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The AFOLU Carbon Calculator



AFOLU CARBON CALCULATOR

THE CROPLAND MANAGEMENT TOOL: UNDERLYING DATA AND METHODS

Winrock International

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1. SCOPE

This document describes the underlying data sources and calculation methods employed in the Cropland Management (CM) Tool of the AFOLU Carbon Calculator (<http://afolucarbon.org>). The CM Tool is designed for project activities that aim at improving the management of croplands to reduce GHG emissions.

2. APPLICABILITY

The activities applicable under the Cropland Management Tool through which GHG emissions could be reduced are:

- Tillage management
- Fertilizer management
- Rice management

3. APPROACH TO THE CROPLAND TOOL

To provide an estimate of the GHG emission related to cropland management, this tool employed methodologies from the IPCC 2006 Guidelines for the Agriculture, Forestry, and Other Land Uses (AFOLU)¹, by using country-specific activity data and default emission factors provided in these guidelines. The GHG sources covered here are: methane from rice management, nitrous oxide from fertilizer use and carbon emissions from soils. Under Required Inputs, only soil carbon emissions from tillage management are considered, with the potential to include nitrous oxide from fertilizer and methane from rice management under Advanced Inputs.

4. DATA SOURCES

The greenhouse gas benefit of cropland activities represents the sum of benefits from tillage, fertilizer, and rice management. The sections below describe how the underlying data used in the calculations were derived.

4.1. SOIL CARBON MANAGEMENT

Soil carbon stocks before conversion to cropland were derived from the default SOC_{REF} numbers given by the IPCC (2006) (Table 1). These stocks were then projected on to the administrative units as follows: Major soil types from the Harmonized World Soil Database (HWSD, 2011)² and IPCC (2006) climate zones were re-grouped to apply to the soil and climate regime category in Table 2.3 of the IPCC AFOLU Guidelines. These datasets were combined with the grassland and cropland category from the

¹ Available at: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol1.html>

² Available at: <http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/>

MODIS 2009 land cover dataset and boundaries for the first level administrative units to link the climate region and soil class per administrative unit with the SOC_{REF} value. Due to the different spatial resolution between the datasets, some administrative units were not covered by all of the three raster datasets (climate, soil, grassland and cropland), as a result some manual edits were performed adopting the value of neighboring administrative units.

Table 1: Default reference SOC stocks (SOC_{REF}) for mineral soils ($t\ C\ ha^{-1}$ in 0-30 cm depth) (Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories)

Climate region	HAC Soil _(a)	LAC Soils _(b)	Sandy soils _(c)	Spodic soils _(d)	Volcanic soils _(e)
Boreal	68	NA	10	117	20
Cold temperate, dry	50	33	34	NA	20
Cold temperate, moist	95	85	71	115	130
Warm temperate, dry	38	24	19	NA	70
Warm temperate,	88	63	34	NA	80
Tropical, dry	38	35	31	NA	50
Tropical, moist	65	47	39	NA	70
Tropical, wet	44	60	66	NA	130
Tropical montane	88	63	34	NA	80

(a) Soils with high activity clay (HAC) minerals are lightly to moderately weathered soils, which are dominated by 2:1 silicate clay minerals (in the World Reference Base for Soil Resources (WRB) classification these include Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, Regosols; in USDA classification includes Mollisols, Vertisols, high-base status Alfisols, Aridisols, Inceptisols);

(b) Soils with low activity clay (LAC) minerals are highly weathered soils, dominated by 1:1 clay minerals and amorphous iron and aluminium oxides (in WRB classification includes Acrisols, Lixisols, Nitisols, Ferralsols, Durisols; in USDA classification includes Ultisols, Oxisols, acidic Alfisols);

(c) Includes all soils (regardless of taxonomic classification) having > 70% sand and < 8% clay, based on standard textural analyses (in WRB classification includes Arenosols; in USDA classification includes Psamments);

(d) Soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols);

(e) Soils derived from volcanic ash with allophanic mineralogy (in WRB classification Andosols; in USDA classification Andisols)

Soil carbon stocks after forest conversion to cropland were based on specific soil stock change factors for land use, management, and inputs (f_{LU} , f_{MG} , f_i , respectively) listed in Table 5.5 of the IPCC (2006). Relevant factors are listed in Table 2. Stock change factors were selected for each land cover type (before and after activity implementation) and multiplied by reference soil carbon stocks. Following the IPCC (2006) Guidelines, the total difference in carbon stocks before and after conversion was annualized to give the total emissions over 20 years.

Table 2: Soil carbon stock change factors for different management activities on cropland (net effect over a period of 20 years) (Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories)

Factor type	Level	Temperature regime	Moisture regime	Factor value	Description and criteria
Land use (f_{LU})	Long-term cultivated	Temperate/Boreal	Dry	0.80	Area has been continuously managed for crops for more than 20 years
			Moist	0.69	
		Tropical	Dry	0.58	
			Moist/Wet	0.48	
Tropical montane	n/a	0.64			
Land use (f_{LU})	Short-term cultivated (< 20 yrs) or set aside (< 5 years)	Temperate/Boreal and Tropical	Dry	0.93	Area has been managed for crops for less than 20 years and/or the area is cropland that has been in a fallow state for less than five years at any point during the last 20 years
			Moist/Wet	0.82	
		Tropical montane	n/a	0.88	
Management (f_{MG})	Full tillage	All	Dry and Moist/Wet	1.00	Substantial soil disturbance with full inversion and/or frequent (within-year) tillage operations. At planting time, little (e.g. <30%) of the surface is covered by residues
Management (f_{MG})	Reduced tillage	Temperate/Boreal	Dry	1.02	Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30% coverage by residues at planting
			Moist	1.08	
		Tropical	Dry	1.09	
			Moist/ Wet	1.15	
		Tropical montane	n/a	1.09	
Management (f_{MG})	No tillage	Temperate/Boreal	Dry	1.10	Direct seeding without primary tillage, with only minimal soil disturbance in the seeding zone. Herbicides are typically used for weed control.
			Moist	1.15	
		Tropical	Dry	1.17	
			Moist/ Wet	1.22	
		Tropical montane	n/a	1.16	
Inputs (f_{IN})	Low	Temperate/Boreal	Dry	0.95	Removal of residues (collection or burning), frequent bare fallowing, production of crops with low residues (e.g. vegetables, tobacco, cotton), no mineral fertilization or nitrogen fixing species
			Moist	0.92	
		Tropical	Dry	0.95	
			Moist/ Wet	0.92	
		Tropical montane	n/a	0.94	
Inputs (f_{IN})	Medium	All	All	1.00	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g., manure) is added. Also requires

Factor type	Level	Temperature regime	Moisture regime	Factor value	Description and criteria
					mineral fertilization or N-fixing crop in rotation.
Inputs (f_{IN})	High without manure	Temperate / Boreal / Tropical	Dry	1.04	Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied (see row below).
			Moist/Wet	1.11	
		Tropical montane	n/a	1.08	
Inputs (f_{IN})	High with manure	Temperate / Boreal / Tropical	Dry	1.37	Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure.
			Moist/Wet	1.44	
		Tropical montane	n/a	1.41	

4.2. FERTILIZER MANAGEMENT

Emissions from fertilizer are derived from direct emissions from application, indirect emissions from runoff/leaching, emissions from atmospheric deposition of volatilized N, and emissions from initial fertilizer production. They will vary depending on which fertilizer is applied. The approach is from IPCC (2006) Tier 1. In the calculator, percentage nitrogen in fertilizer types are derived from extension service information (Table 3) and fertilizer production emission factors are derived from CDM methodology III.A³ (Table 4). The default values for direct emissions, runoff and volatilization emissions are given in Section 6.2.

Table 3: % N by fertilizer type

Fertilizer Type	N %
Urea	46
Ammonia	82
Ammonium sulphate	11
Monammonium sulphate (MAP)	18
Diammonium sulphate (DAP)	21
Ammonium nitrate	33.5
Calcium ammonium nitrate	25
Manure	3.3
Poultry litter	4.5

Derived from *The Agronomy Guide 2013-2014*. Penn State College of Agricultural Sciences.

³ <http://cdm.unfccc.int/methodologies/DB/4OC3QS857382TW2ILYYOJLTX3HHQKK>

Table 4: Fertilizer types and associated emission factors derived from CDM methodology III.A.

Fertilizer Type	EF (t CO ₂) per ton of fertilizer
Urea	1.54
Ammonia	1.35
Ammonium sulphate	0.35
Monammonium sulphate (MAP)	0.18
Diammonium sulphate (DAP)	0.30
Ammonium nitrate	0.55
Calcium ammonium nitrate	0.43
Manure	0
Poultry litter	0

4.3 RICE MANAGEMENT

Rice emissions under the IPCC approach are calculated from the area multiplied by the number of days of cultivation multiplied by an emission factor. The emission factor has a default value of 1.30 t CO₂ which is adjusted by scaling factors for differences in water regime during the cultivation period (Table 5), differences in water regime in the pre-season before cultivation, for type and amount of organic amendment, for soil type and for rice cultivar.

Table 5: Water regime scaling factors for calculation of emissions from rice management from IPCC AFOLU 2006 Table 5.12.

Water regime		Water Regime Scaling Factor
Upland		0
Irrigation	Continuous flooding	1.0
	Intermittent flooding with sing aeration	0.6
	Intermittent flooding with multiple aeration	0.52
Rainfed	Regular	0.28
	Drought-prone	0.25
	Deep water potential	0.31

5. UNCERTAINTY OF ESTIMATES

Uncertainty is a property of a parameter estimate and reflects the degree of lack of knowledge of the true parameter value because of factors such as bias, random error, quality and quantity of data, state of knowledge of the analyst, and knowledge of underlying processes. Uncertainty can be expressed as the size of the half width of a specified confidence interval as a percentage of the mean value. For example, if

the area of forest land converted to cropland (mean value) is 100 ha, with a 95% confidence interval ranging from 90 to 110 ha, we can say that the uncertainty in the area estimate is $\pm 10\%$ of the mean (from GOF-C-GOLD 2013).

Uncertainty is an unavoidable attribute of practically any type of data including land area and estimates of carbon stocks and many other parameters used in the estimation of the AFOLU carbon benefits from activities on the land. Identification of the sources and quantification of the magnitude of uncertainty will help to better understand the contribution of each source to the overall accuracy and precision of the final estimate.

The proper manner of dealing with uncertainty is fundamental in the IPCC and UNFCCC contexts. The IPCC defines estimates that are consistent with good practice as those which contain neither over- nor underestimates so far as can be judged, and in which uncertainties are reduced as far as practicable. The first step in an uncertainty analysis is to identify the potential sources of uncertainty. Many sources are possible including measurement errors due to human errors or errors in calibration; measurement errors in the predictor variables; modelling errors due to inability of the model to fully describe the phenomenon; parameter uncertainty, and residual uncertainty; erroneous definitions or classifications that lead to double-counting or non-counting; unrepresentative samples; and variability resulting from the use of samples rather than censuses. In this section, the potential sources of uncertainty are identified and an assessment of their likely range of uncertainties used in the calculation of the carbon benefit in this tool is presented (Table 6). A brief primer of the steps involved in assessing total uncertainties for each carbon benefit estimate is provided with a couple of simple examples to demonstrate the process. The reader is referred to the GOF-C-GOLD 2013 sourcebook for more details on all sources of uncertainty and how to reduce them. These analyses are not provided in the Tools.

In addition to the uncertainties associated with each parameter, when parameters are combined as in e.g. estimating emissions from combining area treated and carbon loss rates, then overall error of the product will change. Uncertainties in individual parameter estimates can be combined using either (1) error propagation (IPCC Tier 1) or (2) Monte Carlo simulation (IPCC Tier 2). Tier 1 method is based on simple error propagation, and cannot therefore handle all kinds of uncertainty estimates. The key assumptions of Tier 1 method are (from GOF-C-GOLD 2013):

- estimation of carbon emissions and removals is based on addition, subtraction and multiplication
- there are no correlations across parameters (or if there is, they can be aggregated in a manner that the correlations become unimportant)
- none of the parameter estimates has an uncertainty greater than about $\pm 60\%$
- uncertainties are symmetric and follow normal distributions

However, even in the case that not all of the conditions are satisfied, the method can be used to obtain approximate results. In the case of asymmetric distributions, the uncertainty bound with the greater absolute value should be used in the calculation. The Tier 2 method is based on Monte Carlo simulation, which is able to deal with any kind of models, correlations and distribution. However, application of Tier 2 methods requires more resources than that of Tier 1.

The key parameters are low to medium uncertainty. The other parameter used in the calculations is area under cultivation—it is assumed that this will be well known with an uncertainty of about 5% or less.

Table 6: Key parameters used to estimate the carbon benefits of cropland activities and an assessment of their uncertainties.

Component	Parameter	Uncertainty			Comment
		Low (<20%)	Medium (20-60%)	High (>60%)	
Soil Carbon Management	Pre-conversion soil carbon stocks		X		IPCC defaults and world soil map
	Soil carbon stock change factors		X		IPCC defaults
Fertilizer Management	% N by fertilizer type	X			Derived from extension service information
	Emission factor from fertilizer production and application	X			Derived from CDM methodology III.A
Rice Management	Rice water regime		X		IPCC defaults
	Default rice emission factor		X		Default value multiplied by IPCC scaling factor

5.1 COMBINING UNCERTAINTIES FOR MULTIPLICATION

The simple error propagation method is based on two equations: one for multiplication and one for addition and subtraction of uncertainties. The equation to be used in case of multiplication is:

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2}$$

Where:

U_i = percentage uncertainty associated with each of the parameters

U_{total} = the percentage uncertainty in the product of the parameters

An example of combining uncertainties in estimating rice emissions with project using the Tier I method is shown below:

	Mean value	Uncertainty (% of mean)
Area cultivated (ha)	1,000	5
Rice water regime scaling factor (unit-less)	0.28	40
Default emission factor (t C/ha)	2.652	40

Thus the carbon emissions are:

$$1,000 \text{ ha} * 0.28 * 2.652 \text{ t C/ha} = 743 \text{ t C}$$

And the uncertainty = $\sqrt{5^2 + 40^2 + 40^2} = \pm 57\%$

5.2 COMBINING UNCERTAINTIES FOR ADDITION AND SUBTRACTION

In the case of addition and subtraction, for example when carbon emissions are summed up, the following equation will be applied:

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 \dots (U_n * x_n)^2}}{|x_1 + x_2 \dots + x_n|}$$

Where:

U_i = percentage uncertainty associated with each of the parameters

x_i = the value of the parameter

U_{total} = the percentage uncertainty in the sum of the parameters

An example of this application is in the yearly CO₂ benefit (addition) shown below:

Component	Mean benefit (t CO ₂)	Uncertainty (% of mean)
Soil carbon benefit	400	45
Fertilizer management benefit	1000	15
Rice management benefit	600	50

In this example, the total benefit is 2000 t CO₂ and the uncertainty =

$$\frac{\sqrt{(45\% * 400)^2 + (15\% * 1000)^2 + (50\% * 600)^2}}{|400 + 1000 + 600|} = \pm 19\%$$

Using this simple error propagation method is applicable to the calculations used in this AR Tool. The Monte Carlo type analysis is more complicated to apply, but gives more reliable results particularly where uncertainties are large, distributions are non-normal, or correlations exist. Furthermore, Tier 2 method can be applied to models or equations, which are not based only on addition, subtraction and multiplication. (The reader is referred to Chapter 5 of IPCC GPG LULUCF for more details on how to implement the Monte Carlo analysis).

6. CALCULATION METHODS

The greenhouse gas benefit of cropland activities represents the sum of benefits from tillage management, fertilizer management and rice management. The sections below outline individual components of the overall calculation (Box 1), and describe how default values for each parameter within an equation were derived.

Box 1: Overarching methodology for calculating carbon benefits in Cropland Calculator

Yearly CO₂ benefit (t CO₂ y⁻¹) = (Soil carbon benefit) + (Fertilizer management benefit) + (Rice management benefit)

Total CO₂ benefit (t CO₂) = SUM of Yearly CO₂ benefits

Parameters in blue must be specified by the user under Required Inputs. Parameters in red have default values under Advanced Inputs, but can be changed by the user. Parameters in black are fixed within the calculations.

6.1 SOIL CARBON MANAGEMENT

The soil carbon term represents the difference in stable carbon stock between the two management approaches divided by 20 which is assumed (following the IPCC Guidelines) to be the number of years to transition from one stable stock to the other. The terms shown are in the equations below, and the default values used for each parameter are described.

Box 2: Estimating emissions from tillage management

Soil benefit = [(Soil carbon with project – Soil carbon without project) / 20] × (44/12) (Eq. 1)

Changes in soil carbon stocks were calculated based on Section 2.3.3.1 of the IPCC (2006) Guidelines. The equation calculates the difference in carbon stocks in the soil before and after agricultural conversion, and divides this value by the assumed time period over which the change is forecasted to occur (20 years). However, in this Tool we assume the all the soil emissions associated with agricultural conversion occur in the first year.

$$\text{Soil carbon with or without project} = \text{Area} * \text{SOC}_{REF} * f_{LU} * f_{MG} * f_i \quad (\text{Eq. 2})$$

Where:

SOC_{REF} = reference carbon stock; t C/ha

f_{LU} = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

f_{MG} = stock change factor for management regime, dimensionless

f_i = stock change factor for input of organic matter, dimensionless

6.2 FERTILIZER MANAGEMENT

Fertilizer management benefits are calculated through the difference in emissions with and without the emission reduction activity (eq. 3). The emissions are calculated using an IPCC Tier I approach based on Section 11.2 of the 2006 Guidelines on Agriculture, Forestry and Other Land Use with fertilizer production emission factors derived from CDM methodology III.A. Emissions are derived from direct emissions from application, indirect emissions from application, emissions from atmospheric deposition of volatilized N and emissions from initial fertilizer production.

Box 3: Estimating benefit of fertilizer management

Fertilizer management benefit = fertilizer emissions without project – fertilizer emissions with-project
(eq. 3)

Fertilizer emissions with or without project = Fertilizer Area * Fertilizer Applied * %N * (6.205 + EF_{CO_2})
(eq. 4)

Post-fertilizer application emissions under Tier I are calculated from the quantity of fertilizer applied multiplied by default constants as described below

- Direct emissions = annual application kg N yr⁻¹ * 0.01 * 1.5714 * 298
- Leaching/runoff emissions = annual application kg N yr⁻¹ * 0.3 * 0.0075 * 1.5714 * 298
- Volatilization and deposition emissions = annual application kg N yr⁻¹ * 0.1 * 0.01 * 1.5714 * 298
- Production emissions = annual application kg N yr⁻¹ * EF_{CO_2}

Where:

- 0.01 is the default for the emission factor for direct emissions and for emission from atmospheric deposition of N on soils and water surfaces
- 1.5714 is the ratio for conversion of N₂O-N to N₂O
- 298 is the global warming potential of nitrous oxide (for conversion of N₂O emissions to CO₂-equivalent emissions)
- 0.1 is the default fraction of synthetic fertilizer that volatilizes

These equations can be summed using the defaults to 6.205 multiplied by the emission factor for fertilizer production EF_{CO_2} which varies by fertilizer type applied (Table 4).

6.3 RICE MANAGEMENT

Rice management benefits are calculated through the difference in emissions with and without the emission reduction activity (eq. 5). The emissions are calculated using an IPCC Tier I approach based on Section 5.5 of the IPCC (2006) (Box 4 and eq. 6). We assumed that:

- Soil exposure by default was non-flooded soil for more than 180 days before planting
- No inputs were applied
- There are no specific differences by soil type or rice cultivar
- Cultivation is for 120 days

Box 4: Estimating benefit of rice management

Rice management = rice emissions without project – rice emissions with-project (eq. 5)

Rice emissions with or without project = Rice Area * Rice Water Regime *2.652 (eq. 6)

Rice emissions under the IPCC approach are calculated from the area multiplied by the number of days of cultivation multiplied by an emission factor. The emission factor has a default value of 1.30 kg CH₄ ha⁻¹ day⁻¹ which is adjusted by scaling factors for differences in water regime during the cultivation period, differences in water regime in the pre-season before cultivation, for type and amount of organic amendment, for soil type and for rice cultivar.

Here the equation is simplified with the assumptions above allowing the calculation of emissions with just the entered rice area and a drop-down decision on the water regime during cultivation.

So that the default emission factor (eq. 7) is multiplied by 0.68 for flooding regime before cultivation and by 120 cultivation days and by the global warming potential of methane to convert from tons of methane to tons of CO₂ equivalent (25 from AR4 2007). This number is multiplied by 0.001 to convert from grams to tons.

$$\text{Default rice emission factor} = 1.30 * 0.68 * 120 * 25 * 0.001 = 2.652 \quad \text{eq. 7}$$

6.4 HYPOTHETICAL EXAMPLE

A hypothetical project activity taking place over 500 hectares of cropland in Mozambique is given as an example here. First, users must select the geographic location of the project, which in this example is Inhambane, Mozambique.

After entering the total area of the cropland management project activity (500 ha), the user has select the tillage practice used before the project from a drop down menu (full, reduced or no till) and the level of inputs before the intervention (e.g. low, medium, high with manure or high without manure). In this example, the cropland management practices will improve practices from full tillage and high inputs with no manure, to no-tillage and low inputs. Given the same options, users must then select the appropriate actions for the after intervention scenario.

Thus, benefits are calculated as:

$$\text{Benefits (tCO}_2\text{)} = \{[(\text{Area} * \text{SOC}_{\text{REF}} * f_{LU} * f_{MG, \text{no-till}} * f_{I, \text{low}}) - (\text{Area} * \text{SOC}_{\text{REF}} * f_{LU} * f_{MG, \text{full-till}} * f_{I, \text{high-without manure}})] / 20\} * (44/12)$$

Where:

Area	= 500 ha
SOC_{REF}	= 24 t C ha ⁻¹
f_{LU}	= 0.58
$f_{MG, \text{no-till}}$	= 1.17
$f_{I, \text{low}}$	= 0.95
$f_{MG, \text{full-till}}$	= 1.0
$f_{I, \text{high-without manure}}$	= 1.04

Thus equating to:

$$\text{Benefits} = \{[(500 * 24 * 0.58 * 1.17 * 0.95) - (500 * 24 * 0.58 * 1 * 1.04)] / 20\} * (44/12)$$

$$\text{Benefits} = \mathbf{93 \text{ tCO}_2\text{e}}$$

In this hypothetical example, improvement of management of 500 ha of cropland in Inhambane, Mozambique has resulted in a carbon benefit of approximately **93 t CO₂e** each per year.

7. OVERRIDING DEFAULT DATA

The Cropland Management Tool can generate results using only information entered under Required Inputs, or users can opt to override the default data and enter additional information under Advanced Inputs.

Under Required Inputs, the only data required to generate a CO₂e impact result of the project activity is:

- Location of the activity
- Size or area of the activity, associated with the cropland activity
- Previous tillage:
 - Full
 - Reduced
 - No
- With-project tillage:
 - Full
 - Reduced
 - No
- Previous soil inputs:
 - Low
 - Medium
 - High without manure
 - High with manure
- With-project soil inputs:
 - Low
 - Medium
 - High without manure
 - High with manure
- Fertilizer:
 - Previous management amount of fertilizer applied per hectare
 - Previous management type of fertilizer
 - Urea
 - Ammonia
 - Ammonium sulphate
 - Monammonium sulphate (MAP)
 - Diammonium sulphate (DAP)
 - Ammonium nitrate
 - Calcium ammonium nitrate
 - Manure
 - Poultry litter
 - With project amount of fertilizer applied per hectare
 - With project type of fertilizer
 - Urea
 - Ammonia
 - Ammonium sulphate
 - Monammonium sulphate (MAP)
 - Diammonium sulphate (DAP)

- Ammonium nitrate
 - Calcium ammonium nitrate
 - Manure
 - Poultry litter
- Rice Management:
- Previous rice management system
 - Upland
 - Irrigation
 - Continuous flooding
 - Intermittent flooding with single aeration
 - Intermittent flooding with multiple aerations
 - Rainfed
 - Regular
 - Drought-prone
 - Deep water potential
 - With project rice management system:
 - Upland
 - Irrigation
 - Continuous flooding
 - Intermittent flooding with single aeration
 - Intermittent flooding with multiple aerations
 - Rainfed
 - Regular
 - Drought-prone
 - Deep water potential

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