NOTE: The tool has been made public for comments and is not yet approved by the Board.

Annex 11

DRAFT Methodological tool

"Tool to estimate emissions associated with the cultivation of lands to produce biomass"

(Version 01)

I. DEFINITIONS, SCOPE, APPLICABILITY AND PARAMETERS

Scope and applicability

This tool provides procedures to estimate the net emissions increase from cultivating renewable biomass on dedicated degraded land areas (in the following referred to as "plantation"). It may be referred to in methodologies that use renewable biomass for energy purposes or for the production of biofuels. This tool does not cover procedures

- to estimate emissions associated with the transportation, processing and use of the biomass/biofuels;
- to account for emission credits from the use of by-products from the biomass/biofuel production process;
- to address shifts of pre-project activities or increases of net GHG removals by sinks that may occur in the absence of the project on the land area.[1]

This tool is applicable under the following conditions:

- Grazing will not occur on the land area of the biomass plantation in the project situation;
- In case the plantation is irrigated, the water used for irrigation is not from a desalination plant;
- No rice is cultivated at the biomass plantation;
- If the land-use under the project activity is cropland or grassland, the land area of the biomass plantation has not been forest by 31 December 2006.[2] This should be demonstrated by providing transparent information that:
    - o Vegetation on the land was below the forest thresholds (tree crown cover or equivalent stocking level, tree height at maturity *in situ*, minimum land area) adopted for the definition of forest by the host country under decisions 16/CMP.1 and 5/CMP.1 as communicated by the respective DNA; and

[1] Methodologies that use this tool may need to include methodological approaches to take these effects into account.
[2] This applicability condition is provided to avoid situations where the land-use is changed for the purpose of the CDM project activity some time before registering or starting the CDM project activity. For example, a forest could be deforested two years prior to formally establishing the CDM biomass plantation and starting the CDM project activity.

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- All young natural stands and all plantations on the land are not expected to reach the minimum crown cover and minimum height chosen by the host country to define forest; and
- The land was not temporarily unstocked, as a result of human intervention such as harvesting or natural causes.[3]

Definitions

For the purpose of this tool, the following definitions apply:

- ***Above-ground biomass*** is all biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage (2006 IPCC Guidelines, Volume 4, Chapter 1, Table 1.1).

- ***Below-ground biomass*** is all biomass of live roots (2006 IPCC Guidelines, Volume 4, Chapter 1, Table 1.1).

- ***Organic soils*** are found in wetlands or have been drained and converted to other land-use types (2006 IPCC Guidelines, Volume 4, Chapter 3, Annex 3A5). Organic soils are defined as soils where criteria 1 and 2 or criteria 1 and 3 apply:

  1. Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20 cm must have 12 percent or more organic carbon when mixed to a depth of 20 cm.
  2. Soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).
  3. Soils are subject to water saturation episodes and have either:

     (a) At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay; or
     (b) At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay; or
     (c) An intermediate, proportional amount of organic carbon for intermediate amounts of clay.

- ***Mineral soil*** is a soil that is not classified as an organic soil according to the definition provided above. Mineral soils typically have relatively low amounts of organic matter, occur under moderate to well drained conditions, and predominate in most ecosystems except wetlands.

- ***Forest Land.*** This category includes all land with woody vegetation consistent with thresholds used to define Forest Land, as communicated by the DNA of the host country to UNFCCC. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category.

[3] If the host country has not yet communicated a forest definition to UNFCCC, project participants may use 30% as minimum tree crown cover and 2 meters as minimum height at maturity in situ.

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- ***Cropland.*** This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.

- ***Grassland.*** This category includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions.

- ***Wetlands.*** This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
- ***Project area.*** The total land area where biomass is cultivated under the CDM project activity.

Parameters

This tool provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$PE_{BC,y}$	t CO_2e	Project emissions from cultivating biomass in year *y*

II. BASELINE METHODOLOGY PROCEDURE

Project emissions from the cultivation of biomass are calculated in two steps: In Step 1, the project area is identified and, if necessary, stratified. In Step 2, project emissions are calculated for all relevant emission sources.

Step 1: Identification and stratification of the project area

Project participants should identify and transparently document the project area (i.e. the land area where biomass is cultivated under the CDM project activity) in the CDM-PDD, delineating the project area with GPS data.

Project participants should identify and describe in the CDM-PDD the key features of the project area, including, inter alia, the following elements:

- the applicable climate region according to the default IPCC classification, applying the guidance in Annex 3A.5 of Chapter 3, Volume 4, of the 2006 IPCC Guidelines;
- the relevant soil type according to World Reference Base for Soil Resources (WRB) or USDA soil classifications, following the decision trees in Annex 3A.5 of Chapter 3, Volume 4, of the 2006 IPCC Guidelines;
- the land-use type during the last 10 years before implementation of the project activity, including any changes in the land-use during that period;

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- the land management practice(s) during the last 10 years before implementation of the project activity, including any changes in the management practice during that period;
- the vegetation type before the implementation of the project activity;
- whether and how any land clearance is undertaken (e.g. harvesting, burning, etc);
- the land-use type (forest or cropland) under the project activity;
- the land management practices that are applied under the project activity.

If one or several of the above-mentioned features differ within the project area, project participants should stratify the land area in different strata *s* according to the features above. The land area of each stratum ($A_{PJ,s}$) should be clearly delineated in the CDM-PDD, using GPS data, and the features of each stratum should be transparently documented. Project participants may use geographical information systems (GIS) for that purpose.

Step 2: Calculation of project emissions

(Note that this tool contains some emission sources that are likely not be significant on degraded lands. The procedures are provided to possibly extent the scope of the tool at a later stage.)
Total project emissions from cultivating biomass are given as follows:

$$PE_{BC,y} = PE_{CL} + PE_{FB,y} + PE_{CO2,soil,y} + PE_{FC,PL,y} + PE_{FP,y} + PE_{N2O,soil,y} + PE_{urea,y} + PE_{lime,y} + PE_{IR,y} \quad \textbf{(1)}$$

where:

$PE_{BC,y}$	=	Project emissions from cultivating biomass in year *y* (tCO_2e/yr)
PE_{CL}	=	Project emissions from clearance of land prior to the establishment of the biomass plantation (tCO_2e)
$PE_{FB,y}$	=	Project emissions from field burning of biomass at the plantation site in year *y* (tCO_2e/yr)
$PE_{CO2,soil,y}$	=	Project emissions of CO_2 in year *y* resulting from changes in soil carbon stocks following a land use change or a change in the land management practices (tCO_2/yr)
$PE_{FC,PL,y}$	=	Project emissions from fossil fuel consumption for agricultural operations in year *y* (tCO_2/yr)
$PE_{FP,y}$	=	Project emissions related to the production of synthetic fertilizer that is used at the plantation in year *y* (tCO_2e/yr)
$PE_{N2O,soil,y}$	=	Project emissions of N_2O from land management at the plantation in year *y* (tCO_2e/yr)
$PE_{urea,y}$	=	Project emissions from urea application at the plantation in year *y* (tCO_2/yr)
$PE_{lime,y}$	=	Project emissions from application of limestone and dolomite at the plantation in year *y* (tCO_2/yr)
$PE_{IR,y}$	=	Project emissions resulting from irrigation at the plantation in year *y* (tCO_2e/yr)

In the following, procedures are provided to determine these emission sources. Note that if an emission source is not applicable to a specific project activity then this source does not need to be included. The procedures below provide guidance, in which cases emission sources may be omitted.

Step 2.1: Emissions from clearance of land prior to the establishment of the biomass plantation (PE_{CL})

NOTE: The tool has been made public for comments and is not yet approved by the Board.

Emissions from clearance of land prior to the establishment of the biomass plantation include CO_2 emissions resulting from losses of biomass stocks (above-ground and below-ground) and, in case of slash and burn, CH_4 and N_2O emissions from burning the biomass.

$$PE_{CL} = PE_{CL,CO2} + PE_{CL,non\text{-}CO2} \quad \textbf{(2)}$$

Where:

PE_{CL}	=	Project emissions from clearance of land prior to the establishment of the biomass plantation (tCO_2e)
$PE_{CL,CO2}$	=	Project emissions of CO_2 from losses of biomass stocks (above-ground and below-ground) as a result of clearance of land prior to the establishment of the biomass plantation (tCO_2/yr)
$PE_{CL,non\text{-}CO2}$	=	Project emissions of CH_4 and N_2O from burning biomass stocks prior to the establishment of the biomass plantation (tCO_2/yr)

All emissions from clearance of land prior to the establishment of the biomass plantation should be accounted in the first year of the first crediting period.

CO_2 emissions from losses of biomass stocks

Project emissions from losses of biomass stocks are calculated based on the difference of the biomass stock before and immediately after clearance of lands, as follows:

$$PE_{CL,CO2} = \sum_{s} \left(B_{BEFORE,s} - B_{PJ,s}\right) \times A_{PJ,s} \times CF \times \frac{44}{12} \quad \textbf{(3)}$$

with

$$B_{BEFORE,s} = B_{AG,BEFORE,s} \times \left(1 + R_{BEFORE,s}\right) \quad \textbf{(4)}$$

Where:

$PE_{CL,CO2}$	=	Project emissions of CO_2 from losses of biomass stocks (above-ground and below-ground) as a result of clearance of land prior to the establishment of the biomass plantation (tCO_2/yr)
$B_{BEFORE,s}$	=	Average biomass stocks (above ground and below ground) per hectare on stratum *s* of the projects area before the clearance of the land (tonnes of dry matter / ha)
$B_{PJ,s}$	=	Average biomass stocks (above ground and below ground) per hectare on stratum *s* of the project area immediately after the start of the project activity (i.e. after the clearance of the land and after seeding/planting) (tonnes of dry matter / ha)
$A_{PJ,s}$	=	Size of the land area of stratum *s* (ha)
CF	=	Carbon fraction in the dry matter of the biomass (t C / tonnes of dry matter)

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$B_{AG,BEFORE,s}$ = Average above-ground biomass stocks per hectare on stratum *s* of the project area before the clearance of the land (tonnes of dry matter / ha)

$R_{BEFORE,s}$ = Ratio of below-ground biomass to above-ground biomass for the biomass stocks on stratum *s* of the project area before the clearance of the land

s = All strata in which the project area is stratified

<u>*CH_4 and N_2O emissions from burning biomass as part of clearance of lands*</u>

In case of burning of biomass as part of the clearance of lands, CH_4 and N_2O emissions from biomass burning should be estimated as follows:

$$PE_{CL,non\text{-}CO2} = \sum_{s_{CL,B}} A_{PJ,s_{CL,B}} \times M_{B,s_{CL,B}} \times C_{f,s_{CL,B}} \times \left(EF_{N2O,CL} \times GWP_{N2O} + EF_{CH4,CL} \times GWP_{CH4}\right) \quad \textbf{(5)}$$

Where:

$PE_{CL,non\text{-}CO2}$ = Project emissions of CH_4 and N_2O from burning biomass stocks prior to the establishment of the biomass plantation (tCO_2/yr)

$A_{PJ,s_{CL,B}}$ = Size of the land area of stratum $s_{CL,B}$ (ha)

$M_{B,s_{CL,B}}$ = Average mass of biomass available for burning on stratum $s_{CL,B}$ of the project area (t dry matter/ha)

$C_{f,s_{CL,B}}$ = Combustion factor, accounting for the proportion of biomass that is actually burnt on stratum $s_{CL,B}$ of the project area (dimensionless)

$EF_{N2O,CL}$ = N_2O emission factor for burning of biomass prior to the establishment of the biomass plantation (tN_2O/tonne of dry matter)

GWP_{N2O} = Global Warming Potential of nitrous oxide valid for the commitment period (tCO_2e/tN_2O)

$EF_{CH4,CL}$ = CH_4 emission factor for burning of biomass prior to the establishment of the biomass plantation (tCH_4/tonne of dry matter)

GWP_{CH4} = Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)

$s_{CL,B}$ = Strata of the project area where biomass is burnt as part of land clearance prior to the establishment of the biomass plantation

Note that the term $\left(M_{B,s_{CL,B}} \times C_{f,s_{CL,B}}\right)$ corresponds to the term $\left(B_{BEFORE,s} - B_{PJ,s}\right)$ if land clearance is only undertaken by burning the existing vegetation (and not by harvesting). If part of the existing vegetation is harvested or used for other purposes, the term $\left(M_{B,s_{CL,B}} \times C_{f,s_{CL,B}}\right)$ should be smaller than the term $\left(B_{BEFORE,s} - B_{PJ,s}\right)$.

Step 2.2: CH_4 and N_2O emissions from field burning of biomass ($PE_{FB,y}$)

Biomass from the plantation may be burnt regularly during the crediting period (e.g. after harvest). In these cases, CH_4 and N_2O emissions should be calculated for each time that field burning is occurring, as follows:

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$$PE_{FB,y} = \sum_{s_{FB}} A_{PJ,s_{FB}} \cdot M_{B,s_{FB}} \cdot C_{f,s_{FB}} \cdot \left(EF_{N2O,FB} \cdot GWP_{N2O} + EF_{CH4,FB} \cdot GWP_{CH4}\right) \quad \textbf{(6)}$$

where:

$PE_{FB,y}$	=	Project emissions from field burning of biomass at the plantation site in year *y* (tCO_2e/yr)
$A_{PJ,s_{FB}}$	=	Size of the land area of stratum s_{FB} (ha)
$M_{B,s_{FB}}$	=	Average mass of biomass available for burning on stratum s_{FB} (t dry matter/ha)
$C_{f,s_{FB}}$	=	Combustion factor, accounting for the proportion of biomass that is actually burnt on stratum s_{FB} (dimensionless)
$EF_{N2O,FB}$	=	N_2O emission factor for field burning of biomass (tN_2O/tonne of dry matter)
GWP_{N2O}	=	Global Warming Potential of nitrous oxide valid for the commitment period (tCO_2e/tN_2O)
$EF_{CH4,FB}$	=	CH_4 emission factor for field burning of biomass (tCH_4/tonne of dry matter)
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)
s_{FB}	=	Strata of the project area where biomass is burnt in year *y*[4]

Step 2.3: CO_2 emissions resulting from changes in soil carbon stocks following land use changes or changes in the land management practices ($PE_{CO2,soil,y}$)

If no land use change or change in land management practices is introduced with the cultivation of biomass under the project activity, then this emission source can be omitted.

In other cases, CO_2 emissions from decreases of carbon stocks in soil carbon pools as a result of land use changes or changes in management practices should be estimated, using the IPCC Tier 1/2 approaches in the 2006 Guidelines for National GHG Inventories. In cases where carbon stocks in soil carbon pools increase as a result of the project activity, these increases should not be accounted as emission reductions and $PE_{CO2,soil,y}$ should be assumed as zero.
The approach to estimate carbon stock changes in soil organic carbon pools is different for organic and mineral soils. Changes in inorganic soil carbon are neglected. Project emissions may include emissions from mineral and organic soils within the project area:

$$PE_{CO2,soil,y} = PE_{CO2,MS,y} + PE_{CO2,OS,y} \quad \textbf{(7)}$$

where:

$PE_{CO2,soil,y}$	=	Project emissions of CO_2 in year *y* resulting from changes in soil carbon stocks following a land use change or a change in the land management practices (tCO_2/yr)
$PE_{CO2,MS,y}$	=	Project emissions of CO_2 in year *y* resulting from changes in soil carbon stocks of mineral soils following a land use change or a change in the land management practices (tCO_2/yr)
$PE_{CO2,MS,y}$	=	Project emissions of CO_2 in year *y* resulting from changes in soil carbon stocks of organic soils following a land use change or a change in the land management practices (tCO_2/yr)

CO_2 emissions from mineral soils

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[4] If biomass on a stratum is burnt two or more times in the year, emissions from this stratum should be accounted each time burning is occuring.

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For mineral soils, the IPCC Tier 1 method is used to estimate soil carbon emissions. Consistent with the IPCC Tier 1 approach, it is assumed that soil carbon stocks were in an equilibrium before the implementation of the project activity (or would have reached an equilibrium in the absence of the project activity) and change in a linear fashion during a transition period to a new equilibrium as result of the change in the land use or land management practice.

Annual CO_2 emissions from soil carbon stock changes are calculated based on the difference between the soil organic carbon stock before and after implementation of the project activity and the duration of the transition period (i.e. the time dependence of the stock change factors *T*), as follows:

$$PE_{CO2,MS,y} = \sum_{s_{MS}} \frac{SOC_{historic,s_{MS}} - SOC_{PJ,s_{MS}}}{T} \times A_{PJ,s_{MS}} \times \frac{44}{12} \quad \textbf{(8)}$$

where:

$PE_{CO2,MS,y}$	=	Project emissions of CO_2 in year *y* resulting from changes in soil carbon stocks of mineral soils following a land use change or a change in the land management practices (tCO_2/yr)
$SOC_{historic,s_{MS}}$	=	Soil organic carbon stock with the land use and land management practices on stratum s_{MS} before the implementation of the project activity (tC/ha)
$SOC_{PJ,s_{MS}}$	=	Soil organic carbon stock with the land use and land management practices on stratum s_{MS} under the project activity (tC/ha)
$A_{PJ,s_{MS}}$	=	Size of the land area of stratum s_{MS} (ha)
T	=	Time dependence of the stock change factors (years)
s_{MS}	=	Strata of the project area with mineral soils

The soil organic carbon stock is calculated based on reference soil organic carbon stock value of stratum s_{MS} ($SOC_{REF,s_{MS}}$) for the relevant soil type and climate region and stock change factors (F_{LU}, F_{MG} and F_I) that reflect that land-use type, the land management practices and any carbon input in the soil, as follows:

$$SOC_{historic,s_{MS}} = SOC_{REF,s_{MS}} \times F_{LU,historic,s_{MS}} \times F_{MG,historic,s_{MS}} \times F_{I,historic,s_{MS}} \quad \textbf{(9)}$$

and

$$SOC_{PJ,s_{MS}} = SOC_{REF,s_{MS}} \times F_{LU,PJ,s_{MS}} \times F_{MG,PJ,s_{MS}} \times F_{I,PJ,s_{MS}} \quad \textbf{(10)}$$

Where:

$SOC_{historic,s_{MS}}$	=	Soil organic carbon stock with the land use and land management practices on stratum s_{MS} before the implementation of the project activity (tC/ha)
$SOC_{PJ,s_{MS}}$	=	Soil organic carbon stock with the land use and land management practices on stratum s_{MS} under the project activity (tC/ha)
$SOC_{REF,s_{MS}}$	=	Reference soil organic carbon stock value for stratum s_{MS} (tC/ha)

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$F_{LU,historic,s_{MS}}$	= Stock change factor for the historic land-use system on stratum s_{MS}
$F_{LU,PJ,s_{MS}}$	= Stock change factor for the land-use system on stratum s_{MS} under the project activity
$F_{MG,historic,s_{MS}}$	= Stock change factor for the historic land management regime on stratum s_{MS}
$F_{MG,PJ,s_{MS}}$	= Stock change factor for the land management regime on stratum s_{MS} under the project activity
$F_{I,historic,s_{MS}}$	= Stock change factor for input of organic matter on stratum s_{MS} for the historical situation
$F_{I,PJ,s_{MS}}$	= Stock change factor for input of organic matter on stratum s_{MS} under the project activity
s_{MS}	= Strata of the project activity with mineral soils

CO_2 emissions from organic soils

For organic soils, the land area is multiplied with an annual emission factor that estimates the losses of carbon following drainage. Annual project emissions are calculated as follows:

$$PE_{CO2,OS,y} = \sum_{s_{OS}} A_{PJ,s_{OS}} \times EF_{organic,s_{OS}} \times \frac{44}{12} \qquad \textbf{(11)}$$

Where:

$PE_{CO2,OS,y}$	= Project emissions of CO_2 in year *y* resulting from changes in soil carbon stocks of organic soils following a land use change or a change in the land management practices (tCO_2/yr)
$A_{PJ,s_{OS}}$	= Size of the land area of stratum s_{OS} (ha)
$EF_{organic,s_{OS}}$	= Emission factor for carbon soil losses for organic soils on stratum s_{OS} (tonnes C per ha and year)
s_{OS}	= Strata of the project area with organic soils

Step 2.4: CO_2 emissions from fossil fuel consumption for agricultural operations ($PE_{FC,PL,y}$)

CO_2 emissions associated with fossil fuel consumption for agricultural operations (e.g. operation of agricultural machinery) should be calculated as follows:

$$PE_{FC,PL,y} = \sum_{i} FC_{PL,i,y} \cdot NCV_i \cdot EF_{CO_2,FF,i} \qquad \textbf{(12)}$$

Where:

$PE_{FC,PL,y}$	= Project emissions related to fossil fuel consumption for agricultural operations in year *y* (tCO_2/yr)
$FC_{PL,i,y}$	= Amount of fuel type *i* that is combusted for agricultural operations in year *y* (mass or volume unit[5])

[5] Preferably use a mass unit for solid fuels and a volume unit for liquid and gaseous fuels.

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NCV_i	=	Net calorific value of fuel type *i* (GJ / mass or volume unit)
$EF_{CO2,FF,i}$	=	CO_2 emission factor of fuel type *i* (tCO_2/GJ)
i	=	Fuel types used for agricultural operations in year *y*

Step 2.5: Emissions from the production of synthetic fertilizer that is used at the plantation ($PE_{FP,y}$)

The GHG emissions from the production of synthetic fertilizer are estimated for each synthetic fertilizer type *q* by multiplying an emission factor with the monitored quantity of fertilizer applied at the plantation during the year *y*, as follows:

$$PE_{FP,y} = \sum_{q} EF_{CO2e,FP,q} \times M_{SF,q,y} \quad \textbf{(13)}$$

Where:

$PE_{FP,y}$	=	Project emissions related to the production of synthetic fertilizer that is used at the dedicated plantation in year *y* (tCO_2e/yr)
$EF_{CO2e,FP,f}$	=	Emission factor for GHG emissions associated with the production of fertilizer type *f* (tCO_2e/t fertilizer)
$M_{SF,q,y}$	=	Amount of synthetic fertilizer q applied at the plantation in year *y* (t synthetic fertilizer/yr)
q	=	Synthetic fertilizers types applied at the plantation in year *y*

Step 2.6: N_2O emissions from land management at the plantation ($PE_{N2O,soil,y}$)

N_2O emissions from land management at the plantation can occur from the following activities:

- Application of synthetic fertilizers;
- Application of organic fertilizers (e.g., animal manure, compost, sewage sludge, rendering waste);
- N in crop residues (above-ground and below-ground);
- N mineralization associated with loss of soil organic matter resulting from change of land use or a change of management practices of mineral soils (applicable in case of mineral soils);
- Drainage/management of organic soils (applicable in case of organic soils).

Some emission sources may not be relevant for certain project types. For example, at some plantations no fertilizer may be applied. Project participants should document and justify in the CDM-PDD which of these activities may occur in the context of the proposed project activity.

N_2O emissions are emitted through direct soil emissions and indirect emissions from atmospheric deposition and leaching and run-off. The approach in the 2006 IPCC Guidelines is used to determine these emissions. Emissions are calculated as follows:

$$PE_{N2O,soil,y} = GWP_{N2O} \cdot \frac{44}{28} \cdot \left(PE_{N2O-N,dir,y} + PE_{N2O-N,ind,y} \right) \quad \textbf{(14)}$$

where:

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$PE_{N2O,soil,y}$	=	Project emissions of N_2O from land management at the plantation in year *y* (tCO_2e/yr)
GWP_{N2O}	=	Global Warming Potential of nitrous oxide valid for the commitment period (tCO_2e/tN_2O)
$PE_{N2O\text{-}N,dir,y}$	=	Direct N_2O-N emissions from land management at the plantation in year *y* (tN_2O-N/yr)
$PE_{N2O\text{-}N,ind,y}$	=	Indirect N_2O-N emissions from land management at the plantation in year *y* (tN_2O-N/yr)

Direct soil N_2O emissions

Direct soil N_2O emissions are calculated as follows:

$$PE_{N2O-N,dir,y} = \left(F_{ON,y} + F_{SN,y} + \sum_{s_{CR}} F_{CR,s_{CR},y} \right) \times EF_{N2O-N,dir} + \sum_{s_{MS}} \left[F_{SOM,s_{MS},y} \times EF_{N2O-N,dir} \right] + \sum_{s_{OS}} \left[A_{PJ,s_{OS},y} \times EF_{N2O,N,OS} \right] \quad (15)$$

where:

$PE_{N2O\text{-}N,dir,y}$	=	Direct N_2O-N emissions from land management at the plantation in year *y* (tN_2O-N/yr)
$F_{ON,y}$	=	Amount of organic fertilizer nitrogen from animal manure, sewage, compost or other organic amendments applied at the plantation in year *y* (t N/yr)
$F_{SN,y}$	=	Amount of synthetic fertilizer nitrogen applied at the plantation in year *y* (t N/yr)
$EF_{N2O\text{-}N,dir}$	=	Emission factor for direct nitrous oxide emissions from N inputs (t N_2O-N/t N)
$F_{CR,s_{CR},y}$	=	Amount of N in crop residues (above ground and below ground), including N-fixing crops, returned to the soil on stratum s_{CR} in year *y* (t N/yr)
$F_{SOM,s_{MS},y}$	=	Amount of N in the mineral soil that is mineralized on stratum s_{MS} in year *y* in association with loss of soil carbon from soil organic matter as a result of a land use change or a change in the land management practice (t N/yr)
$A_{PJ,s_{OS},y}$	=	Size of the land area of stratum s_{OS} (ha)
$EF_{N2O,N,OS}$	=	Emission factor for direct nitrous oxide emissions from drained/managed organic soils (t N_2O-N per ha and year)
s_{CR}	=	Strata of the project area where crops residues, including N-fixing crops, are returned to the soil
s_{MS}	=	Strata of the project area with mineral soils
s_{OS}	=	Strata of the project area with organic soils

The amount of organic fertilizer N applied at the plantation ($F_{ON,y}$) is calculated based on the quantity of organic fertilizer applied and the N content in the organic fertilizer, as follows:

$$F_{ON,y} = \sum_{p} M_{OF,p,y} \times w_{N,p,y} \quad (16)$$

Where:

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$F_{ON,y}$ = Amount of organic fertilizer nitrogen from animal manure, sewage, compost or other organic amendments applied at the plantation in year *y* (t N/yr)
$M_{OF,p,y}$ = Amount of organic fertilizer *p* applied at the plantation in year *y* (tonnes)
$w_{N,p,y}$ = Weight fraction of nitrogen in organic fertilizer type *p* (t N / t organic fertilizer)
p = Organic fertilizer types (animal manure, sewage, compost or other organic amendments) applied at the plantation in year *y*

The amount of synthetic fertilizer N applied at the plantation ($F_{SN,y}$) is calculated based on the quantity of synthetic fertilizer applied and the N content in the synthetic fertilizer, as follows:

$$F_{SN,y} = \sum_{q} M_{SF,q,y} \times w_{N,q,y} \tag{17}$$

Where:
$F_{SN,y}$ = Amount of synthetic fertilizer nitrogen applied at the plantation in year *y* (t N/yr)
$M_{SF,q,y}$ = Amount of synthetic fertilizer *q* applied at the plantation in year *y* (t synthetic fertilizer/yr)
$w_{N,q,y}$ = Weight fraction of nitrogen in synthetic fertilizer type *q* (t N / t synthetic fertilizer)
q = Synthetic fertilizer types applied at the plantation in year *y*

The amount of N in crops residues returned to the soil ($F_{CR,s_{CR},y}$) is calculated for each stratum s_{CR} as follows:

$$F_{CR,s_{CR},y} = \sum_{c} M_{c,s_{CR},y} \times \left[1 - f_{burnt,s_{CR},c,y} \times \left(1 - C_{f,c}\right)\right] \times \left[R_{AG,c} \times w_{N,AG,c} \times \left(1 - Frac_{REMOVE,c,y}\right) + R_{BG,c} \times w_{N,BG,c}\right] \tag{18}$$

Where:
$F_{CR,s_{CR},y}$ = Amount of N in crop residues (above ground and below ground), including N-fixing crops, returned to the soil on stratum s_{CR} in year *y* (t N/yr)
$M_{c,s_{CR},y}$ = Quantity of crop type *c* that is harvested on stratum s_{CR} in year *y* (t dry matter)
$f_{burnt,s_{CR},c,y}$ = Fraction of the area of stratum s_{CR}, cultivated with crop type *c*, that is burnt in year *y*
$C_{f,c}$ = Combustion factor, accounting for the proportion of the crop residues from crop type *c* that are actually combusted when undertaking field burning
$R_{AG,c}$ = Ratio of above-ground residue of crop type *c* to harvested yield for crop type *c*
$w_{N,AG,c}$ = N content in the above-ground residues of crop type *c* (t N/t dry matter)
$Frac_{REMOVE,c,y}$ = Fraction of above-ground biomass residues of crop type c that are removed from the plantation in year *y*
$R_{BG,c}$ = Ratio of below-ground residue of crop type *c* to harvested yield for crop type *c*
$w_{N,BG,c}$ = N content in the below-ground residues of crop type *c* (t N/t dry matter)
c = Crop types harvested on stratum s_{CR} in year *y*
s_{CR} = Strata of the project area where crops residues, including N-fixing crops, are returned to the soil

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When soil C is lost through oxidation as a result of a land use change or a change in land management practices, this loss will be accompanied by a simultaneous mineralization of N. This N is regarded as an additional source of N available for conversion to N_2O. This quantity of N ($F_{SOM,sMS,y}$) is estimated for each stratum s_{MS} as follows:

$$F_{SOM,s_{MS},y} = \frac{SOC_{historic,s_{MS}} - SOC_{PJ,s_{MS}}}{T} \times \frac{1}{R} \times A_{PJ,s_{MS}} \quad \textbf{(19)}$$

Where:

$F_{SOM,s_{MS},y}$	=	Amount of N in the mineral soil that is mineralized on stratum s_{MS} in year y in association with loss of soil carbon from soil organic matter as a result of a land use change or a change in the land management practice (t N/yr)
$SOC_{historic,s_{MS}}$	=	Soil organic carbon stock with the land use and land management practices on stratum s_{MS} before the implementation of the project activity (tC/ha)
$SOC_{PJ,s_{MS}}$	=	Soil organic carbon stock with the land use and land management practices on stratum s_{MS} under the project activity (tC/ha)
T	=	Time dependence of the stock change factors (years)
R	=	C:N ratio of the soil organic matter
$A_{PJ,s_{MS}}$	=	Size of the land area of stratum s_{MS} (ha)

Indirect N_2O emissions

Indirect N_2O emissions comprise N_2O emissions due to atmospheric decomposition of N volatilized from the plantation and N_2O emissions from leaching/run-off:

$$PE_{N2O-N,ind,y} = PE_{N2O-N,ind,ATD,y} + PE_{N2O-N,ind,L,y} \quad \textbf{(20)}$$

Where:

$PE_{N2O\text{-}N,ind,y}$	=	Indirect N_2O-N emissions from land management at the plantation in year y (tN_2O-N/yr)
$PE_{N2O\text{-}N,ind,ATD,y}$	=	Indirect N_2O-N emissions due to atmospheric deposition of nitrogen volatilized from the soil of the plantation in year y (tN_2O-N/yr)
$PE_{N2O\text{-}N,ind,L,y}$	=	Indirect N_2O-N emissions due to leaching/run-off as a result of nitrogen application at the plantation in year y (tN_2O-N/yr)

Indirect N_2O emissions due to atmospheric deposition of nitrogen volatilized from the soil of the plantation are calculated as follows:

$$PE_{N2O-N,ind,ATD,y} = \left(F_{SN,y} \cdot Frac_{GASF} + F_{ON,y} \cdot Frac_{GASM}\right) \cdot EF_{N2O-N,ATD} \quad \textbf{(21)}$$

Where:

$PE_{N2O\text{-}N,ind,ATD,y}$	=	Indirect N_2O-N emissions due to atmospheric deposition of nitrogen volatilized from

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		the soil of the plantation in year *y* (tN_2O-N/yr)
$F_{SN,y}$	=	Amount of synthetic fertilizer nitrogen applied at the plantation in year *y* (t N/yr)
$Frac_{GASF}$	=	Fraction of synthetic fertilizer N that volatilizes as NH_3 and NO_X (t N volatilized / t N applied)
$F_{ON,y}$	=	Amount of organic fertilizer nitrogen from animal manure, sewage, compost or other organic amendments applied at the plantation in year *y* (t N/yr)
$Frac_{GASM}$	=	Fraction of organic N fertilizer that volatilizes as NH_3 and NO_X (t N volatilized / t N applied)
$EF_{N2O\text{-}N,ATD}$	=	Emission factor for atmospheric deposition of N on soils and water surfaces (t N_2O-N / t N volatilized)

Indirect N_2O emissions due to leaching and runoff only need to be estimated if leaching and runoff occurs. They are calculated as follows:

$$PE_{N2O-N,ind,L,y} = \left(F_{SN,y} + F_{ON,y} + \sum_{s_{CR}} F_{CR,s_{CR},y} + \sum_{s_{MS}} F_{SOM,s_{MS},y} \right) \cdot Frac_{LEACH} \cdot EF_{N2O-N,L} \quad \textbf{(22)}$$

Where:

$PE_{N2O\text{-}N,ind,L,y}$	=	Indirect N_2O-N emissions due to leaching/run-off as a result of nitrogen application at the plantation in year *y* (tN_2O-N/yr)
$F_{SN,y}$	=	Amount of synthetic fertilizer nitrogen applied at the plantation in year *y* (t N/yr)
$F_{ON,y}$	=	Amount of organic fertilizer nitrogen from animal manure, sewage, compost or other organic amendments applied at the plantation in year *y* (t N/yr)
$F_{CR,s_{CR},y}$	=	Amount of N in crop residues (above ground and below ground), including N-fixing crops, returned to the soil on stratum s_{CR} in year *y* (t N/yr)
$F_{SOM,s_{MS},y}$	=	Amount of N in the mineral soil that is mineralized on stratum s_{MS} in year *y* in association with loss of soil carbon from soil organic matter as a result of a land use change or a change in the land management practice (t N/yr)
$Frac_{LEACH}$	=	Fraction of all N added to/mineralized in the soil of the plantation that is lost through leaching and runoff (t N leached and runoff / t N applied)
$EF_{N2O\text{-}N,L}$	=	Emission factor for N_2O emissions from N leaching and runoff (t N_2O-N / t N leached and runoff)
s_{CR}	=	Strata of the project area where crops residues, including N-fixing crops, are returned to the soil
s_{MS}	=	Strata of the project area with mineral soils

Step 2.7: CO_2 emissions from urea application

If urea is applied as a nitrogen source at the plantation, then CO_2 emissions from urea application should be estimated. If urea is not used then this step can be omitted.

Adding urea to soils leads to a loss of CO_2 that was fixed in the industrial production process. Urea ($CO(NH_2)_2$) is converted into ammonium, hydroxyl ion and bicarbonate in the presence of water and urease

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enzymes in the soil. The bicarbonate evolves into CO_2 and water. CO_2 emissions from urea application are calculated as follows:

$$PE_{urea,y} = M_{urea,y} \times EF_{CO2,urea} \times \frac{44}{12} \quad \textbf{(23)}$$

where:

$PE_{urea,y}$	=	Project emissions from urea application at the plantation in year *y* (tCO_2/yr)
$M_{urea,y}$	=	Quantity of urea applied at the plantation in year y (tonnes urea / yr)
$EF_{CO2,urea}$	=	CO_2 emission factor for urea application (t CO_2 / t urea)

Step 2.8: CO_2 emissions from application of limestone and dolomite

If limestone or dolomite is applied to the plantation to reduce soil acidity and improve plant growth, then CO_2 emissions from application of limestone or dolomite should be estimated. If limestone and dolomite are not applied, then this step can be omitted.

Adding carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) leads to CO_2 emissions as the limes dissolve and release bicarbonate, which evolves into CO_2 and water. The Tier 1 approach from the 2006 IPCC Guidelines for National GHG Inventories is used to estimate these emissions. CO_2 emissions from liming at the plantation are estimated as follows:

$$PE_{lime,y} = \left(M_{limestone,y} \times EF_{limestone} + M_{dolomite,y} \times EF_{dolomite}\right) \times \frac{44}{12} \quad \textbf{(24)}$$

where:

$PE_{lime,y}$	=	Project emissions from application of limestone and dolomite at the plantation in year *y* (tCO_2/yr)
$M_{limestone,y}$	=	Quantity of calcic limestone ($CaCO_3$) applied at the plantation in year *y* (t $CaCO_3$**/yr)**
$M_{dolomite,y}$	=	Quantity of dolomite ($CaMg(CO_3)_2$) applied at the plantation in year *y* (t Ca $Mg(CO_3)_2$**/yr)**
$EF_{limestone}$	=	Carbon emission factor for calcic limestone ($CaCO_3$) application (t C / t $CaCO_3$)
$EF_{dolomite}$	=	Carbon emission factor for dolomite ($CaMg(CO_3)_2$) application (t C / t $CaMg(CO_3)_2$)

Step 2.9: Emissions associated with irrigation ($PE_{IR,y}$)

If irrigation is undertaken at the plantation, CO_2 emissions associated with fossil fuel consumption and/or electricity consumption should be estimated. If no irrigation is undertaken, this step can be omitted.

For irrigating the plantation, energy is required for collection, transportation and distribution of the water on the field. CO_2 emissions from this energy requirement should be estimated based on the quantity of electricity consumed and/or the quantity of fossil fuels consumed, as follows:

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$$PE_{IR,y} = EC_{IR,y} \times EF_{CO2,EL,IR,y} + \sum_{i} FC_{IR,i,y} \times NCV_i \times EF_{CO2,FF,i} \quad \textbf{(25)}$$

where:

$PE_{IR,y}$	=	Project emissions resulting from irrigation at the plantation in year *y* (tCO_2e/yr)
$EC_{IR,y}$	=	Quantity of electricity consumed in year *y* for irrigating the plantation (MWh)
$EF_{CO2,EL,IR,y}$	=	CO_2 emission factor for electricity consumed for irrigation at the plantation in year *y* (tCO_2/MWh)
$FC_{IR,i,y}$	=	Quantity of fossil fuel type *i* consumed in year *y* for irrigating the plantation (mass or volume unit / yr)[5]
NCV_i	=	Net calorific value of fossil fuel type *i* (GJ / mass or volume unit)
$EF_{CO2,FF,i}$	=	CO_2 emission factor for fossil fuel type *i* (tCO_2/GJ)
i	=	Fossil fuel types consumed for irrigating the plantation

If electricity is purchased from the grid, the CO_2 emission factor for electricity ($EF_{CO2,EL,IR,,y}$) may be determined by one of the following options:

- Use a default emission factor of 1.2 t CO_2/MWh;
- Use the combined margin emission factor, determined according to the latest approved version of ACM0002;
- Use the approach described in small-scale methodology AMS.1.D if the quantity of electricity used by the project activity is less than 15 GWh/yr.

If electricity for irrigation is generated in a captive power plant, the CO_2 emission factor for electricity ($EF_{CO2,EL,IR,,y}$) may be determined by one of the following options:

- Use a default emission factor of 1.2 t CO_2/MWh;
- Calculate the emission factor of the captive power plant at the project site, calculated based on the fuel consumption and electricity generation in year *y*, as follows:

$$EF_{CO2,EL,IR,y} = \frac{\sum_{k} FC_{EL,CP,k,y} \times NCV_k \times EF_{CO2,k}}{EC_{CP,y}} \quad \textbf{(26)}$$

where:

$EF_{CO2,EL,IR,y}$	=	CO_2 emission factor for electricity consumed for irrigation at the plantation in year *y* (tCO_2/MWh)
$FC_{EL,CP,k,y}$	=	Quantity of fuel type *k* combusted in the captive power plant that provides electricity for irrigation in year *y* (mass or volume unit)[5]
NCV_k	=	Net calorific value of fuel type *k* (GJ/mass or volume unit)
$EF_{CO2,k}$	=	Emission factor of fuel type *k* (t CO_2/GJ)
$EC_{CP,y}$	=	Quantity of electricity generated in the captive power plant in year *y* (MWh)
k	=	Fuel types fired in the captive power plant in year *y*

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Data and parameters not monitored

Parameter:	**Data required to classify the climate region, including mean annual temperature (MAT), mean annual precipitation (MAP), mean annual precipitation to potential evapotransporation ratio (MAP:PET), and frost occurrence.**
Data unit:	Temperature: °C Precipitation: mm Precipitation to potential evapotransportation: - Frost occurance: days
Description:	
Source of data:	National or international meteorological institutes
Value to be applied:	
Any comment:	
Parameter:	$\mathbf{B_{AG,BEFORE,s}}$
Data unit:	tonnes of dry matter / ha
Description:	Average above-ground biomass stocks per hectare on stratum *s* of the project area before the clearance of the land where *s* are all strata in which the project area is stratified
Source of data:	Choose between the following two approaches: • Use the upper end of the range of IPCC default values for the above-ground biomass of the relevant forest type and ecological zone, as contained in Tables 4.7 and 4.8 of Volume 4, Chapter 4 of the 2006 IPCC Guidelines. If the land area has a different cover than those categories provided in these tables, choose a similar forest type that represents a conservative estimate. If the table only provides one single value and not a range for the above-ground biomass, project participants should apply the range of similar categories. • Representative sampling of the above-ground biomass on the land area by project participants
Measurement procedures (if any):	In case of measurements, project participants should use appropriate procedures from the 2006 IPCC Guidelines to estimate $B_{AG,BEFORE,s}$
Any comment:	

Parameter:	$\mathbf{R_{BEFORE,s}}$
Data unit:	-
Description:	Ratio of below-ground biomass to above-ground biomass for the biomass stocks on stratum *s* of the project area before the clearance of the land where *s* are all strata in which the project area is stratified
Source of data:	Use the applicable IPCC default value from Table 4.4 of Volume 4, Chapter 4 of the 2006 IPCC Guidelines.
Measurement procedures (if any):	-
Any comment:	

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Parameter:	**CF**
Data unit:	t C / tonnes of dry matter
Description:	Carbon fraction in the dry matter of the biomass
Source of data:	Default value, 2006 IPCC Guidelines, Volume 4, Chapter 4, Table 4.3
Value to be applied:	0.47
Any comment:	

Parameter:	**GWP_{N2O}**
Data unit:	tCO_2e/tN_2O
Description:	Global Warming Potential of nitrous oxide valid for the commitment period
Source of data:	IPCC 1996
Value to be applied:	310 for the first commitment period
Any comment:	

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Parameter:	$\mathbf{GWP_{CH4}}$
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential of methane valid for the commitment period
Source of data:	IPCC 1996
Value to be applied:	21 for the first commitment period
Any comment:	

Parameter:	$\mathbf{EF_{N2O,FB}}$
Data unit:	t N_2O / tonnes of dry matter of biomass
Description:	N_2O emission factor for field burning of biomass
Source of data:	Use the IPCC default for biofuel burning from the 2006 IPCC Guidelines, Vol. 4, Ch. 2, Table 2.5
Value to be applied:	0.00006
Any comment:	

Parameter:	$\mathbf{EF_{CH4,FB}}$
Data unit:	t CH_4 / tonnes of dry matter of biomass
Description:	CH_4 emission factor for field burning of biomass
Source of data:	Use the IPCC default value for biofuel burning from the 2006 IPCC Guidelines, Vol. 4, Ch. 2, Table 2.5
Value to be applied:	0.0061
Any comment:	

Parameter:	$SOC_{REF,s_{MS}}$
Data unit:	tC/ha
Description:	Reference soil organic carbon stock value for stratum s_{MS} where s_{MS} are the strata of the project area with mineral soils
Source of data:	Select the applicable value for the soil type identified from the 2006 IPCC Guidelines, Vol. 4, Ch. 2, Table 2.3
Value to be applied:	
Any comment:	

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Parameter:	$\mathbf{F_{LU,historic,sMS}}$, $\mathbf{F_{MG,historic,sMS}}$, $\mathbf{F_{I,historic,sMS}}$
Data unit:	dimensionless
Description:	Stock change factor on stratum s_{MS} for the historic land-use system ($\mathbf{F_{LU,historic,sMS}}$), for the historic management regime ($\mathbf{F_{MG,historic,sMS}}$) and for input of organic matter for the historical situation ($\mathbf{F_{I,historic,sMS}}$)
Source of data:	If available, reliable, well documented and reasonably representative for the project area, regional or national stock change factors should be used. If such data is not available, the following default values from the 2006 IPCC Guidelines should be used: Forest land: Use 1.0 for all factors Cropland: Vol. 4, Ch. 5, Table 5.5 Grassland: Vol.4, Ch. 6, Table 6.2
Value to be applied:	
Any comment:	

Parameter:	$\mathbf{F_{LU,PJ,sMS}}$, $\mathbf{F_{MG,PJ,sMS}}$, $\mathbf{F_{I,PJ,sMS}}$
Data unit:	dimensionless
Description:	Stock change factor on stratum s_{MS} for the land-use system ($\mathbf{F_{LU,historic}}$), the historic management regime ($\mathbf{F_{MG,historic}}$) and input of organic matter for the historical situation ($\mathbf{F_{I,historic}}$) under the project activity
Source of data:	If available, reliable, well documented and reasonably representative for the project area, regional or national stock change factors should be used. If such data is not available, the following default values from the 2006 IPCC Guidelines should be used: Forest land: Use 1.0 for all factors Cropland: Vol. 4, Ch. 5, Table 5.5 Grassland: Vol.4, Ch. 6, Table 6.2
Value to be applied:	
Any comment:	

Parameter:	**T**
Data unit:	years
Description:	Time dependence of the stock change factors
Source of data:	-
Value to be applied:	In case of a renewable crediting period: 20 years (commonly used value) In case of a single crediting period: 10 years
Any comment:	

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Data / Parameter:	**$EF_{CO2e,FP,f}$**
Data unit:	t CO_2e/t fertilizer
Description:	Emissions factor for GHG emissions associated with the production of fertilizer type *f*
Source of data:	Use default values as provided in the Tables below.
Value to be applied:	(see tables below)
Any comment:	Source: Calculated based on Wood and Cowie (2004) and Swaminathan (2004)

N Fertilizer Type	**Emission factor ($t\ CO_2$ / t N)**
Urea	1.7
Ammonium nitrate	7.1
Ammonium sulfate	2.0
Calcium nitrate	11.7
Ammonium Phosphate	2.7
Liquid urea/ammonium nitrate	4.9

P Fertilizer Type	**Emission factor (t CO2 / t P_2O_5)**
Phosphate rock	2.0
Ammonium phosphate	0.3
Tripple super phosphate	0.5
Single super phosphate	0.2

K Fertilizer Type	**Emission factor ($t\ CO_2$ / t K_2O)**
Potassium chloride	0.4
Potassium sulphate	0.3

Parameter:	**$EF_{organic,sOS}$**
Data unit:	tonnes C per hectar and year
Description:	Emission factor for carbon soil losses for organic soils on stratum s_{OS}
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 5, Table 5.6
Value to be applied:	Select the suitable default value as follows: The plantation is cropland: Vol. 4, Ch. 5, Table 5.6 The plantation is forest land: Vol. 4, Ch. 4, Table 4.6
Any comment:	

Parameter:	**$EF_{N2O-N,dir}$**
Data unit:	t N_2O-N / t N input
Description:	Emissions factor for direct N_2O emissions from N inputs
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.1
Value to be	0.01

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applied:	
Any comment:	

Parameter:	$\mathbf{EF_{N2O\text{-}N,ATD}}$
Data unit:	t N_2O-N / t N volatilized
Description:	Emissions factor for atmospheric deposition of N on soils and water surfaces
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.3
Value to be applied:	0.01
Any comment:	

Parameter:	$\mathbf{EF_{N2O\text{-}N,L}}$
Data unit:	t N_2O-N / t N leached and runoff
Description:	Emissions factor for N_2O emissions from N leaching and runoff
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.3
Value to be applied:	0.0075
Any comment:	

Parameter:	$\mathbf{EF_{N2O,N,OS}}$
Data unit:	t N_2O-N per ha and year
Description:	Emission factor for direct nitrous oxide emissions from drained/managed organic soils
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.1, as provided below
Value to be applied:	(see table below)
Any comment:	

Applicable climate and soil type	**Emission factor (t N_2O-N / (ha year))**
Temperate organic crop and grassland soils	8
Tropical organic crop and grassland soil	16
Temperate and boreal organic nutrient rich forest soils	0.6
Temperate and boreal organic nutrient poor forest soils	0.1
Tropical organic forest soils	8

Parameter:	$\mathbf{Frac_{GASM}}$
Data unit:	t N volatilized / t N applied
Description:	Fraction of organic N fertilizer that volatilizes as NH_3 and NO_X
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.3
Value to be applied:	0.2
Any comment:	

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Parameter:	**$Frac_{GASF}$**
Data unit:	t N volatilized / t N applied
Description:	Fraction of synthetic fertilizer N that volatilizes as NH_3 and NO_X
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.3
Value to be applied:	0.1
Any comment:	
Parameter:	**$Frac_{LEACH}$**
Data unit:	t N leached and runoff / t N applied
Description:	Fraction of all N added to/mineralized in the soil of the plantation that is lost through leaching and runoff
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11. Table 11.3
Value to be applied:	0.3
Any comment:	

Parameter:	**$EF_{CO2,urea}$**
Data unit:	t CO_2/t of urea
Description:	CO_2 emission factor for urea application
Source of data:	2006 IPCC Guidelines for National GHG Inventories, Vol. 5, Ch. 11, Page 11.32
Value to be applied:	0.2
Any comment:	

Parameter:	**$EF_{limestone}$**
Data unit:	t C / t $CaCO_3$
Description:	Carbon emission factor for calcic limestone ($CaCO_3$) application
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11 Section 11.3.1
Value to be applied:	0.12
Any comment:	

Parameter:	**$EF_{dolomite}$**
Data unit:	t C / t $CaMg(CO_3)_2$)
Description:	Carbon emission factor for dolomite ($CaMg(CO_3)_2$) application
Source of data:	2006 IPCC Guidelines, Vol. 4, Ch. 11 Section 11.3.1
Value to be applied:	0.13
Any comment:	

Data / parameter:	**R**
Data unit:	-
Description:	C:N ratio of the soil organic matter

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Source of data:	If reliable and well documented country-specific or regional data are available, such data should be used. If such data is not available, project participants should assume, consistent with the 2006 IPCC Guidelines, a default value of 15 for situations involving land-use change from forest land or grassland to cropland and a default value of 10 for situations involving management changes on cropland.
Measurement procedures (if any):	-
Any comment:	

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Data / parameter:	**$EF_{CH4,CL}$**
Data unit:	t CH_4 / tonne of dry matter
Description:	CH_4 emission factor for burning of biomass prior to the establishment of the biomass plantation
Source of data:	2006 IPCC Guidelines, Volume 4, Chapter 2, Table 2.5, as provided below
Value to be applied:	see table below
Any comment:	

Category	**Emission factor (t CH_4 / t dry matter)**
Savanna and grassland	0.0023
Agricultural residues	0.0027
Tropical forest	0.0068
Other forest than tropical forest	0.0047

Data / parameter:	**$EF_{N2O,CL}$**
Data unit:	t N_2O / tonne of dry matter
Description:	N_2O emission factor for burning of biomass prior to the establishment of the biomass plantation
Source of data:	2006 IPCC Guidelines, Volume 4, Chapter 2, Table 2.5, as provided below
Value to be applied:	see table below
Any comment:	

Category	**Emission factor (t N_2O/ t dry matter)**
Savanna and grassland	0.00021
Agricultural residues	0.00007
Tropical forest	0.00020
Other forest than tropical forest	0.00026

Data / parameter:	**$M_{B,s_{CL,B}}$**
Data unit:	t dry matter / ha
Description:	Average mass of biomass available for burning on stratum $s_{CL,B}$ of the project area where $s_{CL,B}$ are the strata of the project area where biomass is burnt as part of land clearance prior to the establishment of the biomass plantation
Source of data:	Project participants may either conduct representative sample measurements, according to relevant guidance in the 2006 IPCC Guidelines, or use the most appropriate default value for the term $M_{B,s_{CL,B}} \times C_{f,s_{CL,B}}$, as provided in the 2006

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	IPCC Guidelines, Volume 4, Chapter 2, Table 2.4, adjusted for one standard error as a conservative approach.[6]
Measurement procedures (if any):	
Any comment:	
Data / parameter:	$C_{f,s_{CL,B}}$
Data unit:	-
Description:	Combustion factor, accounting for the proportion of biomass that is actually burnt on stratum $s_{CL,B}$ of the project area where $s_{CL,B}$ are the strata of the project area where biomass is burnt as part of land clearance prior to the establishment of the biomass plantation
Source of data:	Project participants may either conduct representative sample measurements, according to relevant guidance in the 2006 IPCC Guidelines, or use the most appropriate default value for the term $M_{B,s_{CL,B}} \times C_{f,s_{CL,B}}$, as provided in the 2006 IPCC Guidelines, Volume 4, Chapter 2, Table 2.4, adjusted for one standard error as a conservative approach.[6]
Measurement procedures (if any):	
Any comment:	

III. MONITORING METHODOLOGY PROCEDURE

Monitoring procedures

Describe and specify in the draft CDM-PDD all monitoring procedures, including the type of measurement instrumentation used, the responsibilities for monitoring and QA/QC procedures that will be applied. Where the methodology provides different options (e.g. use of default values or on-site measurements), specify which option will be used. All meters and instruments should be calibrated regularly as per industry practices.

Each monitoring report should contain the following information on land use and land management practices within the project area in the year *y*:

- For each stratum *s* information whether and how land-use or land management practices have been changed;
- On which strata of the project area biomass has been burnt in year *y* and the size and location (GPS data) of these strata (s_{FB} and $A_{PJ,s_{FB}}$);

[6] For example, in case of post logging slash burn in a boreal forest a default value of 114.4 = 69.6 + 44.8 tons of dry matter per hectare should be chosen for the term $M_{B,s_{CL,B}} \times C_{f,s_{CL,B}}$.

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- On which strata of the project area crop residues, including N-fixing crops, have been returned to the soil in year *y* and the size and location (GPS data) of these strata (s_{CR} and $A_{PJ,s_{CR}}$) as well as which crop types *c* have been harvested on each stratum s_{CR}.

If the land-use or land management practices change during the crediting period, the stratification of land areas should be updated accordingly. Any such changes to the stratification of the project area compared to the CDM-PDD or the previous monitoring report should be documented in the monitoring report, following the guidance provided in Step 1 of the baseline methodology procedure above.

If the ACM0002 is used to calculate the CO_2 emission factor for electricity consumed for irrigation ($EF_{CO2,EL,IR,y}$), the monitoring provisions of the latest approved version of ACM0002 apply. If the approach described in small-scale methodology AMS.1.D is used, the monitoring provisions in that methodology apply.

Data and parameters monitored

Data / Parameter:	$\mathbf{B_{PJ,s}}$
Data unit:	tonnes of dry matter / ha
Description:	Average biomass stocks (above-ground and below-ground) per hectare on stratum *s* of the project area immediately after the start of the project activity (i.e. after the clearance of the land and after seeding/planting) where *s* are all strata in which the project area is stratified
Source of data:	Project participants may either assume a value of 0 or undertake sampling.
Measurement procedures (if any):	
Monitoring frequency:	Once after the start of the project activity
QA/QC procedures:	
Any comment:	

Data / Parameter:	$\mathbf{M_{SF,q,y}}$
Data unit:	tonnes of synthetic fertilizer / year
Description:	Amount of synthetic fertilizer *q* applied at the plantation in year *y* where *q* are the synthetic fertilizer types applied at the plantation in year *y*
Source of data:	On-site records by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	Cross-check records of applied quantities with purchase receipts
Any comment:	

Data / Parameter:	$\mathbf{M_{OF,p,y}}$
Data unit:	tonnes of organic fertilizer / year
Description:	Amount of organic fertilizer *p* applied at the plantation in year *y* where *p* are the

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	organic fertilizer types (animal manure, sewage, compost or other organic amendments) applied at the plantation in year *y*
Source of data:	On-site records and measurements
Measurement procedures (if any):	Measure the quantities of any animal manure, sewage, compost or other organic amendments applied as fertilizers to the plantation.
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

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Data / Parameter:	$w_{N,p,y}$
Data unit:	t N / t organic fertilizer
Description:	Weight fraction of nitrogen in organic fertilizer type *p* where *p* are the organic fertilizer types (animal manure, sewage, compost or other organic amendments) applied at the plantation in year *y*
Source of data:	Sample measurements by project participants
Measurement procedures (if any):	Where applicable, measure the quantities and nitrogen content of any animal manure, sewage, compost or other organic amendments applied as fertilizers to the dedicated plantation.
Monitoring frequency:	Regularly
QA/QC procedures:	
Any comment:	

Data / Parameter:	$w_{N,q,y}$
Data unit:	t N / t synthetic fertilizer
Description:	Weight fraction of nitrogen in synthetic fertilizer type *q* where *q* are the synthetic fertilizer types applied at the plantation in year *y*
Source of data:	Specifications by the fertilizer manufacturer
Measurement procedures (if any):	-
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / Parameter:	$M_{urea,y}$
Data unit:	tonnes of urea per year
Description:	Quantity of urea applied at the plantation in year *y*
Source of data:	Records by project participants
Measurement procedures (if any):	-
Monitoring frequency:	Continuously
QA/QC procedures:	Cross-check records of applied quantities with purchase receipts
Any comment:	

Data / Parameter:	$M_{B,s_{FB}}$
Data unit:	ton dry matter per hectare
Description:	Average mass of biomass available for burning on stratum s_{FB} where s_{FB} are the strata of the project area where biomass is burnt in year *y*
Source of data:	Sample measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Each time field burning takes place
QA/QC procedures:	
Any comment:	

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Data / Parameter:	$\mathbf{C_{f,s_{FB}}}$
Data unit:	-
Description:	Combustion factor, accounting for the proportion of biomass that is actually burnt on stratum s_{FB} where s_{FB} are the strata of the project area where biomass is burnt in year *y*
Source of data:	Sample measurements by project participants or assume a default value of 1
Measurement procedures (if any):	Measure the remaining biomass after field burning (if any)
Monitoring frequency:	Each time field burning takes place
QA/QC procedures:	
Any comment:	

Data / parameter:	$\mathbf{M_{Limestone,y}}$
Data unit:	t $CaCO_3$/**year**
Description:	Quantity of calcic limestone ($CaCO_3$) applied at the plantation in year *y*
Source of data:	Records by project participants
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	Cross-check records of applied quantities with purchase receipts
Any comment:	

Data / Parameter:	$\mathbf{M_{Dolomite,y}}$
Data unit:	t $CaMg(CO_3)_2$/**year**
Description:	Quantity of dolomite ($CaMg(CO_3)_2$) applied at the plantation in year *y*
Source of data:	Records by project participants
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	Cross-check records of applied quantities with purchase receipts
Any comment:	

Data / parameter:	$\mathbf{FC_{PL,i,y}}$
Data unit:	Mass or volume unit[5]
Description:	Amount of fuel type *i* that is combusted for agricultural operations in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	Cross-check measurements with fuel purchase records
Any comment:	

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Data / parameter:	**$EC_{CP,y}$**
Data unit:	MWh
Description:	Quantity of electricity generated in the captive power plant in year *y*
Source of data:	Records by project proponents
Measurement procedures (if any):	Electricity meters
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	Only applicable if electricity used for irrigation is generated in a captive power plant

Data / parameter:	**$EC_{IR,y}$**
Data unit:	MWh
Description:	Quantity of electricity consumed in year *y* for irrigating the plantation
Source of data:	Measurements by project proponents
Measurement procedures (if any):	Electricity meter
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	**$EF_{CO2,FF,i}$ and $EF_{CO2,k}$**
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor for fossil fuel type *i* or *k*
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default emission factors (country-specific, if available) if they are deemed to reasonably represent local circumstances. Choose the value in a conservative manner and justify the choice.
Measurement procedures (if any):	Measurements shall be carried out at reputed laboratories and according to relevant international standards.
Monitoring frequency:	<u>In case of measurements:</u> At least every six months, taking at least three samples for each measurement. <u>In case of other data sources:</u> Review the appropriateness of the data annually.
QA/QC procedures:	Check consistency of measurements and local / national data with default values by the IPCC. If the values differ significantly from IPCC default values, collect additional information or conduct additional measurements.
Any comment:	

Data / parameter:	**q**
Data unit:	-
Description:	Types of synthetic fertilizers applied at the dedicated plantation
Source of data:	Records by project proponents
Measurement	

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procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	
Data / parameter:	$\mathbf{f_{burnt,s_{CR},c,y}}$
Data unit:	-
Description:	Fraction of the area of stratum s_{CR}, cultivated with crop type *c*, that is burnt in year *y* where • *c* are the crop types harvested on stratum s_{CR} in year *y*, and • s_{CR} are the strata of the project area where crops residues, including N-fixing crops, are returned to the soil
Source of data:	Records by project proponents
Measurement procedures (if any):	
Monitoring frequency:	Each time field burning is taking place
QA/QC procedures:	
Any comment:	

Data / parameter:	$\mathbf{FC_{EL,CP,k,y}}$
Data unit:	Mass or volume unit[5]
Description:	Quantity of fuel type *k* combusted in the captive power plant that provides electricity for irrigation in year *y* where *k* are the fuel types fired in the captive power plant in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	Weight or volume meters
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	$\mathbf{FC_{IR,i,y}}$
Data unit:	mass or volume unit / yr[5]
Description:	Quantity of fossil fuel type *i* consumed in year *y* for irrigating the plantation
Source of data:	Measurements by project proponents
Measurement procedures (if any):	Weight or volume meters
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

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Data / parameter:	**$Frac_{REMOVE,c,y}$**
Data unit:	-
Description:	Fraction of above-ground biomass residues of crop type c that are removed from the plantation in year *y* where • *c* are the crop types harvested on stratum s_{CR} in year *y*, and • s_{CR} are the strata of the project area where crops residues, including N-fixing crops, are returned to the soil where *c* are the crop types harvested on stratum s_{CR} in year *y*
Source of data:	Records by project proponents
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	**$M_{c,s_{CR},y}$**
Data unit:	t dry matter
Description:	Quantity of crop type *c* that is harvested on stratum s_{CR} in year *y* where • *c* are the crop types harvested on stratum s_{CR} in year *y*, and • s_{CR} are the strata of the project area where crops residues, including N-fixing crops, are returned to the soil where *c* are the crop types harvested on stratum s_{CR} in year *y*
Source of data:	Records by project proponents
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	**NCV_i and NCV_k**
Data unit:	GJ / mass or volume unit
Description:	Net calorific value of fossil fuel types *i* and *k*
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default net calorific values (country-specific, if available) if they are deemed to reasonably represent local circumstances. Choose the values in a conservative manner and justify the choice.
Measurement procedures (if any):	Measurements shall be carried out at reputed laboratories and according to relevant international standards. Measure the NCV of biomass based on the dry matter.
Monitoring frequency:	In case of measurements: At least every six months, taking at least three samples for each measurement. In case of other data sources: Review the appropriateness of the data annually.
QA/QC procedures:	

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Any comment:	
Data / parameter:	$\mathbf{R}_{AG,c}$
Data unit:	-
Description:	Ratio of above-ground residue of crop type *c* to harvested yield for crop type *c*
Source of data:	Records by project proponents
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

References and any other information

Swaminathan, B.: Technology Transfer and Mitigation of Climate Change: the Fertilizer Industry Perspective. IPCC Expert Meeting On Industrial Technology Development, Transfer And Diffusion. 21-23 September 2004, Tokyo, Japan

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