Appendix C: Supplemental Guidance for Monitoring Methods and GHG Emission Calculations in the Philippines

This appendix provides additional explanations for the monitoring parameters and methods used in this methodology. Project participants have a certain degree of freedom to select the monitoring methods depending on the situation. This appendix also explains the procedures how to calculate CH_4 and N_2O emissions in specific cases regarding the success of water management. This methodology makes much of the results.

1. Water management in the past 2 years prior to the start of the project

In order to satisfy criterion 1, project participants need to demonstrate the water management practices over the past 2 years through history assessments with resources such as the following:

- "The National Irrigation Master Plan (NIMP) 2020-2030 Abridged Version" (p. 163-165; pdf file, 20.4 MB).
- "Adoption rate of selected technologies under Water Management category (2016 WS-2017 DS)" (web page by PhilRice) and the original source.
- Rotational irrigation schedule in the Philippines (data will be available by formally requesting to contact details and address found on NIA Regional Offices Website)
- Reviewing logbooks (if available) and local experts' comments.

2. Selection of representative fields in each stratum for direct measurement

As to the direct measurement of CH_4 and N_2O under the JCM methodology "Methane Emission Reduction by Water Management in Rice Paddy Fields", the 3 representative fields in terms of environmental and agronomic settings need to be prepared for both project and reference areas in every stratum. This is to avoid over- or under-estimation of the calculated CH_4 and N_2O emission reductions. A pair of project and reference fields should be provided from one farmer to avoid the effect of historical difference in agronomic practice on the CH_4 and N_2O emissions and rice yield. Each of the 3 paired fields should have the same agronomic history for ≥5 year and at least similar environmental settings (i.e., topography and soil texture). Project participants are required to provide the materials to demonstrate this.

3. Confirmation of avoidance of significant rice yield reduction

To demonstrate eligibility criterion 2 of the methodology for maintained rice yield, rice yield sampling is implemented at the total of 6 representative fields in each stratum to confirm that there is no rice yield reduction by the project. For the direct seeding system, 1 m × 2 m area should be selected from each field whereas a rectangle area with 50 rice hills for the transplanting system. Unhulled rice grain yield adjusted to the moisture content of 14% needs to be measured. A sampling area with normal rice growth should be visibly selected at harvest.

The 95% confidence interval (CI) of the yield in 3 fields needs to be calculated for both project and reference areas. If the intervals do not overlap each other, it is considered that there is significant change in rice yield.

The lower and upper limits of 95% CI is calculated using the CONFIDENCE.T function in Excel as follows:

Lower limit = $Y_m - CONFIDENCE.T(0.05, STDEV.S(Y_1, Y_2, Y_3), 3)$

Upper limit = $Y_m + CONFIDENCE.T(0.05, STDEV.S(Y_1, Y_2, Y_3), 3)$

Where:

$Y_m, Y_1, Y_2, and\ Y_3$ are the mean rice yield of the 3 fields, rice yield at the first field, rice yield at the second field, and rice yield at the third field, respectively.

4. Water level monitoring for confirmation of drainage

It is necessary for the project participants to demonstrate the fulfillment of eligibility criterion 2 of the JCM methodology by submitting the following to a Third-Party Entity at the time of verification: photos of the monitored water level with location and time information as well as a handwritten or digital logbook for the water level and/or the number of drained days. In the specific cases listed in Table C-1a, daily rainfall data recorded using an on-site weather station or at the nearest metrological station also need to be provided to ensure that the water level during non-monitoring days is within the allowed range. Remote sensing can be an option for monitoring water existence (>0 cm) and non-existence (≤0 cm) when the project participants demonstrate its sufficient accuracy and reliability to be applied to the independent experts described in Appendix A in advance. In addition to remote sensing, other improved methods to monitor water level could be applied when the independent experts approve those by reviewing the submitted base data in advance.

There are several required timings of taking photos: (1) when the water level reaches −15 cm, (2) at least 3-day interval when the water level maintains ≤0 cm for a total of 10 days consisting of at least 3 consecutive days (e.g., 3 d + 3 d + 4 d and 4 d + 6 d) in case of using the number of drained days as the index, and (3) when the water level reaches ≤0 cm for the first time.

There are 4 cases of the water level change to decide which timing photos should be taken (Table C-1a). In each case, it is strongly recommended to take photos of the water level on the first day when the water level reaches below the soil surface, to secure flexibility in case the water level does not reach −15 cm. These “first day photos” must be taken in Case II and III.

*Logbook must be recorded appropriately in all the cases to support the data.

*The examples in Table C-1a are representatives and do not cover all the cases.

Table C-1a. Four cases of taking photos

<table>
<tr><td>Case</td><td>Scenario, condition, and required photos</td></tr>
<tr><td>I</td><td>Expected water level: −15 cm.
Result: water level −15 cm achieved.
Applicable only in case that the water level previously reached −15 cm in the same cropping season at the same area.
➢ Photos taken when the water level reaches −15 cm.
<table>
<tr><td>Day</td><td colspan="5">Any date</td></tr>
<tr><td>Water Level</td><td><0</td><td><0</td><td><0</td><td><0</td><td>-15</td></tr>
<tr><td>Photo</td><td>(X)</td><td></td><td></td><td></td><td>X</td></tr>
</table>
</td></tr>
<tr><td>II</td><td>Expected water level: −15 cm.
Result: water level −15 cm not achieved.
Applicable only in case that the water level previously reached −15 cm in the same cropping season at the same area.
➢ Principle:
Photos taken when the water level reaches ≤0 cm for the first time. Photos taken at least once every 3 days while the water level maintains ≤0 cm. The water level needs to maintain ≤0 cm for the total of 10 days consisting of at least 3 consecutive days.
Example II-A
<table>
<tr><td>Day</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td>Water Level</td><td><0</td><td><0</td><td><0</td><td><0</td><td><0</td><td><0</td><td><0</td><td><0</td><td><0</td><td><0</td></tr>
<tr><td>Photo</td><td>X</td><td></td><td></td><td>X</td><td></td><td></td><td>X</td><td></td><td></td><td>X</td></tr>
</table>
➢ Alternatives:
Photos taken when the water level reaches ≤0 cm for the first time and taken to prove that the water level remains below the soil surface when the total of 10 days have passed since the first day of the water level reaching ≤0 cm. The water level needs to maintain ≤0 cm for the total of 10 days consisting of at least 3 consecutive days. The days in between two photos are deemed the water level remaining below the soil surface consecutively, as long as the rainfall data indicates no rainfall (0 mm d^{-1}) during the period.</td></tr>
</table>

Example II-B

Day	1	2-9	10
Water Level	<0	<0	<0
Photo	X	No rainfall (proved by data)	X

Example II-C

Day	1	2-5	6	7	8	9*	10*	11
Water Level	<0	<0	<0	>0	<0	<0	<0	<0
Photo	X	No rainfall (proved by data)	X	Rainfall	X			X

*The water level can be deemed below the soil surface for day 9 and 10 as these days are between day 8 and day 11 where photos are taken once every 3 days to indicate the water level ≤0 cm (see the Principle of Case II).

Example II-D

Day	1	2-5*	6	7	8	9	10	11	12
Water Level	<0	<0	>0	>0	<0	<0	<0	<0	<0
Photo	X	No rainfall (proved by data)	Rainfall		X			X	X

*When there is appropriate rainfall data as well as logbook records, this period (day 2-5) can be deemed the water level below the soil surface. A photo of the first day of the water level reaching below the soil surface again (day 8) must be taken for the record of the following days.

III

Expected water level: below the soil surface but above −15 cm.

Result: water level −15 cm not achieved.

Applicable also in case that the previous water level data are not available.

- Principle:

  Photos taken when the water level reaches ≤0 cm for the first time. Photos then taken at least once every 3 days while the water level remains ≤0 cm. These photos prove that the water level remains ≤0 cm for the total of 10 days consisting of at least 3 consecutive days.

Example III-A

Day	1	2	3	4	5	6	7	8	9	10
Water Level	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0
Photo	X			X			X			X

➢ Alternatives:

Photos taken when the water level reaches ≤0 cm for the first time and taken to prove that the water level remains below the soil surface when total of 10 days have passed since the first day of the water level reaching ≤0 cm. The water level needs to maintain ≤0 cm for the total of 10 days consisting of at least 3 consecutive days. The days in between two photos are deemed the water level remaining below the soil surface consecutively, as long as the rainfall data indicates no rainfall during the period.

Example III-B

Day	1	2-9	10
Water Level	<0	<0	<0
Photo	X	No rainfall (proved by data)	X

Example III-C

Day	1	2-5	6	7	8	9	10	11
Water Level	<0	<0	<0	0>	<0	<0	<0	<0
Photo	X	No rainfall (proved by data)	X	Rainfall	X			X

*The water level can be deemed below the soil surface for day 9 and 10 as these days are between day 8 and day 11 where photos are taken once every 3 days to indicate the water level <0 (see the Principle of Case III).

Example III-D

Day	1	2-5*	6	7	8	9	10	11	12
Water Level	<0	<0	>0	>0	<0	<0	<0	<0	<0
Photo	X	No rainfall (proved by data)	Rainfall		X			X	X

*When there is appropriate rainfall data as well as logbook records, this period (day 2-5) can be deemed the water level below the soil surface. A photo of the first day

	of the water level reaching below the soil surface again (day 8) must be taken for the record of the following days.
IV	Expected water level: below the soil surface but above −15 cm. Result: water level -15cm achieved. Applicable also in case that the previous water level data are not available. ➢ Photos taken when the water level reaches −15 cm.

Day	Any date				
Water Level	<0	<0	<0	<0	-15
Photo	(X)		(X)		X

In multiple drainage, the project participants cannot start counting the days of water level until the project field is flooded by irrigation after the completion of the previous drainage. The examples are shown in the Table C-1b.

As shown in the single drainage case of Table C-1b, it is considered as a single drainage even if 10 days drainage (Case II or III) is achieved more than once.

However, as shown in the case of multiple drainage in Table C-1b below, it is considered as a multiple drainage when -15cm drainage (Case I or IV) and 10 days drainage (Case II or III) are implemented and these two types of drainage can be distinguished by the irrigation of the water level above the soil surface after the completion of the previous drainage.

Table C-1b. Examples of multiple drainage scenario and single drainage scenario

Case	Scenario and condition
Multiple drainage	

Day	1-5	6	7	8	9-10	11-14	15-16	17	18-22
Water Level	<0	-15	<0	<0	>0	<0	>0	<0	<0
10 days drainage (Case II or III)*		1st drainage completion		Irrigation start		X	Rainfall	X	X(3-day interval)l 2nd drainage completion

*X: Countable into 10days drainage (Case II or III).

<table>
<tr>
<td></td>
<td>Day 1 to 5 and Day 7 to 8 are excluded from the 10 days of Case II or III since these days show the process of water level decrease down to -15cm or deeper. An irrigation with the water level above the soil surface is conducted from Day 8 to distinguish the start of the latter 10 days drainage (Day 11) from the completion of the previous -15 cm drainage (Day 6).</td>
</tr>
<tr>
<td>Single drainage</td>
<td>
<table>
<tr><td>Day</td><td>1-3</td><td>4</td><td>5</td><td>6-11</td><td>12</td><td>13-14</td><td>15-24</td></tr>
<tr><td>Water Level</td><td><0</td><td>>0</td><td><0</td><td><0</td><td><0</td><td>>0</td><td><0</td></tr>
<tr><td>Case II and III Drainage*</td><td>X</td><td>rainfall</td><td>X</td><td>X(3-day interval)l
1st drainage completion</td><td>Irrigation start</td><td></td><td></td></tr>
</table>
*X: countable into 10days of Case II or III.

Day 1 to 3 and Day 5 to 11 are counted into the 10 days of Case II or III drainage. However, Day 15 to 24 cannot be counted as drainage since Case II or III drainage can be applied only once in the cropping period.
</td>
</tr>
</table>

5. Calculation of CH_4 and N_2O emission reductions by the direct measurement

Calculation methods for CH_4 emission reductions by the direct measurement differ year by year. In the years when the direct measurement is implemented, the measured $EF_{CH4,R,s,st}$ or $EF_{CH4,R,s,d,st}$, and $EF_{CH4,P,s,st}$ or $EF_{CH4,P,s,d,st}$, $EF_{N2O,R,s,st}$ or $EF_{N2O,P,s,st}$ (hereafter, simply referred to as EF in this section) need to be used for the calculation. On the other hand, in the years when the direct measurement is not implemented, the mean EF of the previous ≥3-year measurements need to be used[1]. The 3-year initial measurements are conducted to derive the initial daily EF. The minimum interval of the direct measurement is every 5 years after the 3-year initial measurements. The examples 1 and 2 in Table C-2 show 3-year interval measurement. More frequent measurements are available as shown in the example 3 (every 2 years) or every year after the 3-year initial measurements. If the initial measured daily EF is not reasonable for project participants due to abnormal weather conditions and/or poor water management, additional measurement is possible

[1] We assume that 3-year measurement is scientifically sound duration to derive the mean (representative) EF in a certain area in case there is no temporal change in environmental and agronomic settings. However, this assumption may not apply to several years later (due to climate change, etc.). To confirm and correct (if necessary) the initial EF, once per 3-5 years measurement is required after the 3-year initial measurement.

to derive the initial daily EF as shown in the example 4. Using the example 1, if the newly measured EF in “Y”ear 5 [Meas (in)] is with“in” of the 95% confidence interval of the previously calculated mean daily EF [Calc (B12), see table footnote for details], Calc (B12) can be still used in “Y”ears 6 and 7. On the other hand, using the example 2, if the newly measured EF in ”Y”ear 6 [Meas (out)] is “out” of the 95% confidence interval of the previously calculated mean daily EF [Calc (123)], the mean daily EF needs to be recalculated by adding the newly measured EF [Meas (out) in ”Y”ear 6] as Calc (1236) for “Y”ears 7 and 8. The examples of the schedule for the direct measurement of 5-year and 4-year intervals are shown in Table C-3.

Table C-2. Examples of schedule for the direct measurement at 3-year interval

Year	Example 1	Example 2	Example 3	Example 4
Before	Meas	No meas	No meas	Meas
Y1	Meas	Meas	Meas	Meas
Y2	Meas	Meas	Meas	Meas (bad weather)
Y3	Calc (B12)	Meas	Meas	Additional meas
Y4	Calc (B12)	Calc (123)	Calc (123)	Calc (B13)
Y5	Meas (in)	Calc (123)	Meas (in)	Calc (B13)
Y6	Calc (B12)	Meas (out)	Calc (123)	Meas (in)
Y7	Calc (B12)	Calc (1236)	Meas (out)	Calc (B13)
Y8	Meas (in)	Calc (1236)	Calc (1237)	Calc (B13)
Y9	Calc (B12)	Meas (out)	Meas (in)	Meas (in)
Y10	Calc (B12)	Calc (12369)	Calc (1237)	Calc (B13)

Meas: Measurement, No meas: No measurement, Calc: Calculation, B: Before.

*The figures in parentheses indicate the years of measurement used to calculate the mean EF. For instance, Calc (B13) is derived using the data from the year “B”efore the project, “Y”ear 1, and “Y”ear 3).

Table C-3. Examples of schedule for the direct measurement at 5-year and 4-year intervals.

Year	Example 5 (5-year)	Example 6 (5-year)	Example 7 (5-year)	Example 8 (4-year)
Before	Meas	No meas	Meas	No meas
Y1	Meas	Meas	Meas	Meas
Y2	Meas	Meas	Meas (bad weather)	Meas
Y3	Calc (B12)	Meas	Additional meas	Meas
Y4	Calc (B12)	Calc (123)	Calc (B13)	Calc (123)
Y5	Calc (B12)	Calc (123)	Calc (B13)	Calc (123)
Y6	Calc (B12)	Calc (123)	Calc (B13)	Calc (123)

Y7	Meas (in)	Calc (123)	Calc (B13)	Meas (out)
Y8	Calc (B12)	Meas (out)	Meas (in)	Calc (1237)
Y9	Calc (B12)	Calc (1238)	Calc (B13)	Calc (1237)
Y10	Calc (B12)	Calc (1238)	Calc (B13)	Calc (1237)

In parentheses, the year numbers used to calculate the mean EF.

6. Calculation of CH_4 emission reductions by the IPCC default scaling factors

Calculation of CH_4 emission reductions by the IPCC's tier-1 and tier-2 default scaling factors requires the direct measurement at least every 5 years to confirm its appropriateness. The year starting the direct measurement can be chosen from that before the project (before) or the first year (Y1) as shown in the examples I and II of Table C-4. However, the project area needs to be fixed before starting the project when using the example I. The appropriate or more conservative $EF_{CH4,R,s,d,st}$ and SF_w should be derived and used to calculate the CH_4 emission reduction as shown in Table C-5. If the measured $EF_{CH4,R,s,d,st}$ and/or SF_w are too conservative and not reasonable for project participants due to abnormal weather condition and/or abnormal agronomic practices, additional measurement is possible as shown in the examples III and IV of Table C-4.

Table C-4. Examples of schedule for the direct measurement for the calculation using the IPCC's tier-1 and tier-2 default scaling factors.

Year	Example I		Example II	Example III	Example IV
Before	Meas				
Y1			Meas	Meas	Meas
Y2				Additional meas	
Y3					
Y4					
Y5	Meas				
Y6			Meas	Meas	Meas
Y7					Additional meas
Y8					
Y9					
Y10					

Table C-5. Procedures to decide the $EF_{CH4,R,s,d,st}$ and SF_w used for the calculation.

Order	Procedure
1	Calculate the 95% confidence interval (CI) of both the measured $EF_{CH4,R,s,d,st}$ and SF_w*.
2	Compare the 95% CI of the measured $EF_{CH4,R,s,d,st}$ and SF_w with the 95% CI of the tier-2 $EF_{CH4,c,s,d}$ ** and tier-1 SF_w***, respectively.
3-1	If the 95% CI of the measured $EF_{CH4,R,s,d,st}$ and the 95% CI of tier-2 $EF_{CH4,c,s,d}$ overlap, the tier-2 $EF_{CH4,c,s,d}$ needs to be used.
3-2	If the 95% CI of the measured $EF_{CH4,R,s,d,st}$ and the 95% CI of tier-2 $EF_{CH4,c,s,d}$ do not overlap and the measured $EF_{CH4,R,s,d,st}$ exceeds the interval, the tier-2 $EF_{CH4,c,s,d}$ needs to be used.
3-3	If the 95% CI of the measured $EF_{CH4,R,s,d,st}$ and the 95% CI of tier-2 $EF_{CH4,c,s,d}$ do not overlap and the measured $EF_{CH4,R,s,d,st}$ falls short of the interval, the measured $EF_{CH4,R,s,d,st}$ needs to be used.
4-1	If the 95% CI of the measured SF_w and the 95% CI of SF_w overlap, the tier-1 SF_w needs to be used.
4-2	If the 95% CI of the measured SF_w and the 95% CI of SF_w do not overlap and the measured SF_w falls short of the interval, the tier-1 SF needs to be used.
4-3	If the 95% CI of the measured SF_w and the 95% CI of SF_w do not overlap and the measured SF_w exceeds the interval, the measured SF_w needs to be used.

* SF_w is calculated as follows:

$$SF_w = \frac{SF_{w1} + SF_{w2} + SF_{w3}}{3}$$

Where:

SF_{w1} = The ratio of CH_4 emission from the first paired project field to CH_4 emission from the first paired reference field.

SF_{w2} = The ratio of CH_4 emission from the second paired project field to CH_4 emission from the second paired reference field.

SF_{w3} = The ratio of CH_4 emission from the third paired project field to CH_4 emission from the third paired reference field.

The lower and upper limits of 95% CI of SF_w is calculated using the CONFIDENCE.T function in Excel as follows:

Lower limit = $SF_w - CONFIDENCE.T(0.05, STDEV.S(SF_{w1}, SF_{w2}, SF_{w3}), 3)$

Upper limit = $SF_w + CONFIDENCE.T(0.05, STDEV.S(SF_{w1}, SF_{w2}, SF_{w3}), 3)$

The same procedure applies to the calculation of 95% CI of $EF_{CH4,R,s,d,st}$.

** The original error range provided to tier-2 $EF_{CH4,c,s,d}$ is that between the minimum and maximum values among the seasonal data used to derive the mean [Tracking Greenhouse Gases:

An Inventory Manual, 2011 (pdf file, 3.6 MB)]. This methodology therefore recalculated the 95% CI of tier-2 $EF_{CH4,c,s,d}$ with referring its source articles (Corton et al., 2000; Wassmann et al., 2000) as follows:

$EF_{CH4,c,s,d}$ for dry season rice: 1.46 (95% CI, 1.08−1.84) (kg ha^{-1} d^{-1})

$EF_{CH4,c,s,d}$ for wet season rice: 2.95 (95% CI, 1.97−3.92) (kg ha^{-1} d^{-1})

Project participants need to use these intervals to decide the EF used for the calculation of CH_4 emission reduction by the IPCC's factors.

*** IPCC's tier-1 SF_w and its 95% CI are as follows:

SF_w for multiple drainage: 0.55 (95% CI, 0.41−0.72)

SF_w for single drainage: 0.71 (95% CI, 0.53−0.94)

7. Spatial heterogeneity of water management

It is unrealistic to apply water management uniformly across all the project fields, due to factors other than stratification parameters, such as different elevation, different soil permeability, and different water availability. This may cause the spatial heterogeneity in the success of water management. For example, it could happen that multiple drainage events are achieved in the representative project fields where the direct measurement is implemented, whereas only one drainage event is achieved in other many project fields, and vice versa.

Because the former causes the overestimation of CH_4 emission reduction, it is necessary to calculate it in a conservative manner. In the case of the direct measurement, the CH_4 emission reduction by single drainage should be estimated by multiplying the measured CH_4 emission reduction by the conversion ratio derived from IPCC's SF_w [(1−0.71)/(1−0.55) = 0.29/0.45]. On the other hand, for the latter case, the measured CH_4 emission reductions by single drainage needs to be applied to all the project fields.

In the case of the calculation using the IPCC's default scaling factors, SF_w suitable to the actual situation (i.e., 0.55 or 0.71) should be used combinationally.

8. Unexpected change from multiple drainage to single drainage

It is difficult to accurately predict the success of water management before the start of the season. For example, no or only one drainage event can be achieved due to intermittent rainfalls throughout the season, even if the farmers originally had aimed for multiple drainage events. There are two unexpected changes in the planned drainage practice. One is the change from the planned multiple drainage to the resultant single drainage (M to S), and the other is the opposite change from the planned single to the resultant multiple (S to M). The project participants need to decide on the suitable SF_w following the procedures described in Table B-1.

Table B-1. Four cases to decide SF_w used for the calculation.

Case	Procedure
M to S with the direct measurement	The measured SF_w is used in that year/season. Additional measurement is possible to derive suitable calculated SF_w of multiple drainage as shown in Tables C-2 and C-3.
M to S without the direct measurement	The calculated or teir-1 SF_w of multiple drainage needs to be corrected by multiplying by 0.29/0.45.
S to M with the direct measurement	The measured SF_w is used in that year/season. However, this SF_w cannot be directly used to derive the calculated SF_w of single drainage. Instead, the measured SF_w needs to be corrected by multiplying by 0.29/0.45 for this purpose.
S to M without the direct measurement	The calculated or teir-1 SF_w of single drainage needs to be used in a conservative manner.

9. N_2O emission factor not affected by the success of water management

The description in the above sections 6 and 7 is not applied to the calculation of N_2O emission. This is because the current IPCC's N_2O emission factor (EF_{1FR}) does not distinguish between single drainage and multiple drainage. That is, the same EF_{1FR} is used without regard to the number of drainage events achieved (i.e., one or more). This is true for the direct measurement. The measured $EF_{N2O,R,s,st}$ is used in that year/season and the calculated $EF_{N2O,R,s,st}$ is derived from the previous ≥3-year measurements without regard to the number of drainage events achieved. It is possible but not necessary to implement additional measurement for deriving suitable $EF_{N2O,R,s,st}$.