Continuously flooded) =				=0.06
			Error range[1]	0.04-0.07

[1] Error ranges are proportional to the values calculated in Annex 5.A.2 using statistical model and updated database.

B.19. Thus, it can be proposed for its use in Spain a SF_w = 0.06, when using multiple drainage periods during the cultivation of rice.

E. Development of emissions and scaling factors for CH4 emissions

B.20. The development of emissions and scaling factors for methane emissions in paddy rice fields in Spain has been done using the published scientific literature relevant to Spain rice growing conditions.

B.21. Some requirements and criteria that must be considered to develop these emission and scaling factors are mentioned below

F. Further References on Quantification to Determine Country-Specific Emission and Scaling Factors:

Table B.7: Further References on Quantification to Determine Country-Specific Emission and Scaling Factors:

Document	Purpose
IPCC guidelines (2019)[15] volume 4	Good practice guideline that describes the criteria for collecting and selecting data that can be included in the data set
ASB0008-2020[16]	Has been used as an example for the development of emission factors in the Philippines

[15] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 4, chapter 5.5.

[16] Methane Emissions from Rice Cultivation in the Republic of the Philippines (version 01.0).

CDM[17] guidelines document	To identify credible data and information
Standard document of CDM[18]	For determining data coverage and validity of standardized baselines

B.22. For the example on emission factor for Spain given above in this document (Appendix B), baseline emission factor is determined based on scientific data reaching the minimum of three years.

B.23. Regarding the scaling factors, less than three years were available for the determination of scaling factors (one year, two years and two years for post-harvest water regime, for multiple drainage periods, and for fallow season, respectively. We consider that the scaling factors proposed in this document are more accurate that model-derived observations for the rice cultivation conditions in Spain. Indeed, similar values obtained by other authors in different climatic conditions for the three scaling factors proposed:

a. Post-harvest water regime: Fey et al. (2004), Sander et al. (2014) and Zhang et al. (2010);

b. Multiple drainage periods: Linquist et al., 2014, Peyron et al., 2016;

c. Fallow season (Fitzgerald et al., 2000, Pittelkow et al., 2013).

G. REFERENCES AND ANY OTHER RELEVANT INFORMATION

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