Voluntary Emission Reductions in Rice Management Systems

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Voluntary Emission Reductions in Rice Management Systems[1]

1 Sources

- DNDC (i.e. DeNitrification-DeComposition) Model Version 9.4
- DNDC User Manual

2 Summary Description of the Methodology/Revision

2.1 Options to Reduce GHG Emissions in Rice Cultivation

Flooded rice fields are a source of atmospheric methane. Flooding results in anaerobic conditions in soils, which triggers anaerobic decomposition of organic matter by methanogens, a class of soil bacteria. Methanogens produce methane as the product of the microbial decomposition of organic matter. Soon after flooding of rice fields, the oxygen in soil pores is depleted, and the process of anaerobic decomposition of organic matter starts, leading to methane emissions. The organic matter used during anaerobic decomposition can originate from organic amendments, plant residues or root exudates. The amount of methane produced is proportional to the duration of flooding (during the growing season and outside the growing season during the winter months) and is impacted by the rice cultivar and the availability of crop residues and organic matter. Examples of concrete management practices that will decrease greenhouse gas emissions from rice fields include:

- Reducing the duration of flooding during the growing season, both by shortening the growing season and by practices such as dry seeding and alternately flooding and draining fields (including through use of soil moisture detection technologies to inform when flooding is needed)
- Reducing the amount of flooding outside of the growing season ("winter flooding")
- Removing crop residues after harvest and before winter flooding

Note that these management practices must be implemented so that potentially negative environmental impacts are minimized, for example the amount of winter-flooded area may not be reduced by more than 10% in areas that are of significance to waterfowl (see Section 2.3.3). This methodology uses the biogeochemical process model DNDC to quantify soil carbon dynamics, N_2O and CH_4 emissions under the baseline and project scenarios. Even though the DNDC model has been shown to be highly valid across a wide range of management practices and geographic areas, this methodology only allows practices and geographic regions for which the DNDC model has been explicitly calibrated with empirical data. This requirement is necessary because the quantification of uncertainty around modeled results can only

[1] "Voluntary" here refers to the fact that use of this methodology to create GHG offsets is purely voluntary for growers, not to the intended market (voluntary, pre-compliance or compliance) for the resulting offsets.

be done with local and specific data. Instead of requiring project proponents to demonstrate that the DNDC model is valid at a project-by-project basis, this methodology simplifies the work of a project proponent by pre-approving specific management activities in certain areas and quantifying an appropriate uncertainty discounting factor that is appropriate for these pre-approved management activities. In this version of the methodology, three management options are pre-approved: (1) minimizing the duration and frequency of winter flooding (referred to elsewhere in this methodology as "ACT1"), (2) removal of rice straw from the field after harvest and before winter flooding (referred to as "ACT2"), and (3) replacing water seeding with dry seeding (referred to as "ACT3"). In this version of the methodology, only rice fields in California are pre-approved. However, this methodology is set up so that follow-up modules can include other project activities than the ones outlined above and expand the allowed geographical regions to other areas in the US and outside the US. The requirements to do so are outlined in Section 15.4.

2.2 Common Rice Cultivation Practices in California

California is the second largest rice-producing state in the United States, producing rice on approximately 202,343 ha (500,000 acres) and contributing $1.3 billion to the state's economy (Sumner and Brunke, 2003). Before 1990, in California, the most common post-harvest straw management option was burning. However, burning was significantly phased down between 1991 and 2000, and is now only practiced on a limited and highly regulated basis for disease control purposes. Currently, the most commonly used post-harvest operations for straw management on rice fields, listed in order of degree of use, are (UCCE, 2007): (1), chopping and/or disking, followed by winter-flooding, and sometimes rolling, (2) chopping and/or disking without winter-flooding or (3) burning in the fall and/or spring for disease control. In 2007, the University of California Cooperative Extension estimated that rice straw burning occurred on 13% of the area, winter flooding on 60% of the area, and incorporation without winter flooding on the 27% of the area. Therefore, when designing the management schedule for use with the mechanistic model to calculate emissions, a burn event must be scheduled every 8 years, even if no burning was implemented on the field in the past. It is estimated that 3 to 5% of the rice acreage has straw baled for use later for various purposes (California Rice Commission 2009). This methodology allows project proponents to voluntarily generate methane emission reductions by (1) minimizing the duration and frequency of winter flooding, (2) removing rice straw from the field after harvest and before winter flooding, and (3) replacing water seeding with dry seeding.

2.3 Overview of Methodology

2.3.1 Overview of Accounting Mechanics

- The emission reductions from implementing specific project activities are quantified using the DNDC model. A deduction is applied to modeled emission reductions to account for uncertainty induced by the model and variation in input parameters.

- Project proponents must explicitly demonstrate that the DNDC model is calibrated and the uncertainty around modeled emission reductions are quantified for the project activities and in the geographic region of the project. The quantification of uncertainty around modeled emission reductions requires empirical measurements of N_2O fluxes. In addition, this methodology contains a number of pre-approved project activities and regions for which the DNDC model has already been calibrated and no separate calibration has to be supplied by the project proponents. Follow-up modules to this methodology may contain further pre-approved project activities and geographical regions.
- Emission reductions from changes in rice management in a given year are permanent and cannot be reversed. As a result, credits generated by optimizing agricultural management remain permanent, regardless of future changes in management. The buffer contribution or other approved reversal risk mitigation mechanism required for project activities with the potential for reversal is therefore not required in this methodology.
- The pre-approved project activities in this methodology may affect (1) the duration and frequency of the winter flooding period, (2) post-harvest rice straw residue management, and (3) seeding practices. All parameters or management decisions that are not related to the project activities must be identical between the project and baseline scenarios. For example, planting and harvesting dates, N fertilizer application rates, and flooding and draining dates during the growing season (if no dry seeding is used) must be the same between the project and baseline scenario.
- Baseline emissions must be calculated using (1) five-year historical records of the actual management on each of the individual rice fields that participate and (2) five-year historical weather information. *Ex-ante* project emissions must be calculated using exactly the same management information as used for the baseline scenario, apart from the parameters related to project activities. Five years after the start of the crediting period, baseline emissions must be re-calculated using common practice data.
- In contrast to other carbon projects in which baselines are entirely fixed *ex-ante,* in the current methodology, baselines are only partially fixed *ex-ante*. This is due to the significant impact of weather on methane emissions and the grower's management decisions such as planting or harvesting dates. If baseline emissions would be entirely fixed *ex-ante*, artificial emission reductions could be generated due to extreme or outlying weather circumstances that are not captured under the baseline scenario. To avoid the generation of such artificial emission reductions, the baseline emissions must be recalculated *ex-post*[2] using the actual historical weather information. In

[2] Meaning at verification, after project activities occurred.

addition, since certain management decisions are dependent on weather (e.g., planting and harvesting dates), the baseline scenario must be recalculated using the actual values of these management decisions.

2.3.2 Importance of Spatial Aggregation

Given the complexity of the calculations, it is most likely that several agricultural fields managed by different growers will be combined within one GHG Project Plan through an aggregating entity. This aggregating entity will streamline monitoring requirements, third-party verification and other legal and financial requirements that must be put in place to generate carbon credits.

The methodology requires that the project include a minimum of five individual rice fields or 405 ha (1,000 acres) to reduce structural uncertainty related to the model predictions. The methodology's uncertainty deduction mechanism incentivizes further project aggregation since the (relative) deduction will be smaller if more fields are combined within a carbon project package. However, the methodology must still quantify and report GHG emissions for all fields individually.

2.3.3 Environmental Impact

Waterbird species richness is known to be greater in fields with standing water (Day and Colwell 1998). Therefore, rice growers implementing winter flooding make significant environmental contributions. More specifically, winter flooding provides critical habitat for migratory waterfowl for 230 wildlife species and 60 percent of the total number of waterfowl in the Pacific Flyway that use rice fields for habitat and foraging. These rice fields are designated as Shorebird Habitat of International Significance and provide over half of the food consumed by wintering waterfowl in the Sacramento Valley in California (Petrie and Petrik, 2010). One of the management practices that are proposed in this methodology is reducing of winter flooding, potentially leading to a loss of bird habitat.

Elphick and Oring (2003) reported that a composite measure of the waterbird conservation value (incorporating species density, relative abundance and population trend) increased with water depth, peaked between 10 and 15 cm (4 to 6 inches), and then declined (Elphick and Oring 2003). The species richness and abundance was found to be greater in fields that were actively flooded compared to passive (rain-fed) flooding (Elphick and Oring 2003). This methodology allows project participants to reduce the total area of passive winter flooding and supports switching to active flooding (maintenance of water depth of 10 -15 cm level during winter flooding) by rotating winter flooding across fields. This practice leads to GHG benefits while supporting waterbird conservation.

To avoid any significant effects on bird habitat, the area under active or passive winter flooding cannot be reduced by more than 10% compared to the baseline winter flooding area.

3 Definitions and Acronyms

ACT1	Project activities to reduce the duration and frequency of winter flooding
ACT2	Project activities for removal of rice straw from the field after harvest and before winter flooding
ACT3	Project activities to replace water seeding with dry seeding, effectively reducing flooded time during the growing season
Individual rice field	Contiguous parcel of land with homogeneous irrigation management on which rice is grown continuously (i.e., at least 3 out of 5 years). One rice field has one water inlet and one outlet and is usually separated into "checks" by berms inside of perimeter levees that delineate the field's boundaries.
Winter flooding	Flooding of fields during the off-season is practiced to decompose rice straw. In many areas, no irrigation water is needed to provide for intermittent flooding during the winter, as fields can be intermittently flooded simply by closing the field drains to capture water from rain events. Reliable continuous flooding, however, is achieved by actively flooding the fields.
Straw baling and removal	After harvest, rice straw residue is traditionally left on agricultural fields. However, rice straw can be removed by baling. Baled straw can be sold even though the market is small. Rice straw can be used for erosion control, animal bedding or as an alternative feed for cow and calf producers (DANR, publication 8425).
Straw incorporation	After harvest, straw residue incorporation involves chopping and disking the chopped residue in the soil.
Dry Seeding	A seeding method that involves sowing of dry seeds into dry or moist, non-puddled soil. Dry seeding may allow for quicker land preparation and reduces the irrigation water required for crop establishment. Dry seeding can occur through spreading seeds onto the soil surface and transferring soil on top of the seeds or by drilling seeds into a prepared seedbed, a practice known as "drill seeding". Alternatively, seeding normally occurs by distributing seeds on inundated fields using small airplanes, a practice known as "water seeding".
Precision and Accuracy	Accuracy is the degree of proximity of repeated measurements under unchanged conditions to their true or actual value. Precision refers to the degree to which repeated measurements under unchanged conditions show the same results.
Historical period	The 5-year period preceding the start of the crediting period, during which relevant baseline parameters are determined for the first five years of the project period (see Section 8.1)
Critical input parameters	An input parameter to the DNDC model that is changed by the project activities (see Sections 6 and 8.2). Examples of critical input parameters are the fraction of residue left on the field after harvest, or the duration of the flooding period during the off-season.
Non-critical input parameters	An input parameter to the DNDC model that is not changed by the project activities (see Sections 8.3). Examples of non-critical input parameters are weather data or soil texture.
Non-critical Management Parameters	A non-critical parameter that is related to agricultural management. Examples are the date of pre-planting field preparation or fertilization amount.

4 Applicability Conditions

1. The project area must include a minimum of five individual rice fields or 405 ha (1,000 acres) to reduce structural uncertainty related to the model predictions[3]. These five fields or 405 ha (1,000 acres) can be distributed among different farmers/farms or located on one farming operation.
2. The individual rice fields constituting the project area are located in an area for which DNDC has been successfully calibrated for each of the proposed project activities implemented using empirical gas flux data on at least five individual rice fields, in the same area as the project area[4]. In addition, the project area is located in an area for which the accuracy of predicted GHG emissions by DNDC can be quantified following the procedures in this methodology. It is up to the project proponents to justify the boundaries of the area for which DNDC has been calibrated by demonstrating the homogeneity of the area in terms of management practices, rice cultivars planted, and soil types. The following project actions and geographical extents are pre-approved and do not have to be validated in a GHG Project Plan.

Table 1. Overview of allowed project activities and geographical extents.

	Project Activity	Geographical Extent
ACT1	Reducing winter flooding	California
ACT2	Removal of straw after harvest	California
ACT3	Dry seeding	California

Note that these project actions may be applied individually or combined. Follow-up modules to this methodology will expand the allowed geographical areas and allowed project activities.

3. The individual rice fields included in the project area have been under continuous rice cultivation for the five years preceding the start of the crediting period, with not more than one fallow season. The fields must have been flooded for a period of at least four months during the growing season[5].
4. The management records for each of the individual rice fields are available for each of the five years preceding the start of the crediting period. Management records must indicate yields, planting and harvesting dates, flooding and draining dates, and fertilization dates and amounts.
5. If the proposed project activities lead to a statistically significant decrease in the rice yield totaled over all participating fields, compared to the average yields during the five years before the project start, and after normalizing for

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[3]The methodology contains a minimal size and/or minimal number of fields due to concerns related to the structural uncertainty of a biogeochemical model. Fluxes of trace gases such as CH_4 and N_2O are notably spatially variable. Therefore, the (structural) uncertainty around modeled results decreases with increasing area.

[4] This requirement is necessary because the quantification of uncertainty around modeled results can only be done with local and specific data.

[5] In other words, this methodology is only applicable for growing rice under flooded conditions.

differences that are not related to project activities such as weather, credits must be discounted according to the procedures in the methodology[6]. An exact procedure to normalize yields and verify that normalized yields have remained constant is included in the methodology.

6. The project area does not contain any soils with organic carbon content in the top 30 cm greater than 3%[7].
7. The project area is located in a larger geographical context for which the baseline adoption rate of the management practices can be determined through a combination of census data, remote sensing and surveys.
8. If the project area is located in critical waterfowl habitat area, and winter flooding is a dominant residue management practice, the maximum reduction in flooding area (compared to the baseline flooding area) for which credits may be claimed is 10%[8].
9. If the project area is winter flooded, an average water depth of 10 -15 cm is maintained in project areas during winter flooding.

5 Project Boundary

5.1 Geographic Boundary

The management activities that lead to reductions in greenhouse gas emissions take place within the boundaries of one or more agricultural fields. The geographical boundary encompassing these agricultural fields is, therefore, the geographic boundary of the project area. The removal of rice straw from the agricultural field after harvest may increase greenhouse gas emissions outside of the project area. These potential indirect emissions are included in the carbon accounting of this methodology and covered in section 9.4. The following requirements are needed related to geographic boundaries:

- As per one of the applicability conditions, a minimum of five individual project parcels or 1,000 acres must be included within the GHG Project Plan.
- Since this methodology allows for “Programmatic Aggregated Projects”, new project areas may be added to an existing project after the start of the crediting period as long as all the applicability criteria are met for each individual project parcel. Note that different baseline validation periods may exist when project areas are added at different times.

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[6]The methodology does not compare yields directly before and after the change in management, since seasonal effects due to weather may outweigh changes due to management. Yields are first normalized relative to the county yields, before trends over time are investigated.

[7] N_2O emissions become more variable with increases in soil carbon content. To remain conservative and ensure that the biogeochemical model performs well, projects are limited to soils with carbon content less than 3%. The DNDC model has been calibrated primarily for soils with carbon content lower than this threshold.

[8] For example, if under the baseline conditions, on average 1000 acres of a project area of 2000 acres is flooded from October until March, credits can be generated from reducing flooding by not flooding 100 extra acres, so that only 900 acres out of the 2000 acres are flooded.

- The geographical coordinates of the boundaries of each discrete project parcel must be unambiguously defined.

This methodology encourages combining fields spread over a large geographic region within one GHG Project Plan to reduce costs. However, conditions may not be homogeneous across a large geographic region. Non-homogeneous conditions may affect the validity of baseline calculations and additionality checks. Therefore, for large or heterogeneous project areas, it is necessary to stratify the project area into smaller units or strata. Valid parameters that must be used to stratify the project area are:

- Common rice cultivation practices
- Biophysical conditions (soil type, climate, and water quality)
- Landscape type (sloping terrain, flood plains, etc.)
- Differences in legally binding requirements affecting the project area

A description and justification of the stratification procedure must be included in the GHG Project Plan. All subsequent procedures in this methodology, including baseline scenario identification and additionality tests must be done separately for each identified stratum.

5.2 Greenhouse Gas Boundary

Changing management practices may affect each of the three biogenic greenhouse gases

Table 2. Overview of included greenhouse gas sources.

	Source	Gas	Included?	Justification/Explanation
Baseline	Soil bacteria and fungi	CO_2	Yes	Significant changes in CO_2 emissions due to project activities if straw is removed (baled) after harvest.
	Id.	CH_4	Yes	Significant emission source under baseline conditions if fields are inundated.
	Id.	N_2O	Yes	Significant emission source under baseline conditions if fertilizer is applied.
Project	Soil bacteria and fungi	CO_2	Yes	Significant changes in CO_2 emissions due to project activities if straw is removed.
	Id. and ruminants (in case rice straw used as feed under ACT2)	CH_4	Yes	Significant emission source affected by project activities if flooding duration and periods are changed. Emissions from ruminants may be significant if feed is replaced by low-nitrogen rice straw.
	Soil bacteria and fungi	N_2O	Yes	Significant emission source affected by project activities if fertilizer amounts and dates are changed or seeding practices are altered[9]

5.3 Temporal Boundary

The crediting period can only start immediately after a harvest and only end immediately after a subsequent harvest. As a consequence, credits are calculated in one-year increments. Per *ACR Standard*, the duration of the crediting period equals the period of baseline validity, which is 5 years under this methodology.

6 Procedure for Determining the Baseline Scenario

For each of the individual rice fields included in the project (minimum of five but may be more), project proponents must identify credible baseline scenarios describing what would have occurred on the field in absence of the project activities. The identified credible baseline scenarios must be limited to agricultural land uses. A conversion to non-agricultural land use is not allowed as a possible baseline scenario. All areas that are likely to be converted to non-agricultural uses must be excluded from the project area. The likelihood of at least three potential baseline scenarios must be considered:

1. Rice cultivation with a continuation of the management before project start with respect to seeding procedure, straw management and (winter) flooding.
2. Rice cultivation with a change in management before project start with respect to seeding procedure, straw management and (winter) flooding, in the absence of registration as an ACR project activity.

[9] *Dry-seeding* may increase N_2O emissions in the period right after seeding and before flooding, when the soil is kept moist and inorganic N from fertilizer is readily available.

3. Discontinuing rice cultivation and converting the land to an alternative agricultural use.

It must be demonstrated that scenario 1, rice cultivation with a continuation of the management before project start, is the most likely baseline scenario by identifying financial, legal, or other barriers to the alternative scenarios[10]. Provided the project proponent can demonstrate baseline scenario 1 is most likely, the most plausible baseline scenario under the CDM modalities and procedures Decision 5/CMP.1, paragraph 22, is option (a)[11]:

> *Existing or historical, as applicable, changes in carbon stocks in the carbon pools [and/or GHG emissions] within the project boundary.*

This option is most appropriate since this methodology requires that fields remain under continuous rice management in absence of project activities so that historical cultivation practices represent the most likely future cultivation practices. Since fields for which a potential of conversion to non-agricultural uses are excluded from the methodology, no new economically attractive course of action is expected in the future, and option (a) under the CDM modalities and procedures, paragraph 22 is most relevant, and not option (b).

Once it is determined that a continuation of the management before project start is the most likely baseline scenario, the baseline scenario is defined unambiguously by fixing the following values ("critical input parameters") *ex-ante* in the GHG Project Plan:

(1) Frequency and duration of winter flooding (if any)
(2) Residue management (straw residue left on the soil surface after harvest, straw residue incorporated in the soil, straw residue burnt, or straw residue baled and removed[12])
(3) Seeding procedures (dry-seeding or water-seeding)
(4) Fertilizer amounts and timing under baseline conditions must be set

This list of critical input parameters must be revisited when the project activities allowed under this methodology are expanded. Because the values of the critical input parameters unambiguously define the baseline scenario, they are fixed *ex-ante* and are not allowed to change until a baseline update (see Section 13.3). In the case that new project areas are added, the values of the critical input parameters of the existing project area remain fixed and may not be updated. Note that all other non-critical management parameters (e.g. pre-planting soil tillage, field leveling and preparation, planting and harvesting dates, etc.) are not fixed *ex-ante*. In fact, these

[10] In other words, it must be demonstrated that the intended change in management as a project activity would not have been required by law or implemented due to any other reason.
[11] Available at http://unfccc.int/resource/docs/2005/cmp1/eng/08a01.pdf#page=61
[12] Note that the baling before winter flooding may only reduce methane emissions in the long term.

parameters must be identical between project and baseline scenario in both the *ex-ante* and *ex-post* calculations. *Ex-ante*, the non-critical input parameters must be determined based on historical practices, according to the procedures in Section 8. *Ex-post*, the non-critical input parameters must be determined using monitored data.

7 Procedure for Demonstrating Additionality

The project proponent shall demonstrate the additionality of the project activity using ACR's three-pronged additionality test of regulatory surplus, not common practice, and facing one or more implementation barriers.[13]

In applying the three-pronged test, the project proponent must use the latest approved version of the "ACR Tool for Determining the Baseline and Assessing Additionality in REDD Project Activities" or a comparable ACR-approved additionality tool.[14]

8 Baseline Emissions

Under this methodology, the calculation of greenhouse gas emissions under the baseline and project scenarios must be evaluated using the DNDC biogeochemical model version 9.4. For each individual rice field, a separate model run must be executed for the baseline scenario and an appropriate input parameter file ("*.dnd") must be available to the auditor.

There is a large body of evidence that demonstrates that DNDC can predict GHG emissions from rice systems under different management strategies with sufficient accuracy (*Li et al*., 2002; *Cai et al*., 2003; EDF, 2011), on the condition that DNDC is calibrated for local conditions. Process-based biogeochemical models, such as DNDC, can simulate GHG dynamics under a range of changing management conditions (including planting, fertilization, straw management, winter flooding, etc.). This methodology specifies how the input parameters for the DNDC model must be set so that the emissions calculated by DNDC are valid to be used to calculate credits. A detailed explanation on the meaning and impact of each of these parameters and how to use the DNDC model is beyond the scope of this methodology. More practical information on how to run the DNDC model can be found in the DNDC User Manual.

8.1 Duration and Structure of Model Runs

[13] As described in the *ACR Standard*.
[14] Such as the CDM Tool for the Demonstration and Assessment of Additionality at: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf.

Table 3. Schematic of the modeling period.

Year -20 to -15	Year -15 to -10	Year -10 to -5	Year -5 to 0	Year 0 to 5	Year 5 to 10
Historical Period				*Crediting Period*	
Model Equilibration			Crop Yield Calibration	Period 1	Period 2

Table 3 indicates the structure of a DNDC modeling run. The following is required:

- The DNDC model must be run for at least 20 years before the start of the crediting period so that the model can attain equilibrium in certain critical variables for which empirical data is lacking, such as the sizes and the quality of the different carbon pools, and the inorganic nitrogen contents of soil pore water. This period is referred to as the historical period. The input parameters for the 20-year historical period must be set by repeating all parameters from the five years before the start of the crediting period four times, unless otherwise noted.
- The last five years of the historical period must be used to calibrate the modeled crop yields crop yields (see Section 8.4).
- After the start of the crediting period, the model must be run in 5-year increments. The GHG Project Plan must include at least one 5-year cycle after the start of the crediting period.

8.2 Critical Input Parameters

As explained in section 6, all parameters that relate to the project activities are named "critical input parameters" (Table 4), and must be fixed *ex-ante*. In other words, values of critical input parameters must be identical *ex-ante* and *ex-post*.

Table 4. Critical input parameters for project activities included in this methodology.

	Project Activity	Critical Input Parameters
ACT1	Reducing winter flooding	• Frequency of flooding during a 5-year period before the start of the crediting period. • Start of the winter flooding period (if any) • End of the winter flooding period (if any)
ACT2	Removal of straw after harvest	• Proportion of straw removed after harvest (set to 0 if no straw was removed) representative for a period of 5 years before the start of the crediting period. • Additional nitrogen fertilizer to account for nutrient losses during straw removal.
ACT3	Dry seeding	• Planting date • Date of flooding relative to the planting date. • Dates of all fertilization events (both pre-flood and top-dressed after flooding)

8.3 Non-Critical Input Parameters

8.3.1 Weather and Climate

Weather significantly affects methane emissions and, hence, the reduction in methane emissions due to alternative crop management. Variations in temperature not only directly affect methane emissions. Climate also affects annual methane emissions since climate controls the length of the growing season: the exact planting date is dependent on the average temperature in April-May; the harvesting date is dependent on the cumulative growing degree days since planting. Therefore, while *ex-ante*, baseline emissions must be calculated using five years of historical weather data preceding the start of the crediting period, *ex-post* the baseline must be re-calculated with the actual weather. The following requirements must be met:

- Daily climate data must come from a weather station that is located maximally 20 miles away. If the project area is located in California, it is recommended to use weather data from the nearest CIMIS weather station (http://wwwcimis.water.ca.gov).
- Weather data for the five years preceding the start of the crediting period must be collected. Weather data for the historic period must be set by repeating this five-year weather data set. After the start of the crediting period, the same five-year weather data must be used and repeated, if necessary. As indicated before, *ex-post*, actual weather data must be used for all emission calculations.
- Daily values of maximum temperature, minimum temperature, rainfall, and solar radiation must be collected and formatted according to DNDC's "Jday,

MaxT, MinT, Rainfall, Radiation (MJ/m^2/day)" format, which is DNDC's climate file mode 1.

Table 5. Input parameters related to weather.

Input Parameters	Unit
Jday (Julian day)	Day of year
MaxT (Maximum temperature)	°C
MinT (minimum temperature)	°C
Rainfall	mm day^{-1}
Radiation	MJ m^{-2} day^{-1}

8.3.2 Non-critical Management Parameters

All non-critical management variables must be set based on historical information. More specifically, all variables must be collected for the five years before the project start and repeated in cycles of five years during the *ex-ante* modeling of the crediting period. The following variables must be collected:

Table 6. Input parameters related to practices that are not affected by project activities (non-critical management parameters).

Input Parameters	Unit
Date of pre-planting field preparation	Date
Planting date	Date
Fertilization amounts and dates, and type of fertilizer used	Lbs per acre, date, type (e.g., nitrate, ammonium, or urea)
Dates and duration of flooding during growing season	Dates, number of days
Harvesting date	Date
Date and description post-harvest operations	Date and description (mowing, mulching, residue incorporation, etc.)

Note that, regardless of the outcome of the surveys and historical data, a straw burning event must be scheduled every eight years from the five years before the start of the crediting period. For example, if no burning event was reported for the five years preceding the start of the crediting period, a "burn" event must be scheduled in the model runs on year three of the crediting period, regardless of whether this burn event effectively happened. Note that this is a modeling requirement to simulate the estimates (by University of California Cooperative Extension) that rice straw burning occurs on 13%, or 1 in 8, of the rice acres cultivated in California – not a suggestion that burning will actually occur on the project area in the year modeled.

8.3.3 Soil Data

Soil texture affects methane emissions to a significant extent. Therefore, for each of the individual rice fields, empirically measured soil texture data must be available. In addition, measured values for organic carbon content, bulk density and soil pH must be measured. Data may not be older than 10 years at the time of validation. Official soil laboratory statements must be included with the GHG Project Plan. The standard values from DNDC for field capacity, wilting point and hydraulic conductivity for the closest clay content as the one that was measured may be used.

The value for the initial concentration of NO_3^- and NH_4^+ in the soil surface must be set to 0.5 and 0.05 mg N/kg, respectively, which are appropriate initial values commonly used during DNDC model runs. Since the model is run for at least 20 years prior to the start of the crediting period, concentrations of NO_3^- and NH_4^+ in the surface soil will eventually equilibrate.

Table 7. Input parameters related to soil data.

Input Parameters	Unit
Clay content	kg kg^{-1} soil
Sand content	kg kg^{-1} soil
Organic carbon content	kg kg^{-1} soil
Bulk Density	g cm^{-3}
pH	-

8.4 Crop Yield Calibration

The DNDC model includes a calibrated parameter set for a short-to-medium grain japonica rice varieties. This parameterization is sufficient for most japonica varieties as long as the "maximum biomass" parameter is manually tuned to reflect variations in yield due to local soils and climates that are not yet incorporated in the model. More specifically, the "maximum biomass" parameter of the DNDC model must be manually tuned so that DNDC predicts the recorded yields during the five years before the start of the project as well as possible with a maximal relative Root Mean Squared Error (RMSE) of 10% of the observed means. If this is not possible by just adjusting the "maximum biomass" parameter, one or both of the following options may be followed until modeled yields are within a maximal relative RMSE of 10% of observed means.

- If the "Crop" pane of the DNDC results (with title "Cop Yields and Heat-Water-Nitrogen Stresses") indicates that the modeled "Water demand" value is greater than the "Water uptake" value, the value for "water demand, g water/g DM) in the Crop pane of the Farming Practice Management dialog (equal to the "Water_requirement" parameter in the .dnd file) must be reduced.
- Similarly, if the same pane indicates that the "Temperature demand" value is greater than the value for "Thermal degree days for maturity", the "Thermal degree days for maturity" (equal to the "TDD" parameter in the .dnd file) must be reduced.

If no sufficient correspondence can be achieved by following the procedure described above, project proponents must calibrate other crop parameters, including biomass allocation to roots, leaves/stems and grain and the C/N ratio of roots, leaves/stems and grain using laboratory measurements, scientific literature, and/or a crosscalibration with a more sophisticated crop growth model such as the DD-50 model. However, it is up to the project proponents to execute a proper calibration and provide all the necessary justification to the third-party validator.

8.5 Quantification

The DNDC model must be run separately for each of the individual rice fields. The project proponent shall then look up the annual values for “Flux rates” from the “Greenhouse gas” page of the DNDC results.

$$BE_{y,i} = \frac{44}{12} \cdot [CO2]_{baseline,y,i} + 310 \cdot \frac{44}{28} \cdot [N2O]_{baseline,y,i} + 21 \cdot \frac{16}{12} \cdot [CH4]_{baseline,y,i}$$

Where:

$BE_{y,i}$	=	Baseline emissions in year y for individual rice field i
$[CO2]_{baseline,y,i}$	=	Baseline carbon dioxide flux rate from changes in SOC content in year y for individual rice field i as reported by DNDC [kg C ha^{-1}]
$[N2O]_{baseline,y,i}$	=	Baseline nitrous oxide flux rate in year y for individual rice field i as reported by DNDC [kg N ha^{-1}]
$[CH4]_{baseline,y,i}$	=	Baseline methane flux rate in year y for individual rice field i as reported by DNDC [kg C ha^{-1}]

9 Project Emissions

Similarly to baseline emissions, project emissions of CO_2, CH_4 and N_2O must be calculated using the DNDC biogeochemical model. For each individual rice field, a separate model run must be executed for the project scenario and an appropriate input parameter file (“*.dnd”) must be available to the validator.

9.1 Duration and Structure of Model Runs

All input parameters for the historical period for the project scenario runs must be identical to the input parameters for the historical period for the baseline scenario. After the start of the project period, only the critical input parameters are allowed to be different between the baseline and project scenario input parameters.

9.2 Critical Input Parameters

The critical parameters are outlined in Section 8.2 for the baseline scenario; the changed values for these parameters are modeled in DNDC for the project scenario. For *ex-ante* calculations, values for the critical parameters under the project scenario must be set based on expert opinion. For *ex-post* calculations, values for the critical values must be set using farming records and empirical data of what was actually implemented.

9.3 Non-Critical Input Parameters

9.3.1 Calculations

As for baseline emissions, project emissions must be estimated using the DNDC model. Exactly the same model parameters must be used except for the Critical Input Parameters outlined in Section 8.2.

Similarly to the baseline model runs, the DNDC model must be run separately for each of the individual rice fields. The annual project emissions correspond to the annual values for “Flux Rates” from the “Greenhouse gas” page of the DNDC results.

$$PE_{y,i} = \frac{44}{12} \cdot [CO2]_{project,y,i} + 310 \cdot \frac{44}{28} \cdot [N2O]_{project,y,i} + 21 \cdot \frac{16}{12} \cdot [CH4]_{project,y,i}$$

Where:

$BE_{y,i}$	=	Project emissions in year y for individual rice field i
$[CO2]_{project,y,i}$	=	Project carbon dioxide flux rate from changes in SOC content in year y for individual rice field i as reported by DNDC [kg C ha^{-1}]
$[N2O]_{project,y,i}$	=	Project nitrous oxide flux rate in year y for individual rice field i as reported by DNDC [kg N ha^{-1}]
$[CH4]_{project,y,i}$	=	Project methane flux rate in year y for individual rice field i as reported by DNDC [kg C ha^{-1}]

9.4 Off-field emissions from Rice Straw

The end uses for rice straw must be explicitly identified so that any potential increase in emissions due to removing the rice straw, and any subsequent use can be accounted for. Project proponents may use the default emission factors in Table 8, or use their own emission calculations as long as it can be demonstrated that the reported emissions are conservative (Summers and Williams, 2001).

The following end-uses have been identified (ANR, 2010):

- **Dairy replacement heifer feed.** Wheat straw is traditionally used in heifer feed. Rice straw can be used if it is cut to the right length (ANR, 2010). There is no significant effect on enteric fermentation from replacing wheat straw by rice straw. Since the use of rice straw replaces the use of wheat straw, there is no increase in emissions from baling, handling and transportation and these emissions do not have to be accounted for. Quality of the straw (crude protein content, moisture content, etc.) must meet minimal standards before it can be used. There may be some effects on enteric fermentation by feeding lower quality straw. Only emissions from increased emissions from enteric fermentation due to the lower straw quality must be accounted for.
- **Beef cattle feed**. Rice straw is used by beef cattle operations as a dry matter supplement to pasture feeding during fall and winter (ANR, 2010). Cattle

ranchers spread the large bales out on the range in fall and allow the cattle to feed on the bales. Quality of the straw (crude protein content, moisture content, etc.) must meet minimal standards before it can be used. There may be some effects on enteric fermentation by feeding lower quality straw. The use of organic material as a supplement to pasture feeding is a fairly standard practice. Therefore, no emissions from baling, handling and transportation must be accounted for. Only emissions from increased emissions from enteric fermentation due to the lower straw quality must be accounted for.

- **Animal bedding**. Application of straw to soil at dairies and feedlots as a way to help preserve and dry the soil is a well-established, longstanding use of rice straw. The decomposition of the straw will be assumed to be mostly aerobic. Since the use of rice straw replaces other straw materials used for bedding, there is no increase in emissions from baling, handling and transportation and these emissions do not have to be accounted for.
- **Spread out on bare soils as erosion control**. Rice straw is particularly valuable for erosion control since it is produced in an aquatic environment and does not pose a risk of introducing upland weeds, unlike wheat or barley straw. When used for erosion control, rice straw will decompose aerobically. The use of rice straw for erosion control will not necessarily replace other straw materials since many options are available for erosion control. Therefore, emissions from baling, handling and transportation must be accounted for.
- **Stuffed in netted rolls to prevent soil loss**. Rice straw is also used in construction areas to protect bare soil surfaces from soil loss. Netted rolls stuffed with rice straw are placed at the edge of the construction site to trap soil on the site. The use of rice straw in netted rolls to prevent soil loss will replace other straw materials such as wheat. Therefore, emissions from potentially anaerobic decomposition, baling, handling and transportation need not be accounted for.
- **Mushroom production.** Rice straw is an effective substrate for mushroom production. Wheat straw is the primary substrate used for mushroom production (CARB, 1995). Therefore, no increase in emissions from anaerobic decomposition by replacing wheat straw by rice straw is expected. Likewise, no increase in emissions from baling, handling and transportation is expected and these emissions do not have to be accounted for.

Table 8. Emission factors for potential end-uses of removed straw.

Potential end-use	Sources of (Avoided) Emissions	$OFEF_{y,i}$ [kg CO_2-eq t^{-1} dry straw]
Dairy replacement heifer feed	*avoiding post-harvest chopping and disking*	*-10*[15]
	increases in CH_4 emissions from enteric fermentation due to incorporating low-digestible rice straw in feed	*75*[16]
	TOTAL	**65**
Beef cattle feed	*avoiding post-harvest chopping and disking*	*-10*
	increases in CH_4 emissions from enteric fermentation due to incorporating low-digestible rice straw in feed	*75*[17]
	TOTAL	**65**
Animal bedding	*avoiding post-harvest chopping and disking*	*-10*
	TOTAL	**-10**
Spread out on bare soils as erosion control	*avoiding post-harvest chopping and disking*	*-10*
	swathing, raking, baling	*20*
	roadsiding, storing, loading, transport	*60*
	spreading	*10*[18]
	TOTAL	**80**

[15] Assuming a fuel use of 1.5 Gal diesel per acre for chopping and disking (14 l per ha) (cost-and-return studies for rice from the University of California Cooperative Extension (2007), assuming 2/3rds of the “fuel, lube, and repairs” cost category are from fuel, a diesel emission factor of 2.32 kg CO_2 per l of diesel fuel (EPA), emissions are 32.5 kg CO_2-e ha^{-1}. Assuming an average production of 4 t rice straw ha^{-1} yr^{-1}, this accounts to 8 kg CO_2-e t^{-1} straw.

[16] Assuming a calorific value of dry rice straw of 15 MJ kg^{-1} (Pütün et al., 2004), an increase in the cattle CH_4 conversion factor due to switching to low-digestible food of 1% (2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol. 4), and an energy content of methane of 55.65 MJ kg^{-1} CH_4 (id.).

[17] Assuming a calorific value of dry rice straw of 15 MJ kg^{-1} (Pütün et al., 2004), an increase in the cattle CH_4 conversion factor due to switching to low-digestible food of 1% (2006 IPCC Guidelines for National Greenhouse Gas Inventories Vol. 4), and an energy content of methane of 55.65 MJ kg^{-1} CH_4 (id.).

[18] Assumed to be similar to emissions from post-harvest chopping and disking.

Potential end-use	Sources of (Avoided) Emissions	$OFEF_{y,i}$ [kg CO_2-eq t^{-1} dry straw]
Stuffed in netted rolls to prevent soil loss	*avoiding post-harvest chopping and disking*	*-10*
	TOTAL	**-10**
Mushroom production	*avoiding post-harvest chopping and disking*	*-10*
	TOTAL	**-10**
Unused and accumulated in piles near the farm	*avoiding post-harvest chopping and disking*	*-10*
	swathing, raking, baling	*20*
	non-CO_2 emissions during the decomposition of the straw	*250*
	TOTAL	**260**

10 Leakage

Leakage is negligible since yields are not affected per applicability conditions.

11 Quantification of Net GHG Emission Reduction and/or Removals

11.1 Uncertainty Deduction

As this methodology relies on a biogeochemical model to quantifying GHG fluxes, the sources of uncertainty related to using models must be considered. In general, the uncertainty is divided into two sources: (1) uncertainty due to variability in the model input parameters, and (2) structural uncertainty due to imperfections in the model. This section explains how to calculate, combine, and apply deductions for these two sources of uncertainty.

11.1.1 Uncertainty due to Variability in the Input Parameters

Uncertainty due to variability in the input parameters can be captured using a Monte-Carlo analysis, and can be calculated using the built-in tools within DNDC. The following table indicates which parameters must be included in the uncertainty analysis. If no data is available to empirically quantify the variability, the following distribution parameters must be assumed:

Table 9. Distribution parameters for input parameters to execute a Monte Carlo analysis.

Parameter	Value
Distribution of Clay content	Log-Normal
Distribution of Organic carbon content	Log-Normal
Distribution of Bulk Density	Log-Normal
Coefficient of Variation Clay content	10%
Coefficient of Variation of Organic carbon content	10%
Coefficient of Variation of Bulk Density	10%
Correlation between clay content and organic carbon	Calculate with empirical data or assume conservatively to be 0
Correlation between clay content and bulk density	Calculate with empirical data or assume conservatively to be 0
Correlation between organic carbon and bulk density	Calculate with empirical data or assume conservatively to be 0

A multivariate lognormal distribution must be used to sample parameters for the Monte Carlo analysis[19]. The model must be run for at least 1000 (n) different draws out of this multivariate lognormal distribution for both the baseline scenario and the project scenario. For each of the n draws of the distribution, one emission reduction is calculated by subtracting the baseline emissions from the project emissions. Calculate the uncertainty as the value corresponding to the 10% quantile for the distribution of n values.

11.1.2 Uncertainty due to Structural Uncertainty

Structural uncertainty can be quantified by comparing modeled gas fluxes with empirical gas fluxes. The structural uncertainty around the size of the emission reductions of a project that combines multiple individual rice fields will decrease with increasing number of individual rice fields included. For example, Olander and Malin (2010) demonstrate that the RMSE decreases from 9 kg N-N_2O ha^{-1} for an individual rice field to 1.8 kg N-N_2O ha^{-1} if 10 fields are combined within one carbon project. The methodology requires a minimum of five individual project parcels or 1,000 acres be included within the project, and requires estimating a structural uncertainty factor by comparing modeled with measured CH_4 emissions. Procedures to calculate this factor are included in Section 15.2. In addition, uncertainty deduction factors for projects in California are included in Section 15.2.3. Future revisions of this methodology may include uncertainty deduction factors for other regions.

[19] For example, using the `rlnorm` function of the `R` package (http://rss.acs.unt.edu/Rdoc/library/compositions/html/rlnorm.html).

11.1.3 Combining the Sources of Uncertainty

Since the two sources of uncertainty are uncorrelated, one can sum the variance related to uncertainties to get the combined uncertainty. As per ACR requirements, no deduction must be applied if the half-width of the resulting combined confidence interval is within 10% of the mean at 90% confidence. However, if the half-width of the confidence interval is greater than 10%, a deduction must be applied equal to this interval.

11.2 Calculation

The GHG emission reductions for year $y(ER_y)$ are calculated as:

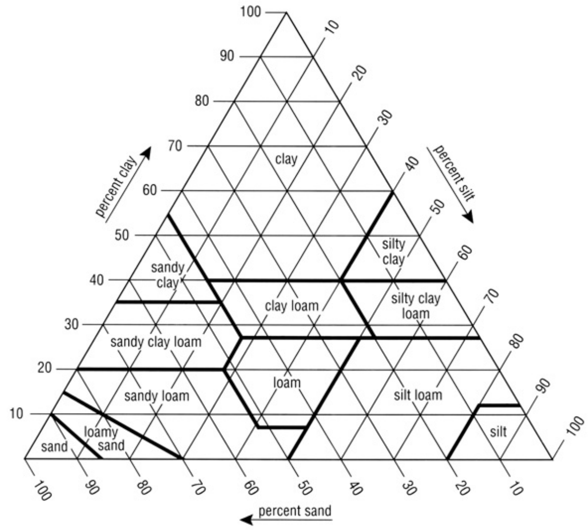
$$ER_y = \sum_{i=1}^{nrFields} u_i\left(PE_{y,i} - BE_{y,i}\right) - OFEF_{y,i} \cdot CR_{y,i}$$

Where:

ER_y	=	GHG emissions reductions and/or removals in year y
$nrFields$	=	Number of individual rice fields included in the project area
u_i	=	Uncertainty deduction factor for individual rice field i
$PE_{y,i}$	=	Project emissions in year y for individual rice field i
$BE_{y,i}$	=	Baseline emissions in year y for individual rice field i
$OFEF_{y,i}$	=	Off-field Emission Factor in year y for individual rice field i [kg CO_2-eq t^{-1} dry straw]
$CR_{y,i}$	=	Crop Residue in year y for individual rice field i [t dry straw]

12 Data and Parameters Not Monitored

Data Unit / Parameter:	Soil_Texture
Data unit:	-
Description:	Soil texture class determined by percent contents of clay, sand and silt particles. Common texture class are – sand, loamy sand, sandy loam, silt loam, loam, sandy clay loam, silty clay loam, clay loam, sandy clay, silty clay, clay and organic soil. The texture class is determined from the content of soil particles. The soil triangle below shows the percentage of clay, silt and sand in basic soil texture class (except for organic soil).

	
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	Soil_pH
Data unit:	-
Description:	Ph of top soil. A measure of the acidity or alkalinity of soil. The range of pH for most soils is from 4 to 10 in logarithmic scale. The scale implies that one numerical pH unit equals a 10-fold change in acidity or alkalinity. For example, a soil with pH of 8 is ten times more alkaline than a soil with a pH of 7.
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, measurement carried out by the project proponents, or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	Soil pH is relatively easy and inexpensive to measure. Portable pH meters can be used to measure the pH directly in the field.
Any comment:	If the measurements were taken by project proponents, the model used to make such measurements must be provided.

Data Unit / Parameter:	SOC_at_Surface

Data unit:	kg C kg^{-1}
Description:	Content of total soil organic carbon (SOC), including litter residue, microbes, humads, and passive humus at surface lays (0 - 5cm).
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, measurement carried out by the project proponents, or analysis carried out by the project proponents at certified soil laboratory(ies).
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	Clay_fraction
Data unit:	Fraction ranging from 0 to 1.
Description:	Fraction of clay in the top horizon
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	Default value will be used from selected soil texture.

Data Unit / Parameter:	Field_capacity
Data unit:	Fraction ranging from 0 to 1.
Description:	Water-filled porosity of soil (WFPS) at soil field capacity.
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	When soil texture is selected, a default field capacity value will be given although it can be modified by users.

Data Unit / Parameter:	Wilting_point
Data unit:	Fraction ranging from 0 to 1.
Description:	Water-field porosity at soil wilting point.
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	When soil texture is selected, a default wilting point will be given although it can be modified by users.

Data Unit / Parameter:	Hydro_conductivity
Data unit:	$m\ hr^{-1}$
Description:	Hydraulic saturation conductivity
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	When soil texture is selected, a default value will be used although it can be modified by users.

Data Unit / Parameter:	Soil_porosity
Data unit:	Fraction ranging from 0 to 1.
Description:	Soil porosity.
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, or analysis carried out by the project proponents at certified soil laboratories.
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	When soil texture is selected, a default value will be used although it can be

	modified by users.

Data Unit / Parameter:	SOC_profile_A
Data unit:	kg C kg^{-1}
Description:	Content of total soil organic carbon (SOC in soil profile A
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, measurement carried out by the project proponents, or analysis carried out by the project proponents at certified soil laboratory(ies).
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	SOC_profile_B
Data unit:	kg C kg^{-1}
Description:	Content of total soil organic carbon (SOC) in soil profile B
Source of data:	Soil laboratory statements from Government agency, recent (i.e. less than 10 year old) peer reviewed literature, measurement carried out by the project proponents, or analysis carried out by the project proponents at certified soil laboratory(ies).
Justification of choice of data or description of measurement methods and procedures applied:	
Any comment:	

Data Unit / Parameter:	Ground_residue
Data unit:	fraction
Description:	Fraction of rice crop residue left on the field after harvest.
Source of data:	Set to 1 in case there is no baling. Measure empirically or use a default of 0.25.
Justification of choice of data or description of measurement methods and procedures	

applied:	
Any comment:	

13 Monitoring Description

13.1 Check Yield Impacts

It must be verified that yields have not been reduced due to the project activities. However, yields fluctuate annually depending on climate (see Figure 1). Therefore, yields must be (1) compared to the natural variation of the yields during the previous five years and (2) yields must be normalized to average annual county yields from NASS statistics. Only when actual yields in the project scenario are significantly smaller than county averages for three years in a row on a specific individual field, does the field become ineligible.

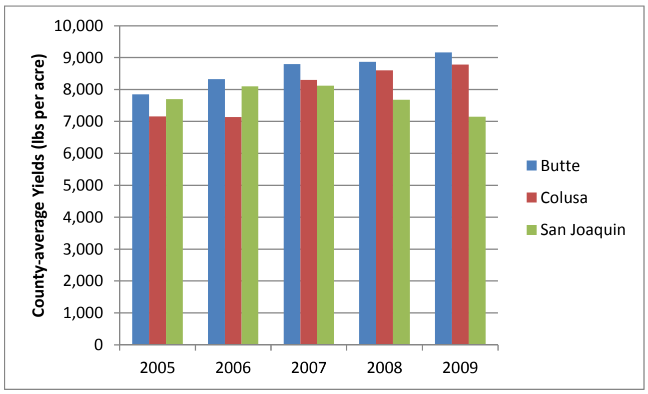


Figure 1. Example of county-average yields for three counties in California.

Use the following procedure to conduct this test.

(1) Normalize the sum of the historical yields for all the rice fields included in the project area by dividing the yield sum by the county average for that specific year, obtained from the USDA NASS (http://quickstats.nass.usda.gov)

For the five years t before t_0 ("historical yields") normalize the yield and calculated the standard deviation and mean of the normalized yields as following:

$$y\_norm_t = \frac{y_t}{y\_county_t}$$

$$s = stdev(y\_norm_t)$$

$$\overline{y\_norm} = average(y\_norm_t)$$

Verify the distribution of y_norm_t values. Most likely, these will be log-normally distributed. Apply the appropriate statistical transformation to y_norm_t to obtain a normal distribution before taking standard deviation and means.

(2) Calculate the “minimum yield threshold" below which normalized yields are significantly smaller than the county average:

$$y\_min = \overline{y\_norm} \quad - t(0.05, n-1) \cdot s$$

where n is 5, and $t(0.05, n-1)$ the t-distribution value with 90% confidence (for a one-tailed test) and $n-1$ degrees of freedom.

(3) For every year of the crediting period, calculate y_norm_t and compare this value to y_min. If y_norm_t is smaller than y_min, y_norm_t is significantly smaller than $\overline{y\_norm}$ and the total credits must be discounted with a factor $\frac{y\_norm_t}{y\_min}$.

13.2 *Ex-post* Monitoring

The following management data must be collected by the farmer once the project is on-going.

- Planting preparation description and date
- Planting date
- Fertilization amounts and dates
- Flooding start and duration
- Harvesting date
- Post-harvesting description and dates

13.3 Baseline update

At project validation, the baseline values for all Critical Input Parameters must be set to the historical values for a specific field. The baseline values of the critical input parameters must be updated every five years after the start of the project according to the common practice within a pre-defined reference region of a specific rice field over the five years before the baseline update. In other words, if the occurrence of a practice such as winter flooding decreases over time, this must be reflected in the baseline management practice for a carbon project. For California projects, the reference region is either the Sacramento Valley or the San Joaquin Valley.

Period	-5 to 0	0 to 5	5 to 10	10 to 15	Etc.
Baseline Procedure		Based on project conditions from year -5 to 0	Based on common practice in county from year 0 to 5	Based on common practice in county from year 5 to 10	Etc.

Common practice must be determined by sampling a number of fields to acquire 10% precision with 90% confidence. For example, if there are 300 fields in a county, at least 37 fields must be sampled. The fields must be selected randomly over all the fields within the county. Data from the common practice determination may be not older than three years old.

Table 10. Parameters that must be updated

Variable	Method
Number of days of mid-season drainage	Remote sensing data[20], Survey
Number of weeks of winter flooding	Remote sensing data, Survey
Straw management	Survey
Seeding procedure	Survey

Regardless of the outcome of the surveys and historical data, a straw burning event must be scheduled every eight years from the five years before the start of the crediting period. For example, if no burning event was reported for the five years preceding the start of the crediting period, a “burn” event must be scheduled on year three of the crediting period. Note that this is a modeling requirement to simulate the estimates (by University of California Cooperative Extension) that rice straw burning occurs on 13%, or 1 in 8, of the rice acres cultivated in California – not a suggestion that burning will actually occur on the project area in the year modeled.

14 Data and Parameters Monitored

Data Unit / Parameter:	Climate Data
Data unit:	DNDC climate data file
Description:	Daily meteorological data files(s) in the plain text (i.e., ASCII) format for each year. Data files are written in format readable in DNDC model.
Source of data:	Weather station data
Description of measurement methods and procedures to be applied:	If the project area is located in California, it is recommended to use weather data from the nearest CIMIS

[20] A combination of dual and cross-polarized Synthetic Aperture Radar (SAR) data may help to identify mid-season drainage dates.

	weather station (http://wwwcimis.water.ca.gov). National Climate Data Center (www.ncdc.noaa.gov/oa/ndcd.html) is another source of climatic data that can be used.
Frequency of monitoring/recording:	Daily
QA/QC procedures to be applied:	Daily climate data must come from a weather station that is located maximally 20 miles away.
Any comment:	See DNDC user manual for guidance on format of files.

Data Unit / Parameter:	Plant_time
Data unit:	-
Description:	Planting month and day. A number from 1 – 12 for month; and a number from 1 to 31 for day.
Source of data:	Agricultural statistical records or from farmers records.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	Harvest_time
Data unit:	-
Description:	Harvesting month and day. A number from 1 – 12 for month; and a number from 1 to 31 for day.
Source of data:	Agricultural statistical records or from farmers records.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	Yield
Data unit:	t DM ha^{-1}
Description:	Crop productivity (i.e. rice productivity for rice) in the growing season
Source of data:	Agricultural statistical records or farmers record.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually or per growing season.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	Tilling Method
Data unit:	-
Description:	Tilling depth defined by different tilling method. Select from following: a. No-till (i.e., only mulching) (0 cm) b. Plowing slightly (5 cm) c. Plowing with disk or chisel (10 cm) d. Deep plowing (30 cm)
Source of data:	Agricultural statistical records or farmers records.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	Residue left after harvest
Data unit:	Fraction
Description:	A fraction of the above-ground crop residue left as stubble in the field after harvest.
Source of data:	Field measurement.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	Use default fraction of 0.10.

Data Unit / Parameter:	Flooding and Draining Dates
Data unit:	Date (month and day)

Description:	Start and end dates for flowing and draining in crop fields. Dates shall be given in month and day combination. If start and end dates fall in different years than year must also be provided.
Source of data:	Agricultural statistical records or farmers record.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	End use of baled straw
Data unit:	-
Description:	The end use for rice straw. Select from the following: a. Dairy replacement heifer feed b. Beef cattle feed c. Animal bedding d. Spread out on bare soils as erosion control e. Stuffed in netted rolls to prevent soil loss f. Mushroom production
Source of data:	Farmers' record
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Any comment:	

15 References and Other Information

15.1 References

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15.2 Determining the Uncertainty Deduction Factor for Structural Uncertainty

15.2.1 Basic Assumptions Underlying Uncertainty Deductions

- The structural error induced by a biogeochemical model such as DNDC is multiplicative, not additional:

$$Y_{field,i} = Y_{model,i} \cdot \varepsilon_i$$

  The multiplicative nature of the deviation between modeled and measured results originates from increasing deviations with increasing modeled values. This assumption is generally valid when moderate changes to input data lead to moderate changes in the results of the biogeochemical model and no sudden non-linear changes exist. Under the applicability conditions of the methodology, the DNDC model will react linearly to moderate changes in input data.

- No bias exists between measured and modeled results, so that $\langle Y_{field} \rangle = \langle Y_{model} \rangle$. In addition, the error ε is log-normally distributed, $\varepsilon \sim \ln \mathcal{N}(0, \sigma)$. The DNDC model has been shown to predict greenhouse fluxes without bias, when correctly calibrated. This methodology specifies how model inputs can be set so that the model is calibrated correctly. It must be explicitly tested that the model calibration strategy does not lead to bias.
- Model results of an alternative treatment are 100% correlated with the model results of the baseline treatment:

$$Y_{field,project} = k \cdot Y_{field,baseline}$$

Where k is dependent on all factors that were not impacted by the project. In other words, changes in emissions due to weather or other non-critical variables are similar between project and baseline scenarios, apart from a linear constant.

15.2.2 Procedure to Calculate the Structural Uncertainty Deduction Factor

Since the structural error is multiplicative, the residual of the log-transformed field and measured results is normally distributed:

$$\ln(Y_{field}) - \ln(Y_{model}) \sim \mathcal{N}(0, \sigma)$$

Assume that n is the number of $(Y_{field,i}, Y_{model,i})$ pairs, σ can be estimated as:

$$s = stdev\left(\ln(Y_{field,i}) - \ln(Y_{model,i})\right)$$

Since σ is not known, traditional statistical theory dictates that confidence and prediction intervals need to be estimated based on the student t-distribution with n degrees of freedom. We are interested in the effect of taking averages of individual fields on the decrease in the uncertainty. However, since the sum of different student t-distribution does not have an easy analytical form, we will assume that the error σ is normally distributed. In this case, the 90%-confidence prediction interval becomes:

$$[-s \cdot \phi(0.025); +s \cdot \phi(0.975)]$$

In case one is looking at the average of m field measurements, the 90%-confidence prediction interval around the m measurements becomes:

$$\left[\frac{-s}{\sqrt{m}} \cdot \phi(0.05); \frac{+s}{\sqrt{m}} \cdot \phi(0.95)\right]$$

The discounting factor u_{struct} must be set so that, with 90% confidence:

$$u_{struct} \cdot \left(Y_{model,alternative} - Y_{model,baseline}\right) < Y_{field,alternative} - Y_{field,baseline}$$

Using assumption 2, this comparison can be simplified as following

$$u_{struct} \cdot Y_{model,baseline} \cdot (1-k) < Y_{field,baseline} \cdot (1-k)$$

$$u_{struct} \cdot Y_{model,baseline} < Y_{field,baseline}$$

After taking a logarithm and rearranging:

$$\ln(u_{struct}) < \ln\left(Y_{field,baseline}\right) - \ln\left(Y_{model,baseline}\right)$$

The discounting factor for structural uncertainty is therefore:

$$u_{struct} = e^{\frac{-s}{\sqrt{m}} \cdot \phi(0.05)}$$

15.2.3 Derivation of Structural Uncertainty Deduction for California Projects

Nine different annual fluxes of CH_4 emissions were measured for a number of different management scenarios. The same practices were modeled using the DNDC model. These scenarios represent the variety of management practices that is covered by this methodology. Results from this exercise are summarized in Table 11. Further details can be found in EDF (2011).

Table 11. Modeled and measured CH_4 fluxes from field trials in California. Data reproduced with permission from EDF (2011).

Seeding	Tillage	Winter Flooding	Residue	Modeled kg CH_4-C ha^{-1}	Measured
Water	Conv	Yes	incorporation	121	130
Water	Conv	Yes	burn	56	52
Water	Conv	No	incorporation	68	75
Water	Conv	Yes	incorporation	166	273
Water	Conv	Yes	burn	56	57
Water	Conv	Yes	incorporation	71	165
Water	Conv	?	?	465	354
Water	Stale seedbed (essentially no-till prior to plant)	WS SSB	?	417	390
Dry		DS	?	254	229

The average of the natural logarithm of the deviations between measured and modeled fluxes is 0.112; the standard deviation is 0.346. Using the equation above, the appropriate discounting factors can be calculated, therefore, as following:

$$u_{struct}(m) = e^{\frac{-0.346}{\sqrt{m}} \cdot 1.64}$$

Table 12 and Figure 2 summarize the results of this equation. This methodology requires that a minimum of five fields (or 1,000 acres) be included. This minimum of 5 required fields corresponds to an uncertainty deduction of 26%. In conclusion, the maximal structural uncertainty deduction is 26%.

Table 12. Structural uncertainty deduction factors for projects within California

Number of fields (m)	u_{struct}	Eligibility
1	57%	Not eligible
2	67%	
3	72%	
4	75%	
5	78%	
6	79%	Eligible
7	81%	
8	82%	
9	83%	
10	84%	
15	86%	
25	89%	
50	92%	
100	94%	
1000	98%	

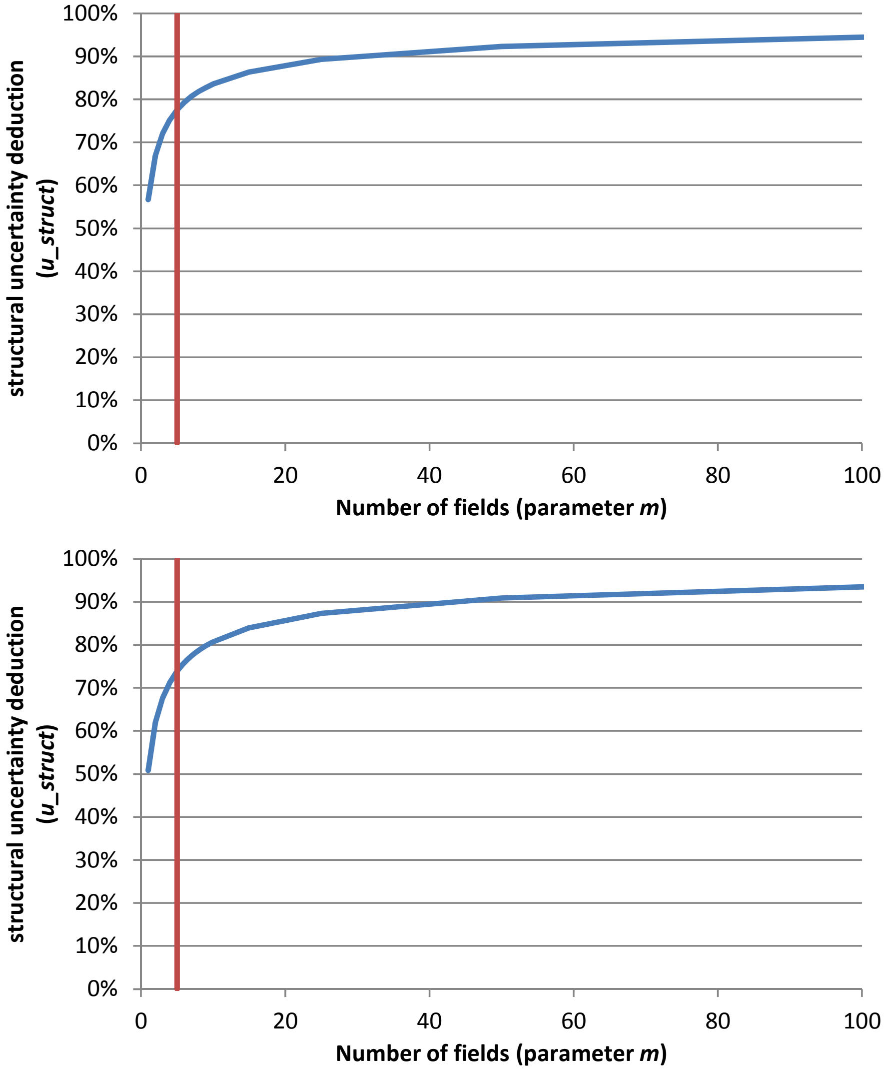

Figure 2. Structural uncertainty as a function of the number of plots included within a project. Note that the area left to the red line is ineligible under this methodology.

15.3 Template .dnd input file

The following table is a template .dnd input file with an indication of fixed default values or if values must be added by project proponents. The input file is set up to represent three years.

Table 13. Template dnd input file

Line	DND Parameter	Default Value
1	Input_Parameters:	
2	--	
3	Site_data:	
4	Simulated_Year:	24
5	Latitude:	43
6	Daily_Record:	0

7	--	
8	Climate_data:	0
9	Climate_Data_Type:	1
10	NO3NH4_in_Rainfall	1
11	NO3_of_Atmosphere	0.06
12	BaseCO2_of_Atmosphere	350
13	Climate_file_count	
14	1	no default
15	Climate_file_mode	1
16	CO2_increase_rate	0
17	--	
18	Soil_data:	0
19	Soil_Texture	Empirical soil measurements
20	Landuse_Type	2
21	Density	Empirical soil measurements
22	Soil_pH	Empirical soil measurements
23	SOC_at_Surface	Empirical soil measurements
24	Clay_fraction	Empirical soil measurements
25	BypassFlow	0
26	Litter_SOC	0.01
27	Humads_SOC	0.003
28	Humus_SOC	0.987
29	Soil_NO3(-)(mgN/kg)	0.5
30	Soil_NH4(+)(mgN/kg)	0.05
31	Moisture	0.405
32	Temperature	no default
33	Field_capacity	Empirical soil measurements
34	Wilting_point	Empirical soil measurements
35	Hydro_conductivity	Empirical soil measurements
36	Soil_porosity	Empirical soil measurements
37	SOC_profile_A	provide soil information
38	SOC_profile_B	provide soil information
39	DC_litter_factor	1
40	DC_humads_factor	1
41	DC_humus_factor	1
42	Humad_CN	10
43	Humus_CN	10
44	Soil_PassiveC	0
45	Soil_microbial_index	1
46	Highest_WT_depth	9.99
47	Depth_WRL_m	0.3
48	Slope	0
49	Use_ION_file	0
50	--	
51	Crop_data:	0

52	Rotation_Number	no default
53	Rotation_ID	no default
54	Totalyear	no default
55	Years_Of_A_Cycle	no default
56	YearID_of_a_cycle	no default
57	Crop_total_Number	no default
58	Crop_ID	no default
59	Crop_Type	no default
60	Plant_time	Exact date required, for example 5 1
61	Harvest_time	Exact date required, for example 9 11
62	Year_of_harvest	1
63	Ground_Residue	1 if no baling is applied, otherwise 0.25 or empirical measurement
64	Yield	Exact data required
65	Rate_reproductive	0.044
66	Rate_vegetative	0.015
67	Psn_efficiency	0.4
68	Psn_maximum	47
69	Initial_biomass	12.5
70	Cover_crop	0
71	Perennial_crop	0
72	Grain_fraction	0.6
73	Shoot_fraction	0.3
74	Root_fraction	0.1
75	Grain_CN	30
76	Shoot_CN	65
77	Root_CN	65
78	TDD	3000
79	Water_requirement	508
80	Max_LAI	6
81	N_fixation	1.05
82	Vascularity	1
83	Tillage_number	5
84	Tillage_ID	1
85	Month/Day/method	Exact date required, for example 4 23 3
86	Tillage_ID	2
87	Month/Day/method	Exact date required, for example 4 26 3
88	Tillage_ID	3
89	Month/Day/method	Exact date required, for example 4 27 2
90	Tillage_ID	4
91	Month/Day/method	Exact date required, for example 4 29 2
92	Tillage_ID	5
93	Month/Day/method	Exact date required, for example 9 15 2
94	Fertil_number	3
95	fertilization_ID	1

96	Month/Day/method	Exact date required, for example 4 30 1
97	Depth	15
98	Nitrate	0
99	AmmBic	0
100	Urea	0
101	Anh	130
102	NH4NO3	0
103	NH42SO4	0
104	NH4HPO4	0
105	Release_rate	1
106	Inhibitor_efficiency	0
107	Inhibitor_duration	0
108	Urease_efficiency	no default
109	Urease_duration	no default
110	fertilization_ID	2
111	Month/Day/method	Exact date required, for example 5 1 0
112	Depth	0.2
113	Nitrate	0
114	AmmBic	0
115	Urea	0
116	Anh	0
117	NH4NO3	0
118	NH42SO4	0
119	NH4HPO4	80
120	Release_rate	1
121	Inhibitor_efficiency	0
122	Inhibitor_duration	0
123	Urease_efficiency	no default
124	Urease_duration	no default
125	fertilization_ID	3
126	Month/Day/method	Exact date required, for example 5 26 0
127	Depth	0.2
128	Nitrate	0
129	AmmBic	0
130	Urea	0
131	Anh	0
132	NH4NO3	0
133	NH42SO4	20
134	NH4HPO4	0
135	Release_rate	1
136	Inhibitor_efficiency	0
137	Inhibitor_duration	0
138	Urease_efficiency	no default
139	Urease_duration	no default
140	FertilizationOption	0

141	Manure_number	0
142	Plastic_applications	no default
143	Ventilation	no default
144	Weed_number	no default
145	Weed_Problem	no default
146	Flood_number	3
147	Leak_type	1
148	Water_control	0
149	Leak_rate	0.08
150	Flooding_ID	1
151	Flood_Month/Day	Exact date required, for example 1 1
152	Drain_Month/Day	Exact date required, for example 1 31
153	Water_N	0
154	Shallow_flood	0
155	Flooding_ID	2
156	Flood_Month/Day	Exact date required, for example 5 1
157	Drain_Month/Day	Exact date required, for example 9 1
158	Water_N	0
159	Shallow_flood	0
160	Flooding_ID	3
161	Flood_Month/Day	Exact date required, for example 11 15
162	Drain_Month/Day	Exact date required, for example 12 35
163	Water_N	0
164	Shallow_flood	0
165	Water_gather	1
166	WT_file	None
167	Empirical_parameters	0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
168	Irrigation_number	0
169	Irrigation_type	0
170	Irrigation_Index	0
171	Grazing_number	0
172	Cut_number	0
173	Rotation_ID	2
174	Totalyear	1
175	Years_Of_A_Cycle	1
176	YearID_of_a_cycle	1
177	Crop_total_Number	1
178	Crop_ID	1
179	Crop_Type	20
180	Plant_time	Exact date required, for example 5 1
181	Harvest_time	Exact date required, for example 9 11
182	Year_of_harvest	1
183	Ground_Residue	1 if no baling is applied, otherwise 0.25 or empirical measurement
184	Yield	3600

185	Rate_reproductive	0.044
186	Rate_vegetative	0.015
187	Psn_efficiency	0.4
188	Psn_maximum	47
189	Initial_biomass	12.5
190	Cover_crop	0
191	Perennial_crop	0
192	Grain_fraction	0.6
193	Shoot_fraction	0.3
194	Root_fraction	0.1
195	Grain_CN	30
196	Shoot_CN	65
197	Root_CN	65
198	TDD	3000
199	Water_requirement	508
200	Max_LAI	6
201	N_fixation	1.05
202	Vascularity	1
203	Tillage_number	5
204	Tillage_ID	1
205	Month/Day/method	Exact date required, for example 4 23 3
206	Tillage_ID	2
207	Month/Day/method	Exact date required, for example 4 26 3
208	Tillage_ID	3
209	Month/Day/method	Exact date required, for example 4 27 2
210	Tillage_ID	4
211	Month/Day/method	Exact date required, for example 4 29 2
212	Tillage_ID	5
213	Month/Day/method	Exact date required
214	Fertil_number	3
215	fertilization_ID	1
216	Month/Day/method	Exact date required, for example 4 30 1
217	Depth	15
218	Nitrate	0
219	AmmBic	0
220	Urea	0
221	Anh	no default
222	NH4NO3	0
223	NH42SO4	0
224	NH4HPO4	0
225	Release_rate	1
226	Inhibitor_efficiency	0
227	Inhibitor_duration	0
228	Urease_efficiency	no default
229	Urease_duration	no default

230	fertilization_ID	2
231	Month/Day/method	Exact date required
232	Depth	0.2
233	Nitrate	0
234	AmmBic	0
235	Urea	0
236	Anh	0
237	NH4NO3	0
238	NH42SO4	0
239	NH4HPO4	no default
240	Release_rate	1
241	Inhibitor_efficiency	0
242	Inhibitor_duration	0
243	Urease_efficiency	0
244	Urease_duration	0
245	fertilization_ID	3
246	Month/Day/method	Exact date required, for example 5 26 0
247	Depth	0.2
248	Nitrate	0
249	AmmBic	0
250	Urea	0
251	Anh	0
252	NH4NO3	0
253	NH42SO4	no default
254	NH4HPO4	0
255	Release_rate	1
256	Inhibitor_efficiency	0
257	Inhibitor_duration	0
258	Urease_efficiency	0
259	Urease_duration	0
260	FertilizationOption	0
261	Manure_number	0
262	Plastic_applications	0
263	Ventilation	no default
264	Weed_number	no default
265	Weed_Problem	no default
266	Flood_number	no default
267	Leak_type	1
268	Water_control	0
269	Leak_rate	0.08
270	Flooding_ID	no default
271	Flood_Month/Day	Exact date required, for example 1 1
272	Drain_Month/Day	Exact date required, for example 1 31
273	Water_N	0
274	Shallow_flood	0

275	Flooding_ID	2
276	Flood_Month/Day	Exact date required
277	Drain_Month/Day	Exact date required
278	Water_N	0
279	Shallow_flood	0
280	Flooding_ID	no default
281	Flood_Month/Day	Exact date required
282	Drain_Month/Day	Exact date required
283	Water_N	no default
284	Shallow_flood	no default
285	Flooding_ID	no default
286	Flood_Month/Day	Exact date required
287	Drain_Month/Day	Exact date required
288	Water_N	0
289	Shallow_flood	0
290	Water_gather	no default
291	WT_file	no default
292	Empirical_parameters	no default
293	Irrigation_number	no default
294	Irrigation_type	0
295	Irrigation_Index	0
296	Irrigation_ID	no default
297	Irr_Month/Day	Exact date required
298	Water_amount/Method	no default
299	Irrigation_ID	no default
300	Irr_Month/Day	Exact date required
301	Water_amount/Method	no default
302	Grazing_number	0
303	Cut_number	0
304	Rotation_ID	3
305	Totalyear	7
306	Years_Of_A_Cycle	1
307	YearID_of_a_cycle	1
308	Crop_total_Number	1
309	Crop_ID	1
310	Crop_Type	20
311	Plant_time	5 1
312	Harvest_time	9 11
313	Year_of_harvest	1
314	Ground_Residue	1 if no baling is applied, otherwise 0.25 or empirical measurement
315	Yield	3600
316	Rate_reproductive	0.044
317	Rate_vegetative	0.015
318	Psn_efficiency	0.4

319	Psn_maximum	47
320	Initial_biomass	12.5
321	Cover_crop	0
322	Perennial_crop	0
323	Grain_fraction	0.6
324	Shoot_fraction	0.3
325	Root_fraction	0.1
326	Grain_CN	30
327	Shoot_CN	65
328	Root_CN	65
329	TDD	3000
330	Water_requirement	508
331	Max_LAI	6
332	N_fixation	1.05
333	Vascularity	1
334	Tillage_number	5
335	Tillage_ID	1
336	Month/Day/method	Exact date required, for example 4 23 3
337	Tillage_ID	2
338	Month/Day/method	Exact date required, for example 4 26 3
339	Tillage_ID	3
340	Month/Day/method	Exact date required, for example 4 27 2
341	Tillage_ID	4
342	Month/Day/method	Exact date required, for example 4 29 2
343	Tillage_ID	5
344	Month/Day/method	no default
345	Fertil_number	3
346	fertilization_ID	1
347	Month/Day/method	Exact date required, for example 4 30 1
348	Depth	15
349	Nitrate	0
350	AmmBic	0
351	Urea	0
352	Anh	Exact value required
353	NH4NO3	0
354	NH42SO4	0
355	NH4HPO4	0
356	Release_rate	1
357	Inhibitor_efficiency	0
358	Inhibitor_duration	0
359	Urease_efficiency	Exact value required
360	Urease_duration	Exact value required
361	fertilization_ID	Exact value required
362	Month/Day/method	Exact date required
363	Depth	0.2

364	Nitrate	0
365	AmmBic	0
366	Urea	0
367	Anh	0
368	NH4NO3	0
369	NH42SO4	0
370	NH4HPO4	Exact value required
371	Release_rate	1
372	Inhibitor_efficiency	0
373	Inhibitor_duration	0
374	Urease_efficiency	no default
375	Urease_duration	no default
376	fertilization_ID	no default
377	Month/Day/method	Exact date required
378	Depth	0.2
379	Nitrate	0
380	AmmBic	0
381	Urea	0
382	Anh	0
383	NH4NO3	0
384	NH42SO4	no default
385	NH4HPO4	0
386	Release_rate	1
387	Inhibitor_efficiency	0
388	Inhibitor_duration	0
389	Urease_efficiency	0
390	Urease_duration	0
391	FertilizationOption	0
392	Manure_number	0
393	Plastic_applications	0
394	Ventilation	no default
395	Weed_number	no default
396	Weed_Problem	no default
397	Flood_number	no default
398	Leak_type	1
399	Water_control	0
400	Leak_rate	0.08
401	Flooding_ID	1
402	Flood_Month/Day	Exact date required
403	Drain_Month/Day	Exact date required
404	Water_N	0
405	Shallow_flood	0
406	Flooding_ID	no default
407	Flood_Month/Day	Exact date required
408	Drain_Month/Day	Exact date required

409	Water_N	no default
410	Shallow_flood	no default
411	Flooding_ID	no default
412	Flood_Month/Day	Exact date required
413	Drain_Month/Day	Exact date required
414	Water_N	no default
415	Shallow_flood	no default
416	Flooding_ID	no default
417	Flood_Month/Day	Exact date required
418	Drain_Month/Day	Exact date required
419	Water_N	0
420	Shallow_flood	0
421	Water_gather	1
422	WT_file	None
423	Empirical_parameters	0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
424	Irrigation_number	no default
425	Irrigation_type	0
426	Irrigation_Index	0
427	Irrigation_ID	no default
428	Irr_Month/Day	Exact date required
429	Water_amount/Method	no default
430	Irrigation_ID	no default
431	Irr_Month/Day	Exact date required
432	Water_amount/Method	no default
433	Grazing_number	0
434	Cut_number	0
435	Crop_model_approach 0	-

15.4 Expanding the Project Actions and Geographical Regions through Follow-up Modules

This methodology can be expanded with new project actions and different allowed geographical regions through follow-up modules. Follow-up modules must contain the following elements:

- Exact and unambiguous description of project activities.
- Exact and unambiguous description of the geographical region on which credits can be generated. This geographical region reflects the area over which one calibration of the DNDC model remains valid.
- A justification of the geographical region on which credits can be generated. Such a calibration region will be typically larger eco-regions such as California's rice growing region, the rice growing area of the Gulf coast in/near Texas and Louisiana, or the rice growing area of the Mississippi watershed in/near Arkansas in the United States (**Error! Reference source not found.**).

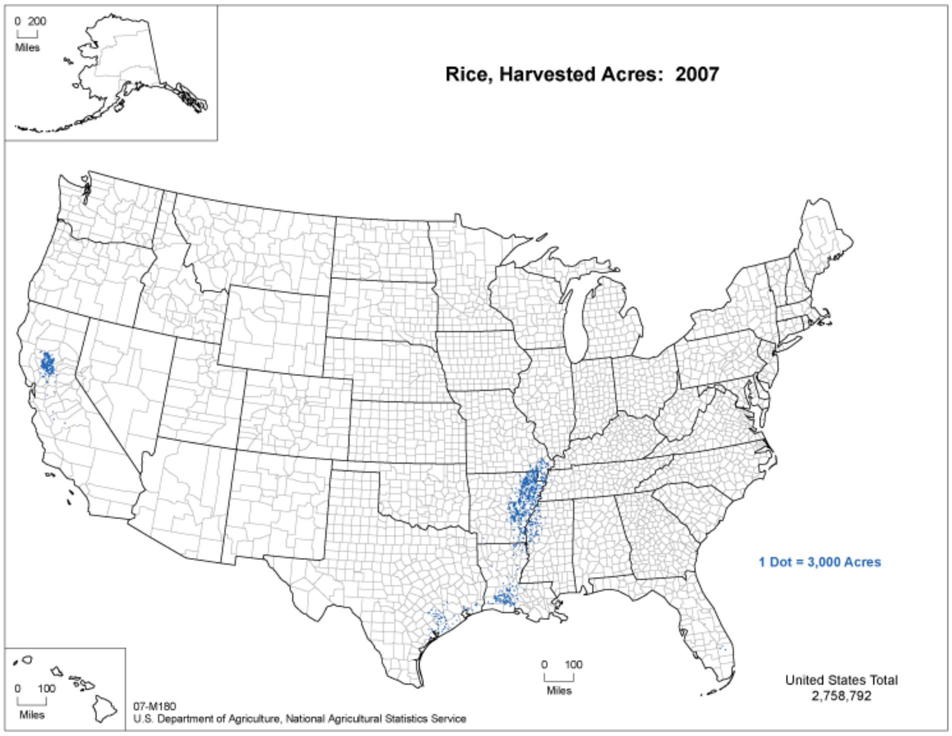

Figure 3. Map 07-M180 of the Agricultural Census of the USDA: Rice, Harvested Acres: 2007. Dot distribution map where each dot represents 3,000 acres of rice harvested in 2007. The largest concentrations of acres are in Arkansas and Louisiana. Available at http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Ag_Atlas_Maps/Crops_and_Plants/Field_Crops_Harvested/07-M180.asp

- List of the "critical input parameters", as defined before.
- Values of measured and modeled fluxes that represent the proposed project actions in the calibration region.
- Table of uncertainty deduction factors as deduced using the procedures in section 15.2.
- Values for each of the DNDC parameters similar to section 15.3, and how they must be derived (default value, lookup table, historical records, field measurements, etc.)