The EX-Ante Carbon-balance Tool

EASYPol Resources for policy making

ANALYTICAL TOOLS

EASYPol MODULE 101

EX-Ante Carbon-balance Tool (EX-ACT)

Technical Guidelines for Version 4

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For the

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, FAO

About EX-ACT: The *Ex Ante* Appraisal Carbon-balance Tool aims at providing *ex-ante* estimations of the impact of agriculture and forestry development projects on GHG emissions and carbon sequestration, indicating its effects on the carbon balance.

See EX-ACT ***website: www.fao.org/tc/exact***

Related resources

- EX-ANTE Carbon-Balance Tool (EX-ACT): (i) ***Technical Guidelines***; (ii) ***Tool;*** (iii) ***Brochure***
- See all EX-ACT resources in EASYPol under the Resource package, ***Investment Planning for Rural Development, EX-Ante Carbon-Balance Appraisal of Investment Projects***

About EASYPol

EASYPol is a multilingual repository of freely downloadable resources for policy making in agriculture, rural development and food security. The EASYPol home page is available at: ***www.fao.org/easypol***. These resources focus on policy findings, methodological tools and capacity development. The site is maintained by FAO's ***Policy Assistance Support Service.***

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ABBREVIATIONS AND ACRONYMS

C	Carbon
CH_4	Methane
CO_2	Carbon Dioxide
EX-ACT	EX-Ante Carbon-balance Tool
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gas
HAC	High Activity Clay
HWP	Harvested Wood Product
IPCC	Intergovernmental Panel on Climate Change
LAC	Low Activity Clay
MAP	Mean Annual Precipitation
MAT	Mean Annual Temperature
N_2O	Nitrous Oxide
NGGI	National Greenhouse Gas Inventories
USDA	US Department of Agriculture
WRB	World Reference Base

1. Executive Summary

EX-Ante Carbon-balance Tool (EX-ACT) is a tool developed by the Food and Agriculture Organization of the United Nations (FAO). It is aimed at providing ex-ante estimates of the mitigation impact of agriculture and forestry development projects, estimating net Carbon (C) balance from greenhouse gas (GHG) emissions and C sequestration. EX-ACT is a land-based accounting system, measuring C stocks, stock changes per unit of land, and CH_4 and N_2O emissions expressed in t CO_2e per hectare and year. The main output of the tool is an estimation of the C-balance that is associated with adoption of alternative land management options, as compared to a 'business as usual' scenario. EX-ACT has been developed using primarily the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, complemented by other existing methodologies and reviews of default coefficients where available. Default values for mitigation options in the agriculture sector are mostly from the 4th Assessment Report of IPCC (2007). Thus, EX-ACT allows for the C–balance appraisal of new investment programmes by ensuring an appropriate method available for donors and planning officers, project designers and decision makers within agriculture and forestry sectors in developing countries. The tool can also help users identify the mitigation impacts of various investment project options, and thus provide an additional criterion for consideration in project selection.

These technical guidelines for EX-ACT aim at providing users with the details on procedures and numbers used to perform calculation of C balance.

2. Introduction and Background

2.1. Introduction

Objectives and target audience: The objectives of this note are to describe the structure of the Ex-Ante Carbon-balance Tool (EX-ACT); to provide a detailed scientific background, to provide users with an explanation on how to use the tool, and how to fully understand the logic of the model and the results of its calculations.

Required background: No specific technical background is required to use the information provided below.

EX-ACT is a tool developed by FAO aimed at providing ex-ante estimates of the impact of agriculture and forestry development projects on GHG emissions and C sequestration, indicating its effects on the Carbon-balance (C balance = reduced GHG emissions + C sequestered above and below ground).

This ex-ante C-balance appraisal is a land-based accounting system, measuring C stocks and stock changes per unit of land, expressed in t eq-CO_2/ha and year. EX-ACT will help project designers to select the project activities that have higher benefits both in economic and CC mitigation terms (added value of the project) and its output could be used to guide the project design process and decision making on funding aspects, complementing the usual ex-ante economic analysis of investment projects.

Readers can follow links included in the text to other EASYPol modules or references[1]. See also the list of EASYPol links included at the end of this module.

2.2. Background

EX-ACT has mostly been developed using the Guidelines for National Greenhouse Gas Inventories[2] in conjunction with other methodologies and reviews of default coefficients for mitigation option as a base, so as to be acceptable to the scientific community. Default values for mitigation options in the agriculture sector are mostly from Smith et al. (2007). Other coefficients such as embodied GHG emissions for farm operations, inputs, transportation and irrigation systems implementation are from Lal (2004).

EX-ACT is an easy tool to be used in the context of ex-ante project/programme formulation: it is cost-effective and includes resources (tables, maps) which can help users find the information required to run the model. It therefore requires a minimum amount of data that project developers can easily provide and is usually collected in the phase of project appraisal. It works at project level but it can easily be up-scaled to programme/sector level as well as at watershed/district/national/regional level.

2.2.1. Generic methodologies for carbon pools changes (CO_2 balance)

Estimates are made using:

i) methods that can be applied in a very similar way for any of the types of land use change (i.e. generic methods) and

ii) methods that only apply to a single land use.

Chapter 2 of Volume 4 of NGGI-IPCC-2006 provides detailed generic information for generic methodologies. Generic methodologies are used **principally to account during conversion between two categories**, and concerns 5 pools: above-ground biomass, below-ground biomass, soil, deadwood and litter. Most calculations, unless specified, use a Tier 1 approach with a stock-difference method for emission of CO_2 (calculated as the change of carbon stocks for the different pools): default values are proposed for each pool of each category (or subcategory or even main vegetation type).

- **Above ground biomass**: Default values correspond to estimates provided by NGGI-IPCC-2006 and expressed in ton of dry matter (dm) per ha. The corresponding C stock (in ton C) is calculated using the specific carbon content indicated, e.g. it is 0.47 for above-ground forest biomass (see page 4.48 of NGGI-IPCC-2006). These factors are detailed in each Module when necessary.

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[1] EASYPol hyperlinks are shown in blue, as follows:

a) training paths are shown in **underlined bold font**
b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
c) links to the glossary are in **bold**; and
d) external links are in *italics*.

[2] IPCC 2006, thereafter named NGGI-IPCC-2006.

- **Below ground biomass**: In most cases the below-ground biomass is estimated using a ratio R of below-ground biomass to above-ground biomass expressed in ton d.m. below-ground biomass. EX-ACT uses the default values provided by NGGI-IPCC-2006. For example, R is 0.37 for all tropical rainforests and 0.27 for tropical mountain systems. These factors are detailed in each module when necessary[3].

- **Litter and dead-wood**: It is assumed that litter and dead wood pools are zero in all non-forest categories (excluding tree crops and perennial systems) and therefore transitions between non-forest categories involve no carbon stock changes in these two pools. Other transition values are detailed in each module when necessary.

- **Soil carbon**: For the soil C estimates, the default values are based on default references for soil organic C stocks for mineral soils to a depth of 30 cm.[4] When Soil Organic C changes over time (land use change or management change), it is assumed that there is a default time period for transition between an equilibrium of 20 years. These values are used either in IPCC 1996 or 2006 Guidelines and are gathered from a large compilation of observations and long-term monitoring. For mineral soils, the default method is based on changes in soil C stocks over a finite period of time. NGGI-IPCC-2006 assumes that:

    i. The change is computed based on C stock after the management change relative to the carbon stock in a reference condition (i.e. native vegetation that is not degraded or improved).
    ii. Over time, soil organic C reaches a spatially-averaged, stable value specific to the soil, climate, land-use and management practices.
    iii. Soil organic C stock changes during the transition to a new equilibrium SOC occurs in a linear fashion.

Assumption (ii) is widely accepted. However, soil carbon changes in response to management changes may often be best described by non linear function. Assumption (iii) greatly simplifies the methodology and provides a good approximation over a multi-year period.

Default Values are provided using the IPCC simplified soil classification (see Table 1 below).

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[3] In some cases the total above plus below ground biomass is used. For instance, in the conversion from forest to grassland the total biomass after conversion is provided from table 6.4 entitled “Default biomass stocks present on grassland, after conversion from other land use”.
Quantities expressed in ton d.m. are converted into tons of carbon using the default carbon content of the dry biomass indicated by NGGI-IPCC-2006. The default value expressed t C per t of biomass d.m. is 0.47 for grassland vegetation (See page 6.9 of NGGI-IPCC-2006), for above-ground forest biomass (see page 4.48 of NGGI-IPCC-2006).

[4] Table 2.3 of NGGI-IPCC-2006

Table 1: Default C stocks for mineral soils to a depth of 30 cm (t $C.ha^{-1}$)

Climate Region	HAC Soils	LAC Soils	Sandy Soils	Spodic Soils	Volcanic Soils	Wetland Soils
Boreal Dry	68		10	117	20	146
Boreal Moist	68		10	117	20	146
Cool Temperate Dry	50	33	34		20	87
Cool Temperate Moist	95	85	71	115	130	87
Warm Temperate Dry	38	24	19		70	88
Warm Temperate Moist	88	63	34		80	88
Tropical Montane Moist	65	47	39		70	86
Tropical Montane Dry	38	35	31		50	86
Tropical Dry	38	35	31		50	86
Tropical Moist	65	47	39		70	86
Tropical Wet	44	60	66		130	86

2.2.2. Generic methodologies for non-CO2 GHG

For N_2O and CH_4 emissions, the generic approach considers multiplying an emission factor for a specific gas or source category with activity date related to the emission source (it can be area, animal numbers or mass unit). Emissions of N_2O and CH_4 are either associated with a specific land use category or subcategory (e.g. CH_4 emission from rice), or are estimated at project aggregated data (e.g. emissions from livestock and N_2O emission from fertilizers).

Emissions from biomass burning for all kinds of biomass are calculated based on the generic methods proposed in section 2.4 (see page 2.40-2.43 of NGGI-IPCC-2006) and principally the Equation 2.27. of NGGI-IPCC-2006. Briefly, the emission of individual GHG (N_2O or CH_4) for one hectare is obtained as follow:

$$GHG_{fire} = M_{Biomass} \times C_F \times G_{ef}$$

Where:

GHG_{fire} = amount of GHG from fire, kg of each GHG e.g., CH_4 or N_2O.
$M_{Biomass}$ = mass of fuel available for combustion, tons.
C_F = combustion factor, dimensionless
G_{ef} = emission factor, g kg^{-1} dry matter burnt

$M_{Biomass}$ theoretically includes biomass, ground litter and dead wood, but litter and dead wood pools are assumed to be zero, except where there is a land-use change (e.g. deforestation module). For the combustion and emissions factors, EX-ACT uses the default values provided for Tier 1 approach (see NGGI-IPCC-2006: Table 2.5 page 2.47 for G_{ef} and Table 2.6 page 2.48-2.49 for C_F). For example, CF is 0.36 for all tropical forest, 0.8 for rice residues, and 0.72 for shrublands. These factors are detailed in each module when necessary.

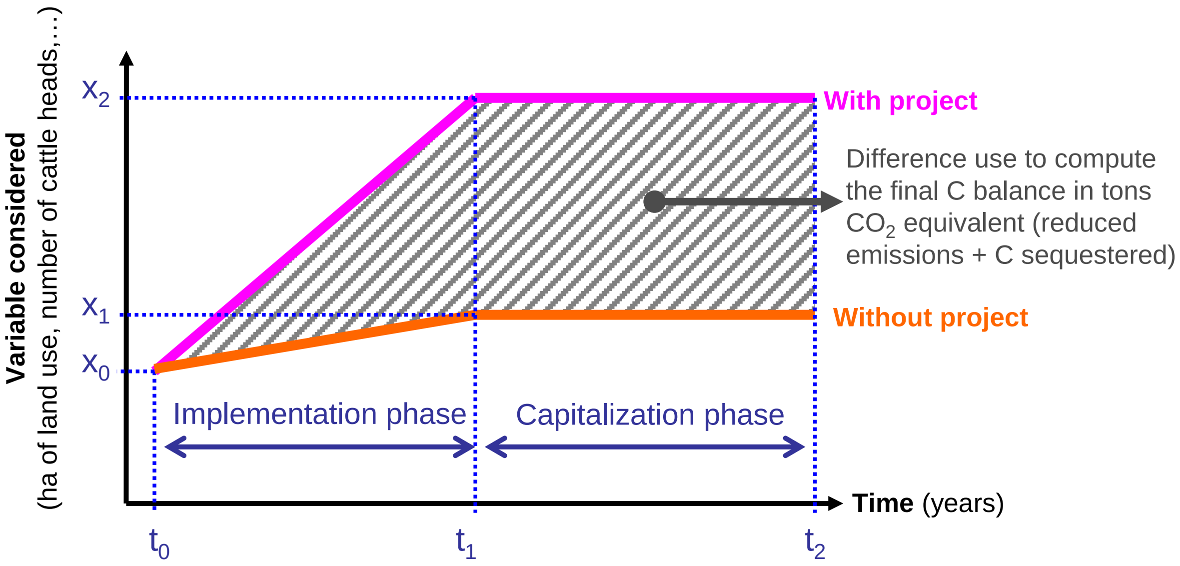
3. EX-ACT

3.1. The logic behind the EX-ACT tool

When performing an ex-ante analysis users should have an idea of what would happen without the project (i.e. the Business As Usual – BAU – Scenario or as it is named in this document the “Baseline”). Thus the final balance is the comparison between the GHG associated with the project implemented and the baseline without the project.

Users can set two different time periods for the project, one referred to as the implementation phase (i.e. the active phase of the project commonly corresponding to the investment phase), and the other as the capitalization phase (i.e. a period where project benefits are still occurring as a consequence of the activities performed during the implementation phase). Users will therefore have information about the duration of the implementation ($t_1 – t_0$) and capitalization ($t_2 – t_1$) phases, the levels of the variables taken into account (hectares converted, number of cattle, amount of inputs …) at the current stage (x_0) and at the end of the implementation phase both for the baseline (without project situation) (x_1) or with the project (x_2) (see Figure 1).

Figure 1: Schematic representation of how the final balance is calculated

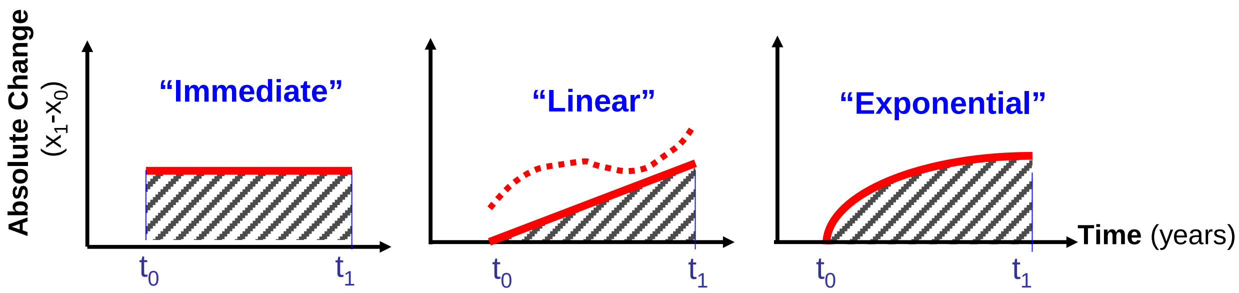


EX-ACT allows users to define a time lag, a delay before the implementation phase. Thus allowing project managers to account for a planning phase before the real and effective implementation of the project. If irrelevant for the case, users can ignore it.

3.2. Dynamics of change

The software allows users to take into account different dynamics of change. Default dynamics adopted and represented here are linear, but advanced users can change the dynamic type either to “Immediate” or “Exponential” (Figure 2).

Figure 2: Schematic representation of the dynamics implemented



The “Immediate” dynamic considers an abrupt change of level; the area in this case corresponds to double of that under the linear situation. The following example will illustrate the impact of the dynamics on the final result: In a determined current situation (x_0) farmers are using fertilizer on 100 ha of land (x_0); it is forecast that over the next 5 years (t_1) due to subsidies, these same farmers will fertilize 200 ha of land (x_1). The fertilizer application is associated with an emission factor (EF) of GHG expressed in t CO_{2e} per ha per year. Under the “immediate” option, the famers will employ fertilizer on an additional 100 ha for the first year resulting in an amount of GHG release for the 5 years being:

$Total_{Immediate} = 100 \times 5 \times EF$.

Under the “Linear” dynamic, which is the default dynamic proposed, farmers will progressively increase the surface concerned with fertilization by 20 ha per year (i.e. (200 – 100) / 5), the total corresponding amount of GHG release is therefore: $Total_{Linear} = 0.5 \times (100 \times 5 \times EF)$. The exponential case represents an intermediary situation. The rate of change is faster at the beginning. The exponential approximation is defined by the equation $\Delta(t) = \Delta_{max} (1 - e^{-kt})$, with $\Delta_{max} = (x_1\text{-}x_0)$, and k is set in order to have $\Delta(t_1) = 99\%$ of Δ_{max}. It can be shown that therefore $Total_{exponential} = 0.78\ Total_{Immediate}$.

In other words, the immediate dynamics correspond to the maximum change (100% level), the linear dynamics correspond to 50%, and the exponential an intermediary situation set to 78%.

Alternatively, when applied to surface concerned with a change in management option, the dynamics can be used to represent the adoption rate of the farmers.

In some cases the dynamic observed follow an "S-shaped" curve (commonly abbreviated S-curve). This curve corresponds mathematically to a logistic function or logistic curve, that is the most common sigmoid curve. It can be shown that the total amount of GHG release associated with a S-curve is similar to a linear curve.

3.3. Categories and representation of land-use areas

The tool is based on the six broad categories (and sub-categories) proposed for reporting GHG inventory, but is focused mostly on 3 categories: Forest land, Cropland and Grassland. Other categories are only considered in the land-use conversions

Three approaches may be used to represent areas of land use according to the level of information available.[5] The tool retains the approach 2 as a basis,[6] i.e. the approach that considers the information on conversions between categories is available, but without full spatially-explicit location data. The final result of this approach can be represented as a land-use change matrix between categories ("Matrix" spreadsheet).

5 See NGGI-IPCC-2006 for details.

6 cf. sections 3.3 and 3.3.1 of NGGI-IPCC-2006.

Figure 3: Land use matrix for the with and without project situations

Mineral soils *Without Project*			FINAL							
			Forest/ Plantation	Cropland			Grassland	Other Land		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	Forest/Plantation		0	*0*	*0*	*0*	*0*	*0*	*0*	0
	Cropland	Annual	*0*	0	*0*	*0*	*0*	*0*	*0*	0
		Perennial	*0*	*0*	0	*0*	*0*	*0*	*0*	0
		Rice	*0*	*0*	*0*	0	*0*	*0*	*0*	0
	Grassland		*0*	*0*	*0*	*0*	0	*0*	*0*	0
	Other Lar	Degraded	*0*	*0*	*0*	*0*	*0*	0	*0*	0
		Other	*0*	*0*	*0*	*0*	*0*	*0*	0	0
		Total Final	0	0	0	0	0	0	0	0
									Organic soils	0

Mineral soils *With Project*			FINAL							
			Forest/ Plantation	Cropland			Grassland	Other Land		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	Forest/Plantation		0	*0*	*0*	*0*	*0*	*0*	*0*	0
	Cropland	Annual	*0*	0	*0*	*0*	*0*	*0*	*0*	0
		Perennial	*0*	*0*	0	*0*	*0*	*0*	*0*	0
		Rice	*0*	*0*	*0*	0	*0*	*0*	*0*	0
	Grassland		*0*	*0*	*0*	*0*	0	*0*	*0*	0
	Other Lar	Degraded	*0*	*0*	*0*	*0*	*0*	0	*0*	0
		Other	*0*	*0*	*0*	*0*	*0*	*0*	0	0
		Total Final	0	0	0	0	0	0	0	0
									Organic soils	0

Numbers in Italic correspond to Land Use Change
Numbers in "normal format" correspond to a change in pratice or management options

- Corresponds to either not implemented or no GHG changes
- Corresponds to "Deforestation" Module
- Corresponds to "Afforestation-Reforestation" Module
- Corresponds to "Other Land-Use Change Module" Module
- Corresponds to Cropland Modules (i.e. Annual, Perennial and Rice)
- Corresponds to Grassland

This approach has several elements of uncertainty.[7]

Additionally to make change in land-use categories, the EX-ACT tool also considers the management practices, or the change of practices, inside categories, when the practice can influence the GHG balance (e.g. tillage intensity for croplands, level of inputs…).

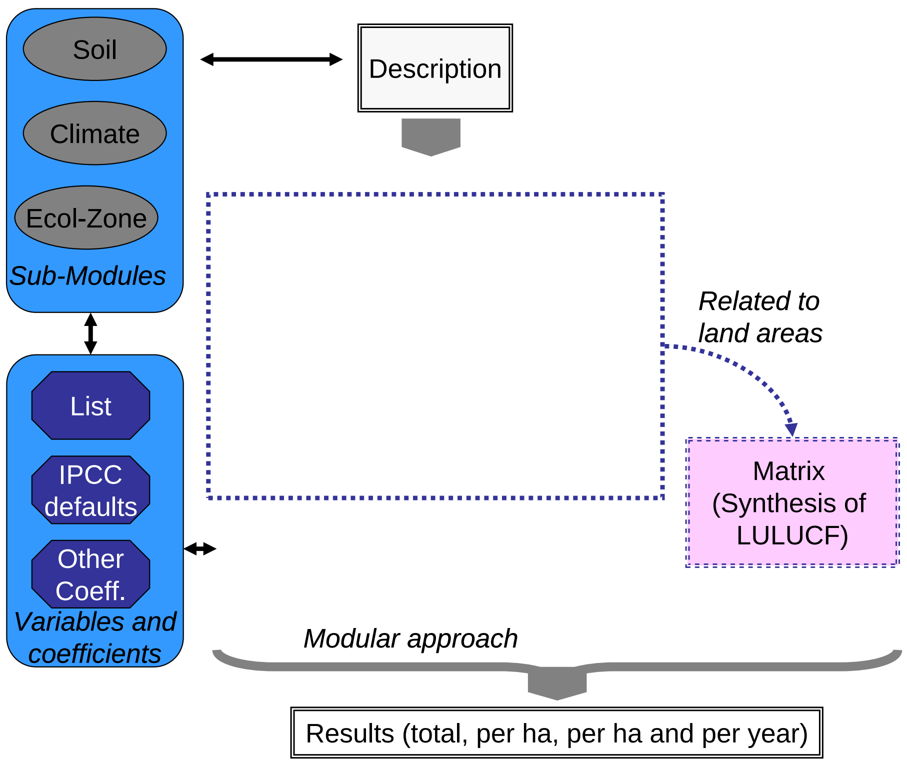
3.4. Structure of the tool

EX-ACT consists of a set of linked Microsoft Excel sheets into which the project designer inserts basic data on land use and management practices foreseen under project activities. EX-ACT adopts a modular approach – each module describing a specific land use – and follows a three-step logical framework (Figure 3).

[7] Users may refer to section 3.5 of NGGI-IPCC-2006 for more details.

a. general description of the project (geographic area, climate and soil characteristics, duration of the project);
b. identification of changes in land use and technologies foreseen by project components using specific modules (deforestation, forest degradation, afforestation/reforestation, annual/perennial crops, rice cultivation, grasslands, organic soils, livestock, inputs, other investments); and
c. computation of C-balance with and without the project using IPCC default values and – when available – ad-hoc coefficients.

Figure 4: Structure of the tool



EX-ACT is organised according to 20 spreadsheets, also named as Modules, where users should provide some information or Sub-Modules when some useful information may help to define or determine some aspects of the project.

- Start
- Description
- Gross results
- Balance
- Matrix
- Deforestation
- Forest Degradation
- A-R (i.e. Afforestation-Reforestation)
- Non-forest land Use Change (LUC)
- Annual

- Perennial
- Irrigated Rice
- Grass
- Organic soils
- Livestock
- Inputs
- Other Investment
- Soil Sub-module
- Climate sub-module
- Ecol-Zone Sub-module

3.5. General information

Figure 5: Screen shot of EX-ACT

The colours used refer to determined action requested or information about links to specific part: baseline, project…

Figure 6: Colours used and their broad significance for users

Colour used	Meaning
(light cyan)	Request an action from the user: either choose from a predetermined list, or fill with a value
(purple)	Default value proposed, can be changed if necessary
(light blue)	No action requested, already calculated or copied from original information
(light orange)	Related to the Baseline
(light pink)	Related to the project proposed

4. Recommendations before applying EX-ACT

4.1. Boundaries of the project

It is recommended that users provide a description of the project zone, including the location of the project, basic physical parameters such as dominant climate and dominant type of soil. It is important to fix the project boundaries to limit the risk of accounting land use and land use changes out of the projects limits, hence allowing for assessing the direct and indirect impacts of the project within its boundaries.

Two zones of the project can be defined:

- the direct zone where activities of the project are implemented, targeting a certain number of farmer.
- the indirect zone which may be affected by the project activities. For example, an agricultural intensification project works on 100 hectares managed by 100 farmers. The intensification may avoid the expansion of agriculture land on deforested land on additional 50 hectares. Consequently users may provide information on a total area of 150 hectares.

EX-ACT currently provides a carbon balance for the totality of hectares accounted (e.g. 150 hectares). Thus the result provided per hectare within EX-ACT includes the direct and the indirect zone of the project. If users want to translate the result only for the direct zone of the project in order to think about a way to remunerate the farmers involved in the project, he will have to recalculate the carbon balance provided by hectare for the zone directly targeted.

When using EX-ACT, it is recommended to list the different activities accounted within the project that may impact on climate change mitigation. In this manner, users should be able to list the different modules they may use before entering data in EX-ACT.

4.2. Building the with project situation

The with project situation reflects most of time the objectives targeted with the adoption of the activities of the project, as formulated in the project design. These objectives may be found in project formulation and appraisal documents or by contacting experts who have been involved in the project. Once the boundaries of the project are established (see previous paragraph) all the direct and indirect land uses and land use changes have to be integrated within the carbon balance appraisal.

When information is missing, users may make assumptions and judgments. In this case it will be necessary to justify all the assumptions taken.

4.3. Building the without project situation

Building the without project situation consist in realizing a baseline projection. Currently, there are no consensual precise methodologies to build the baseline. The future GHG emissions are indeed driven by many factors such as future economic development, population growth, international prices, technological development, etc., thus leading any projections to having more or less uncertainties. In any case, some criteria have to be respected to reach some carbon financed mechanisms.

The baseline corresponds to a description of expected conditions in the project boundaries in the absence of project activities. As mentioned before, the carbon balance provided by EX-ACT allows users to estimate the project impacts against this 'without-project' reference scenario ("business as usual"). This should help users to answer the criteria of conditionality often asked when presenting a "carbon" project, putting forward what additional impacts the project can bring.

If users attempt to reach a global carbon mechanism, it will be necessary to check that the project is answering the different criteria conditioning the access to carbon credits market: indeed a CDM project[8] must provide emission reductions that are additional to what would otherwise have occurred. The projects must qualify through a rigorous and public registration and issuance process[9]. Approval is given by Designated National Authorities.

The main objective is to describe the most plausible baseline scenario (UNFCCC[10]) including the most credible options of land use, possible land use changes and main management practices that could have occurred on the land within the project boundary.

Building baseline scenario can be realized differently depending on the project context:

- considering that the current situation may still occur in the future if the project is not implemented (without situation = start situation). The baseline is assumed to be static in this case (i.e. no change in the land use with respect to the current situation). It may be used especially for small scale project (<1000 ha) or for ex-post analysis to compare the start situation to the situation with project (i.e. for example to study the change of the carbon stock over 20 years in a region).
- integrating the trends of growth in terms of land use and land use changes. In this case, the baseline is assumed to be dynamic (i.e. change in the land use on the basis of some assumptions). It may be used especially for large scale appraisals (country level).
- integrating the current local policies and laws to review the past trends and adapt them to the current context.

[8] Going through the CDM Process. http://www.undp.org/energy/docs/cdmchapter2.pdf
[9] Clean Development Mechanism Website: http://cdm.unfccc.int/EB/index.html
[10] http://cdm.unfccc.int/UserManagement/FileStorage/W9RY2SX45CMGK3QT16ZFPUED7IBN0V

4.4. Transparency of carbon appraisal

The EX-ACT tool is using the IPCC methodology regarding the calculation used to appraise carbon balance. The present document allows users to check the different references used, consequently calculations should be understandable, and results clearly linked with the assumption used.

Whatever the assumptions taken to build the without and with project situation it is important to list all of them to respect the criteria of transparency. All the assumptions have to be justified (literature, consulted experts ...), as well as the conditions used (projections reflecting standby, decrease, linear trends...)

4.5. Building different simulations

After having fixed the without and with project situations, the results obtained may give food for thought and then some assumptions taken may not appear pragmatic. It is always possible to redo the appraisal by building other simulations for the with or without situation. This should help for better planning while confronting the carbon indicator to other indicators. If the purpose of making different simulations is to compare different scenarios, the total area of interest must be the same between the different scenarios.

4.6. Review of users' applications

If the EX-ACT tool is a free tool, it is highly recommended to submit the different uses of the tool to the EX-ACT team in FAO. It should allow users to verify that the tool has been used in a proper manner, and to collect data about mitigation activities implemented worldwide, thus helping to build databases regarding mitigation potential in the AFOLU sector

5. DESCRIPTION MODULE

Here users will find a main description of the project boundaries, and users should identify the main characteristics that apply to all the different components.

Users should fill in the following information:

- **Project name**: Provide project name.

- **Location**: Selection of the "Continent" in which the project takes place: this will influence and condition some default values. Dairy cattle emissions, for instance, are different according to the "continent". A list of choices is proposed, according to the corresponding default coefficient for the different modules: The list of the 11 options available is: Africa / Asia (Continental) / Asia (Indian subcontinent) / Asia (Insular) / Middle East / Western Europe / Eastern Europe / Oceania / North America / Central America / South America.

- **Climate**: Information regarding the climate is essential in most default coefficient or corresponding vegetation systems. Default values can change drastically accordingly to climate, therefore it is important to define the climate as precisely as possible.

Users should indicate:
- The mean climate of the region: List of preset options is: Boreal / Cool Temperate / Warm Temperate / Tropical / Tropical Montane.
- The moisture option regime, default options being: Dry / Wet / Moist.

This set of information was determined as the minimum information required by EX-ACT. Some calculations will only need the first piece of information, or also the moisture regime, whereas other calculations may particularly require the MAT, e.g. the CH_4 emissions from manure management.

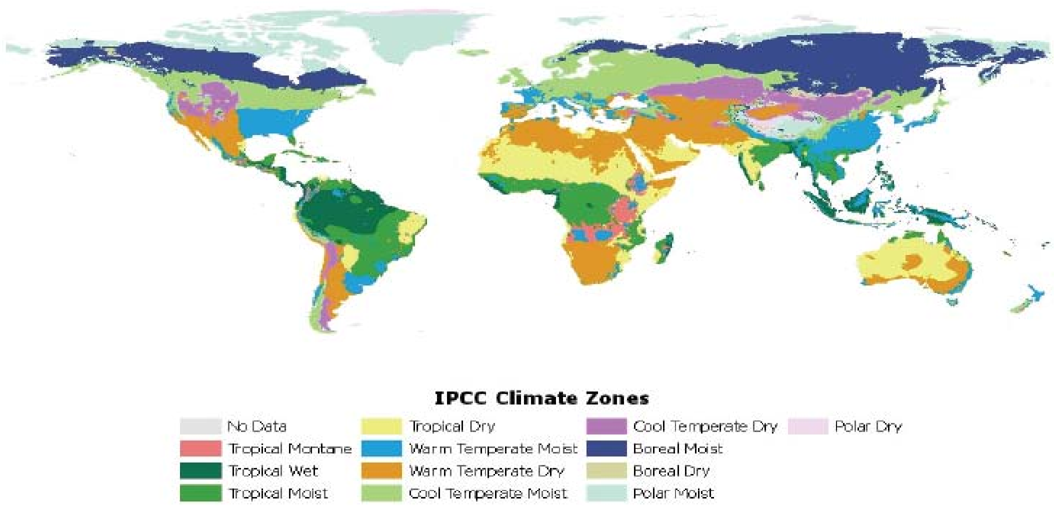
EX-ACT offers some help (maps, tables) and links to find additional information. In this case, the climate sub-module provides some help with different levels of complexity.

5.1. Climate sub-module content

This sub-module provides the following help:

- A visual representation of the IPCC climate zones

Figure 7: Representation of IPCC climate Zone[11]



- A small climate "tool" which could indicate the most probable climate corresponding to the Mean Annual Temperature (MAT) in °C and the Mean Annual Precipitation (MAP) in mm, which users should provide[12].

[11] Source: Figure 3A.5.1 "Delineation of major climate zones, updated from the NGGI-IPCC-2006, Volume 4, Chapter 3 Page 3.38.

[12] This tool is based on the classification scheme for default climate regions proposed in Figure 3A.5.2 (page 3.39 of NGGI-IPCC-2006).

Figure 8: The climate helper tool

Climate Helper : *Help to determine the Climate category with MAT and MAP*			
MAT	*24*	**Tropical**	**Moist**
MAP	*1800*	**or Tropical Montane if elevation >1000m**	

- External resources useful for determining local or regional climate with more precision. These resources were developed by FAO and comprise maps for MAP and MAT and software to download that is useful for estimating the climate using a database built on 28800 stations of FAOCLIM 2.0[13] This software will help users estimate the MAP and MAT of the project based on its location.

Figure 9: Screenshot of the different FAO resources provided for users

FAO ressources:	
MAP and MAT	See the Global Climate map at FAO Annual average rainfall total Annual average temperature
LocClim	LocClim was developed to provide an estimate of climatic conditions at locations for which no observations are available. To achieve this, the programme uses the 28800 stations of FAOCLIM 2.0 Click here to go to the application
Web Loc Clim	For on-line climate data using localisation see also Web LocClim the local monthly climate estimator Go to Web LocClim

- The climate sub-module also proposed for advanced users, a table of correspondence between the IPCC climate zones and the simplified climate zones that may be found in IPCC publications, e.g. in Chapter 8 of the Fourth Assessment Report from working group III of IPCC.[14]

[13] LocClim is available for download at http://www.fao.org/nr/climpag/pub/en3_051002_en.asp and its internet version (Web LocClim) at http://www.fao.org/sd/locclim/srv/locclim.home.

[14] Smith et al., 2007.

Table 2: Correspondence between IPCC climate zones used in NGGI-IPCC-2006 and simplified classification used by Smith et al. (2007)

IPCC Climate Zone	Simplified
Tropical Montane Dry	Warm Dry
Tropical Montane Moist	Warm Moist
Tropical Wet	Warm Moist
Tropical Moist	Warm Moist
Tropical Dry	Warm Dry
Warm Temperate Dry	Warm Dry
Warm Temperate Moist	Warm Moist
Cool Temperate Dry	Cool Dry
Cool Temperate Moist	Cool Moist
Boreal Moist	Boreal Moist
Boreal Dry	Boreal Dry

5.2. Soil Sub-module Content

- **Dominant Soil type**: Users should indicate the main dominant soil type using the simplified IPCC classification. IPCC retains only 6 soil categories: Sandy Soils / Spodic Soils / Volcanic Soils / Wetland Soils / HAC Soils / LAC Soils. HAC stand for High Activity Clay and LAC for Low Activity Clay.

  Description of the categories

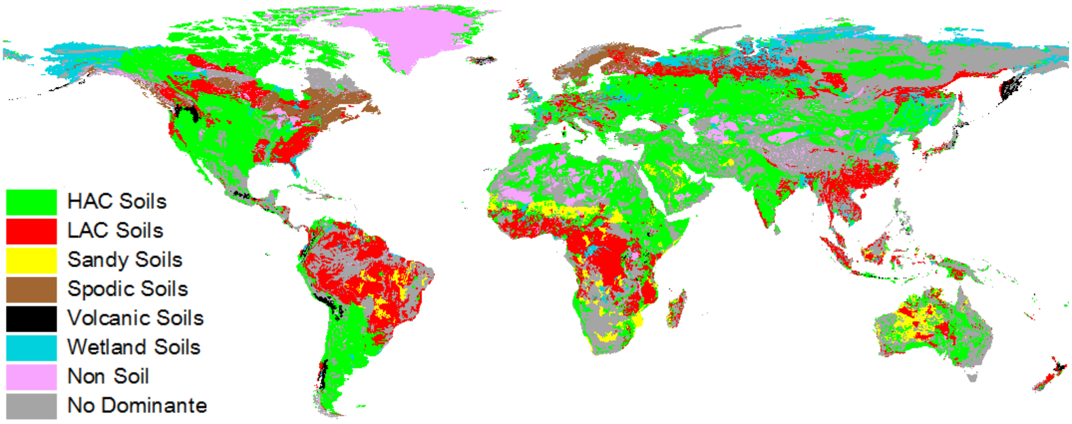
  - **Sandy Soils** includes all soils (regardless of taxonomic classification) having > 70% sand and < 8% clay, based on standard textural analyses (in World Reference Base - WRB - classification includes Aerosols; in US Department of Agriculture - USDA -classification includes Psamments).
  - **Spodic Soils** are soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols).
  - **Volcanic Soils** derived from volcanic ash with allophanic mineralogy (in WRB classification Andosols; in USDA classification Andisols).
  - **Wetland Soils** have restricted drainage leading to periodic flooding and anaerobic conditions (in WRB classification Gleysols; in USDA classification Aquic suborders).
  - **HAC Soils** stand for soils with high activity clay (HAC) minerals. These soils are light 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). But some modifications are necessary mainly for tropical soils: Ferric and Plinthic Luvisol were set as LAC Soils.

- **LAC Soils** stands for Soils with low activity clay (LAC) minerals. These soils 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).

This sub-module provides the following information:

- A tentative map of the distribution of the IPCC soil categories using the FAO soil maps and the decision tree provided by the NGGI-IPCC-2006.

Figure 10: Tentative map of the distribution of the dominant soil type using IPCC classification



- A reproduction of the decision tree from NGGI-IPCC-2006 used to obtain corresponding IPCC classification using either the USDA or the FAO-WRB soil classification.

Figure 11: Classification scheme for mineral soil types based on World Reference Base for Soil Resources (WRB) classification (left) and USDA taxonomy (right)[15]

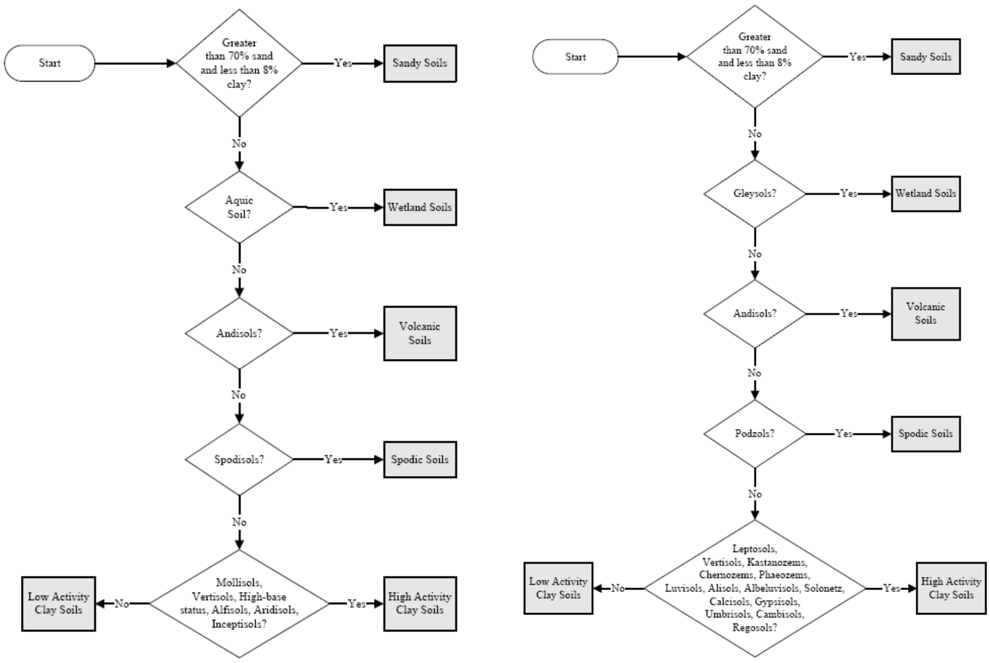
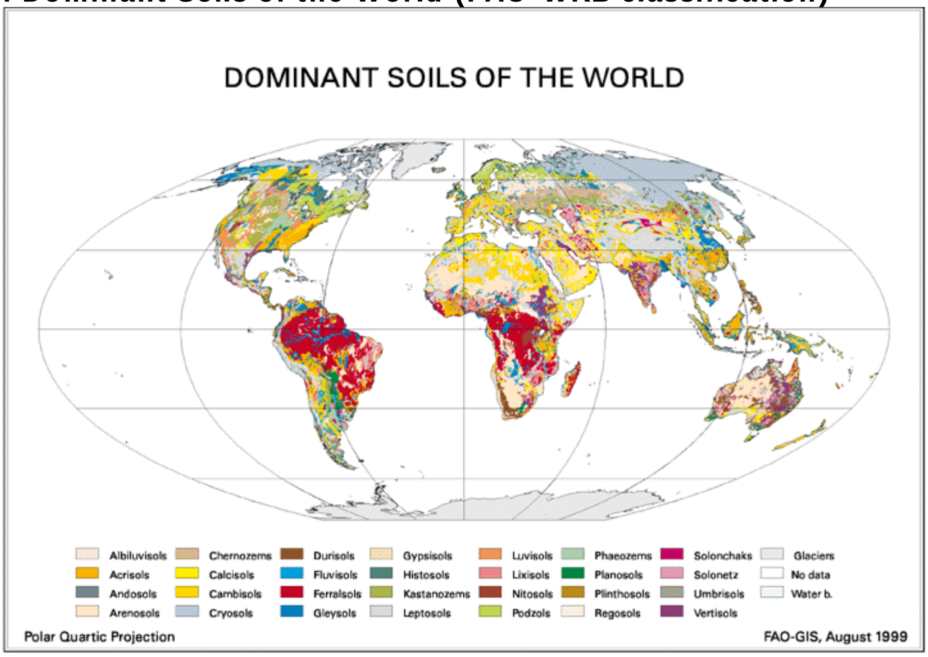


Figure 12: Dominant Soils of the World (FAO-WRB classification)



- A reproduction of the dominant soil order of the US soil Taxonomy classification[16]

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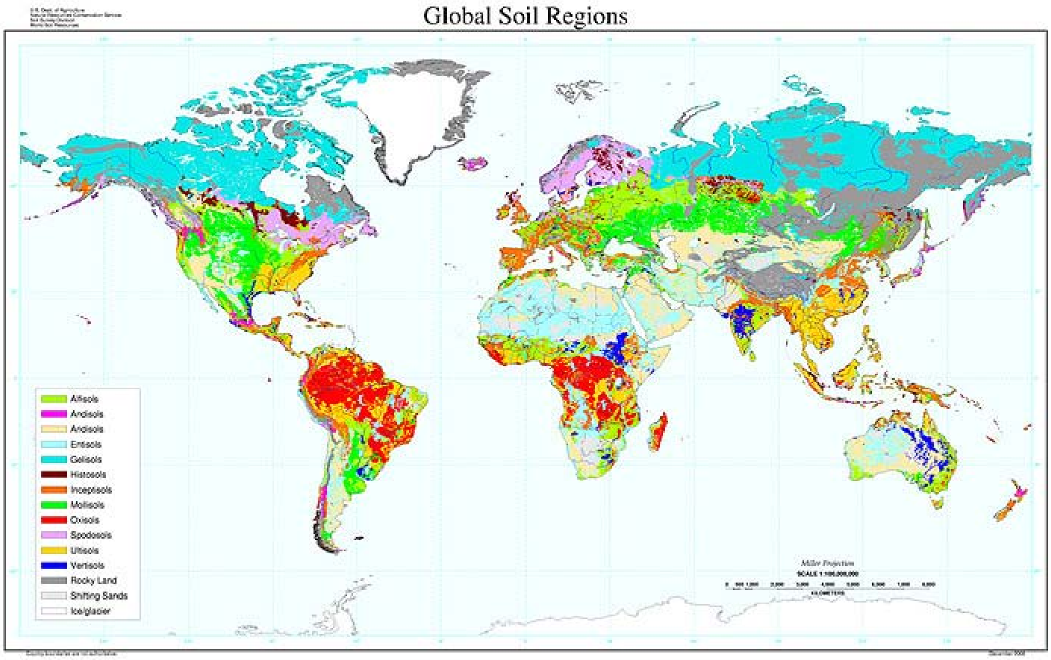
15 A reproduction of the dominant WRB Reference Soil Groups as based on the FAO-Unesco Soil Map of the World available at *http://www.fao.org/ag/agl/agll/wrb/wrbmaps/htm/domsoi.htm*

Figure 13: Global Distribution Map of the 12 soil orders used by USDA soil taxonomy



- **Duration of the Project:** Users can define two different time periods; one for the implementation phase, i.e. the active phase of the project commonly corresponding to the funding and investment phase, and another for the capitalization phase, i.e. a period where the benefits of the investment still occur and may be attributed to the changes induced by the adoption of the project. The total duration of the project is the sum of these two phases. See also the previous explanation concerning the dynamics of change to complete this information. Moreover, version 4.0 enables the integration of a time lag, which can be different for each activity. See chapter 3.1 for more details.

- **Modules:** EX-ACT is made up of different modules which can be used to simulate the impact of project activities on the C balance. Users should only use those modules which are of relevance for the specific project (Figure 13 below). This means that not all the modules have to be used, although complex projects may often need to use more than one module. Details of the procedure, calculation, methodology adopted and coefficients used for each module are given in the following sections.

[16] http://soils.cals.uidaho.edu/soilORDERS/i/worldorders.jpg

Figure 14: Components of the project and corresponding EX-ACT modules

Components of the Project
Deforestation
Forest Degradation
Afforestation and Reforestation
Non Forest Land Use Change
Agriculture
Annual Crops
Agroforestry/Perennial Crops
Irrigated Rice
Grassland
Organic soils and peatlands
Other GHG Emissions
Livestock
Inputs
Other Investment

6. DEFORESTATION MODULE

Users are invited to read the general background and the details on the description module before proceeding.

6.1. Generalities[17]

The Deforestation Module is made up of 3 sections:

Figure 15: Definition of the vegetation

Type of Default forest/plantation proposed within the specified Climatic zone			Suggested Default Values per hectare (/ha)							Combustion		
		Ecological Zone (Go to Map)	Above-Ground Biomass		Below-Ground Biomass		Litter	Dead Wood	Soil C	% released of prefire dm	CH4	N2O
			tonnes dm	t C	tonnes dm	t C	t C	tC	tC			
Natural Forest	Forest1	Tropical rain forest	310	145,7	114,7	53,9	3,65	0	47	0,32	6,8	0,2
	Forest2	Tropical moist deciduous forest	260	122,2	62,4	29,3	3,65	0	47	0,36	6,8	0,2
	Forest3	Tropical dry forest	120	56,4	33,6	15,8	3,65	0	47	0,36	6,8	0,2
	Forest4	Tropical shrubland	70	32,9	28,0	13,2	3,65	0	47	0,72	6,8	0,2
Plantation	Plantation1	Tropical rain forest	150	70,5	55,5	26,1	3,65	0	47	0,32	6,8	0,2
	Plantation2	Tropical moist deciduous forest	120	56,4	24,0	11,3	3,65	0	47	0,36	6,8	0,2
	Plantation3	Tropical dry forest	60	28,2	16,8	7,9	3,65	0	47	0,36	6,8	0,2
	Plantation4	Tropical shrubland	30	14,1	12,0	5,6	3,65	0	47	0,72	6,8	0,2
If you have your own data fill the information ->		Specific Vegetation1		0		0						
		Specific Vegetation2		0		0						
		Specific Vegetation3		0		0						
		Specific Vegetation4		0		0						

[17] Material used to develop this module can be found in Volume 4 (AFOLU) of the NGGI-IPCC-2006, in Chapter 4 entitled "Forest Land", and particularly in Chapter 2 "Generic Methodology Applicable to Multiple Land-Use Categories"

Figure 16: Conversion details

Name	Conversion details (Harvest wood product exported before the conversion, use of fire, final use after conversion)							Looses (positive value) and gain (negative value) per ha							
	Vegetation Type	HWP before		Fire use		Final Use after	Biomass	Biomass		Soil			CH4	N2O	Total
		tonne	t C exported	yes/no	% released	deforestation	1 yr after	t C	t CO2	k_{soil}	Delta C	tCO2/yr	kg	kg	tCO2 eq
Defor. 1	Forest1	0	0	YES	0,32	Perennial/Tree Crop	2,6	203,3	745,3	1,00	0,0	0,0	674,6	19,8	20,3
Defor.2	Forest2	0	0	YES	0,36	Perennial/Tree Crop	2,6	179,8	659,1	1,00	0,0	0,0	636,5	18,7	19,2
Defor.3	Forest2	0	0	NO	0	Perennial/Tree Crop	2,6	179,8	659,1	1,00	0,0	0,0	0,0	0,0	0,0
Defor.4	Forest2	0	0	NO	0	Annual Crop	5	179,8	659,1	0,48	24,4	4,5	0,0	0,0	0,0
Defor.5	Plantation1	0	0	NO	0	Grassland	7,567	128,1	469,5	1,00	0,0	0,0	0,0	0,0	0,0
Defor.6	Plantation3	0	0	NO	0	Annual Crop	5	85,8	314,4	0,48	24,4	4,5	0,0	0,0	0,0
Defor.7	Specific Vegetation1	0	0	NO	0	Annual Crop	5	0	0	0,48	0,0	0,0	0,0	0,0	0,0
Defor.8	Specific Vegetation2	0	0	NO	0	Annual Crop	5	0	0	0,48	0,0	0,0	0,0	0,0	0,0
Defor.9	Specific Vegetation3	0	0	NO	0	Annual Crop	5	0	0	0,48	0,0	0,0	0,0	0,0	0,0
Defor.10	Specific Vegetation4	0	0	NO	0	Annual Crop	5	0	0	0,48	0,0	0,0	0,0	0,0	0,0

Figure 17: Surface and GHG emissions

GHG emissions																		
Vegetation Type	Forested Area (ha)					Area deforested (ha)		Biomass loss		Biomass gain		Soil		Fire		Total Balance		
	Start	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	Without	With	Without	With
	t0	End	Rate	End	Rate			tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
Defor. 1	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.2	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.3	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.4	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.5	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.6	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.7	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.8	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.9	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
Defor.10	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0	0	0
														Deforestation Total		0	0

6.2. Definition of the Vegetation

The first part is dedicated to the description of the vegetation (native or forest plantation) that will suffer deforestation.

According to the climatic information provided in the Description Module, different types of most probable (within the corresponding ecological zone) vegetation are provided with their main characteristics according to the parameters outlined in the Description Module. Up to 8 different types of vegetations are provided for the main groups, either natural vegetation type or plantation vegetation type (Table DM-1). Users can fully describe four additional vegetation types (Specific Vegetation 1 to 4).

Table DM-1: Name of the vegetation (natural or plantation type) according to the Ecological Zone

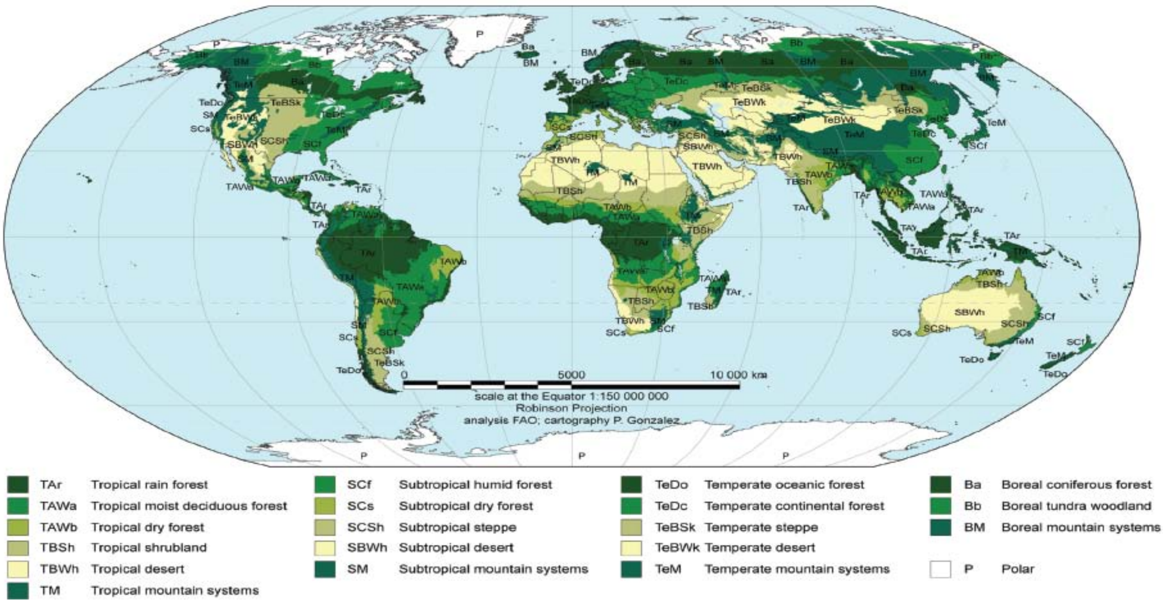
Vegetation type name	Ecological Zone (valid for all continent)				
	Tropical	Warm Temperate	Cool Temperate	Boreal	Tropical Montane
Forest1 or Plantation1	Tropical rain forest	Subtropical humid forest	Temperate oceanic forest	Boreal coniferous forest	Tropical mountain systems
Forest2 or Plantation2	Tropical moist deciduous forest	Subtropical dry forest	Temperate continental forest	Boreal tundra woodland	
Forest3 or Plantation3	Tropical dry forest	Subtropical steppe	Temperate mountain systems	Boreal mountain systems	
Forest4 or Plantation4	Tropical shrubland	Subtropical mountain systems			

Users can go to the map of the Global Ecological zone reproduced in the Ecol_Zone Sub-Module

Figure 18: Global Ecological Zones based on observed climate and vegetation patterns.

Global ecological zones, based on observed climate and vegetation patterns (FAO, 2001). Data for geographic information systems available at http://www.fao.org.

Back to "Deforestation" Module



The distinction in “Native” and “Plantation” is justified by the fact that main characteristics (e.g. the growth rate of trees) strongly depend on management regime, therefore a distinction should be made between intensively (e.g., plantation forestry) and extensively (naturally re-growing stands with reduced or minimum human intervention) managed forests.

For each of the default vegetations proposed, the 5 pools are quantified according to the generic methodologies displayed above, but with specific characteristics for forest vegetation.

Above ground biomass: These values derived from Table 4.7[18] for natural forest; EX-ACT retains either the value proposed or the central value when only a range is proposed. The values are given according to the continent and the ecological zone (Table DM-2). When no specific numbers were available, the default value for a determined continent is proposed.[19]

[18] Pages 4.53-4.54 of NGGI-IPCC-2006.

[19] This value corresponds to the default used for a full tier 1 approach Table 4.12 (page 4.63 of NGGI-IPCC-2006).

Table DM-2: Default aboveground biomass (tons d.m. ha^{-1}) for default native vegetation type according to location

	Africa	Asia (Continental)	Asia (Indian subcontinent)	Asia (Insular)	Middle East	Western Europe	Eastern Europe	Oceania	North America	Central America	South America
FOREST1											
Tropical rain forest	**310**	**280**	**280**	**350**	300	300	300	300	**300**	**300**	**300**
Subtropical humid forest	220	**180**	**180**	**290**	220	220	220	220	**220**	**220**	**220**
Temperate oceanic forest	180	180	180	180	180	**120**	**120**	**360**	**660**	**180**	**180**
Boreal coniferous forest	50	**50**	50	50	50	**50**	**50**	50	**50**	50	50
Tropical mountain systems	**115**	**135**	**135**	**205**	140	140	140	140	**145**	**145**	**145**
FOREST2											
Tropical moist deciduous forest	**260**	**180**	**180**	**290**	180	180	180	180	**220**	**220**	**220**
Subtropical dry forest	**140**	**130**	**130**	**160**	130	130	130	130	**210**	**210**	**210**
Temperate continental forest	120	120	120	120	120	**120**	**120**	120	**130**	**130**	**130**
Boreal tundra woodland	15	**15**	15	15	15	**15**	**15**	15	**15**	15	15
FOREST3											
Tropical dry forest	**120**	**130**	**130**	**160**	130	130	130	130	**210**	**210**	**210**
Subtropical steppe	**70**	**60**	**60**	**70**	70	70	70	70	**80**	**80**	**80**
Temperate mountain systems	100	**130**	**130**	**130**	100	**130**	**130**	100	**130**	**130**	**130**
Boreal mountain systems	30	**50**	**50**	**50**	30	**50**	**50**	30	**50**	30	30
FOREST4											
Tropical shrubland	**70**	**60**	**60**	**70**	70	70	70	70	**80**	**80**	**80**
Subtropical mountain systems	**50**	**135**	**135**	**205**	140	140	140	140	**145**	**145**	**145**

* Values set in Bold were obtained in Table 4.7, other values from Table 4.12.

For the plantation type vegetation, all the values proposed are derived from the Table 4.12 of NGGI-IPCC-2006. It is highly recommended that users consider more precise values if possible, particularly for plantation type vegetation. For this purpose, useful information may be found in Table 4.8 of NGGI-IPCC-2006. This table provides information of aboveground biomass in forest plantation by ecological zone and continent for a range of the principal subcategories of plantation, e.g. Pinus sp., Eucalyptus sp., Tectona grandis, other Broadleaf, sometimes taking into account the age of the plantation (>20 yrs or ≤ 20 years).

Table DM-3: Default aboveground biomass (tons d.m. ha^{-1}) for default planted forest type (Valid for all continents)

Plantation forest type	Above ground biomass t d.m. /ha
Tropical rain forest	150
Tropical moist deciduous forest	120
Tropical dry forest	60
Tropical shrubland	30
Subtropical humid forest	140
Subtropical dry forest	60
Subtropical steppe	30
Subtropical mountain systems	90
Temperate oceanic forest	160
Temperate continental forest	100
Temperate mountain systems	100
Boreal coniferous forest	40
Boreal tundra woodland	15
Boreal mountain systems	30
Tropical mountain systems	90

Below ground biomass: The generic method is used with a specific R ratio of below-ground biomass to above-ground biomass expressed in ton d.m. below-ground biomass (Table DM-4).[20]

[20] The values correspond to default ratio reported in Table 4.4 of NGGI-IPCC-2006.

Table DM-4: Default Ratio used by EXACT to derive below ground biomass

Vegetation type	Above ground biomass range (t d.m. /ha)				
	0-20*	20-50	50-75	75-125	>125
Tropical rain forest	0.37	0.37	0.37	0.37	0.37
Tropical moist deciduous forest	0.20	0.20	0.20	0.20	0.24
Tropical dry forest	0.56	0.28	0.28	0.28	0.28
Tropical shrubland	0.40	0.40	0.40	0.40	0.40
Tropical mountain systems	0.27	0.27	0.27	0.27	0.27
Subtropical humid forest	0.20	0.20	0.20	0.20	0.24
Subtropical dry forest	0.56	0.28	0.28	0.28	0.28
Subtropical steppe	0.32	0.32	0.32	0.32	0.32
Subtropical mountain systems	0.27	0.27	0.27	0.27	0.27
Temperate oceanic forest	0.44	0.44	0.44	0.25	0.22
Temperate continental forest	0.44	0.44	0.44	0.25	0.22
Temperate mountain systems	0.44	0.44	0.44	0.25	0.22
Boreal coniferous forest	0.39	0.39	0.39	0.39	0.24
Boreal tundra woodland	0.39	0.39	0.39	0.39	0.24
Boreal mountain systems	0.39	0.39	0.39	0.39	0.24

* Upper range is excluded.

The default C content used for above and below ground biomass is 0.47.

Litter default values: Proposed values are based on average values between broadleaf deciduous and needleleaf deciduous forest types[21] by climate zone, Table DM-5 below summarized values proposed.

[21] given in Table 2.2 (page 2.27 of NGGI-IPCC-2006).

Table DM-5: Default litter amount in t C per ha

Climate	Litter
Boreal Dry	28.00
Boreal Moist	47.00
Cool Temperate Dry	28.00
Cool Temperate Moist	21.00
Warm Temperate Dry	24.30
Warm Temperate Moist	17.50
Tropical Montane Dry	3.65
Tropical Montane Moist	3.65
Tropical Dry	3.65
Tropical Moist	3.65
Tropical Wet	3.65

For users who want to provide specific information using amount of litter expressed in dm; it is recommended that they consider the default carbon fraction of dry matter for litter of 0.37.[22]

Deadwood: NGGI-IPCC-2006 Tier 1 methodology considers that it is currently not feasible to provide estimates of regional default values for dead wood carbon stock.

Soil: The soil C estimates are based on default references for soil organic C stocks for mineral soils to a depth of 30 cm as previously described in generic methodologies above.

Fire emissions: In addition to the pools characteristic, information is given for the default emission factor associated with the burning of these vegetation types. The emission from burning individual GHG (N_2O or CH_4) is obtained using the generic method: $GHG_{fire} = M_{Biomass} \times C_F \times G_{ef}$

Where:

GHG_{fire} = amount of GHG from fire, kg of each GHG e.g., CH_4 or N_2O.
$M_{Biomass}$ = mass of fuel available for combustion, tons.
C_F = combustion factor, dimensionless
G_{ef} = emission factor, g kg^{-1} dry matter burnt

For this Module the factors C_F and G_{ef} used are detailed in Table DM-6 below, and $M_{Biomass}$ corresponds to the sum of above ground, below ground and litter, but discounting Harvested Wood Product (see below).

[22] page 2.23 of NGGI-IPCC-2006.

Table DM-6: C_F and G_{ef} used in Deforestation Module

	CF	Gef -CH4	Gef -N2O
Tropical rain forest	0.32	6.8	0.2
Tropical moist deciduous forest	0.36	6.8	0.2
Tropical dry forest	0.36	6.8	0.2
Tropical shrubland	0.72	6.8	0.2
Tropical mountain systems	0.36	6.8	0.2
Subtropical humid forest	0.36	4.7	0.26
Subtropical dry forest	0.36	4.7	0.26
Subtropical steppe	0.74	4.7	0.26
Subtropical mountain systems	0.36	4.7	0.26
Temperate oceanic forest	0.45	4.7	0.26
Temperate continental forest	0.45	4.7	0.26
Temperate mountain systems	0.45	4.7	0.26
Boreal coniferous forest	0.34	4.7	0.26
Boreal tundra woodland	0.34	4.7	0.26
Boreal mountain systems	0.34	4.7	0.26

6.3. Conversion details

In this part of the spreadsheet users will have to build the deforestation systems, i.e. describe the type of vegetation concerned, whether there is exportation of Harvested Wood Product (HWP, i.e. the wood harvest from forests) and its quantity, if fire is used in the conversion of forest to the other system, and identify the new land use.

Type of Vegetation: Users can either select one of the preset vegetation systems or use the specific system if defined in the first part.

HWP: Users should provide data about Harvested Wood Product exported before conversion and expressed in ton d.m. per ha. The amount of C exported is determined using the default carbon content of 0.47. Note that the amount of C in HWP is not included in sources nor sinks in the final C balance. Some HWP will act as Sink (wood used in construction), other as a source (woods used for charcoal production, if not used as fuel switching). As it is delicate and complicated and will generally not change the final figure, HWP were not considered in the final balance, reflecting the unresolved issues and ongoing negotiations of including HWP in national inventories.

Fire Use: If set to “yes”, the corresponding default emission factor associated with the vegetation type is used, and applied to $M_{Biomass}$ - defined as the sum of above ground, below ground and litter, but discounting HWP. The amount of CH_4 and N_2O are calculated in kg per GHG, and the sum expressed in t CO_2 equivalent is determined using the GWP indicated in the Description Module.

Final use after conversion: This indication is used to determine default C stock the year following the conversion: biomass and carbon soil. Available options are: Annual Crop; Perennial/Tree Crop; Paddy Rice; Set Aside; Grassland; Degraded; Other.

Proposed default biomass in t C one year after conversion, are detailed in Table DM-7

Table DM-7: Default biomass C stock (t C ha-1) for system implanted after deforestation for the different climatic zones

Climate Region	Annual Crop	Perennial/ Tree Crop	Paddy Rice	Set Aside	Grassland	Other
Boreal Dry	5.00	2.10	5.00	5.00	4.00	0
Boreal Moist	5.00	2.10	5.00	5.00	4.00	0
Cool Temperate Dry	5.00	2.10	5.00	5.00	3.06	0
Cool Temperate Moist	5.00	2.10	5.00	5.00	6.39	0
Warm Temperate Dry	5.00	2.10	5.00	5.00	2.87	0
Warm Temperate Moist	5.00	2.10	5.00	5.00	6.35	0
Tropical Montane Moist	5.00	1.80	5.00	5.00	4.09	0
Tropical Montane Dry	5.00	1.80	5.00	5.00	4.09	0
Tropical Dry	5.00	1.80	5.00	5.00	4.09	0
Tropical Moist	5.00	2.60	5.00	5.00	7.57	0
Tropical Wet	5.00	10.00	5.00	5.00	7.57	0

Values for Annual and Perennial crops correspond to the proposed value[23] for default biomass carbon stocks present on land converted to cropland in the year following conversion. Paddy Rice is considered at the same level of Annual Crop. Set Aside represents temporary set aside of annual cropland and therefore is also set at the same level as Annual Crop.

Values for Grassland are derived from Table 6.4 of NGGI-IPCC-2006 using the default C content of 0.47. Other is set to zero, and can thus be used for constructions, roads, parking lots or any kind of land use where no vegetation will be present.

For soils, the estimation method is based on changes in soil organic C stocks over a finite period following changes in management that impact soil organic C as described previously in the generic methodologies. According to information provided, EX-ACT calculates a coefficient k_{soil} used to estimate the C stocks variation relative to the carbon stock before conversion (Table DM-8). The coefficient k_{soil} is based on the relative factors given by NGGI-IPCC-2006 for croplands systems[24] and Grassland[25]. These factors were fixed to the nominal values, i.e. the value given for a system nominally managed, i.e. non-degraded and sustainably managed but without significant management improvements. Specific option of management and inputs that impact the soil C stocks in the newly implanted systems are treated in the *ad hoc* corresponding module. For instance, if a grassland system is set after deforestation the C stock is unchanged (nominal value is set to 1), but in the Grassland module users can change the management of this specific grassland management system where the initial state is fixed to nominal value (i.e. non degraded in this case). These changes

[23] Table 5.9 of NGGI-IPCC-2006.

[24] Table 5.5 pages 5.17-5.18 of NGGI-IPCC-2006

[25] Table 6.2 page 6.16 of NGGI-IPCC-2006.

therefore have additional mitigation options that are retained in other modules. For the croplands systems, the nominal values correspond to the coefficient F_{LU} reported by NGGI-IPCC-2006.

Table DM-8: Nominal values for the k_{soil} coefficient used to compute the C stock variation over 20 years for system after deforestation

Climate Region	Annual Crop	Perennial/ Tree Crop	Paddy Rice	Set Aside	Grassland	Other
Boreal Dry	0.80	1.00	1.10	0.93	1.00	1.00
Boreal Moist	0.69	1.00	1.10	0.82	1.00	1.00
Cool Temperate Dry	0.80	1.00	1.10	0.93	1.00	1.00
Cool Temperate Moist	0.69	1.00	1.10	0.82	1.00	1.00
Warm Temperate Dry	0.80	1.00	1.10	0.93	1.00	1.00
Warm Temperate Moist	0.69	1.00	1.10	0.82	1.00	1.00
Tropical Montane Moist	0.64	1.00	1.10	0.88	1.00	1.00
Tropical Montane Dry	0.64	1.00	1.10	0.88	1.00	1.00
Tropical Dry	0.58	1.00	1.10	0.93	1.00	1.00
Tropical Moist	0.48	1.00	1.10	0.82	1.00	1.00
Tropical Wet	0.48	1.00	1.10	0.82	1.00	1.00

The change in soil C stock (over the reference period of 20 years), is the computed using corresponding default C content of vegetation submitted to deforestation according to the climatic zone (see Table A1) as follow: DeltaC = Soil C x (1-k_{soil}).

An annual coefficient in t CO_2 per ha is calculated to be used in the last step "Surface and GHG emissions".

6.4. Surface and GHG emissions

Users must insert here the data about land use and land use change, giving information about the changes in surface of forest/plantation associated with each deforestation system described above. The dynamics are set by default to linear, but can be changed (see background part). More details regarding the implementation or not of the project and the associated dynamics is described in the background part. Using the areas indicated, EX-ACT derives the area deforested by a deforestation system. Based on these areas, vegetation characteristics and deforestation details, the GHG balances in CO_2-Eq is calculated for the biomass and soil pool and the eventual emission due to fire.

The surface area considered in the module is also used to compute the matrix of change. The software will also indicate if users need to complete related information in other modules.

7. FOREST DEGRADATION MODULE

Users are invited to read the general background and the details on the description module before proceeding.

7.1. Generalities

The Forest Degradation Module is made up of 3 sections:

Figure 19: Definition of the vegetation

Type of Default forest/plantation proposed within the specified Climatic zone		Ecological Zone (Go to Map)	Suggested Default Values per hectare (/ha) for corresponding non-degraded forest: Above-Ground Biomass tonnes dm	Above-Ground Biomass t C	Below-Ground Biomass tonnes dm	Below-Ground Biomass t C	Litter t C	Dead Wood tC	Soil C tC	Biomass Sub Total tC
Natural Forest	Forest1	Subtropical humid forest	180	84.6	43.2	20.3	17.5	0	63	122.4
	Forest2	Subtropical dry forest	130	61.1	36.4	17.1	17.5	0	63	95.7
	Forest3	Subtropical steppe	60	28.2	19.2	9.0	17.5	0	63	54.7
	Forest4	Subtropical mountains systems	135	63.5	36.5	17.1	17.5	0	63	98.1
Plantation	Plantation1	Subtropical humid forest	140	65.8	33.6	15.8	17.5	0	63	99.1
	Plantation2	Subtropical dry forest	60	28.2	16.8	7.9	17.5	0	63	53.6
	Plantation3	Subtropical steppe	30	14.1	9.6	4.5	17.5	0	63	36.1
	Plantation4	Subtropical mountains systems	90	42.3	24.3	11.4	17.5	0	63	71.2
If you have your own data fill the information ->		Specific Vegetation 1	0	0	0	0	0	0	0	0.0
		Specific Vegetation 2	0	0	0	0	0	0	0	0.0
		Specific Vegetation 3	0	0	0	0	0	0	0	0.0
		Specific Vegetation 4	0	0	0	0	0	0	0	0.0

Figure 20: Conversion details regarding forest state

Sequence Type	Vegetation Type concerned	Initial State Degradation Level	%	Final State Without Project Degradation Level	%	Final State WithProject Degradation Level	%	Biomass Initial tC	Biomass Without tC	Biomass With tC	Soil (variation in 20 yrs) Initial tC	Soil Without tC	Soil With tC	Delta C Soil* Without tCO2	Delta C Soil* With tCO2
Veget.1	Please specify the vegetation	Select level	0	Select level	0	Select level	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.2	Please specify the vegetation	Select level	0	Select level	0	Select level	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.3	Please specify the vegetation	Select level	0	Select level	0	Select level	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.4	Please specify the vegetation	Select level	0	Select level	0	Select level	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.5	Please specify the vegetation	Select level	0	Select level	0	Select level	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.6	Please specify the vegetation	Select level	0	Select level	0	Select level	0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.7	Specific Vegetation 1		0		0		0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.8	Specific Vegetation 2		0		0		0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.9	Specific Vegetation 3		0		0		0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Veget.10	Specific Vegetation 4		0		0		0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Figure 21: Surface and GHG emissions

GHG emissions

Sequence Type	Degraded Forest Area (ha) Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Biomass variation Without tCO2	Biomass variation With tCO2	Soil Without tCO2	Soil With tCO2	Total Balance Without tCO2	Total Balance With tCO2	Difference tCO2
Veget.1		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.2		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.3		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.4		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.5		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.6		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.7		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.8		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.9		0	Linear	0	Linear	0	0	0	0	0	0	0
Veget.10		0	Linear	0	Linear	0	0	0	0	0	0	0
						Degradation Total				0	0	0

7.2. Definition of the Vegetation

The first part is dedicated to the description of the vegetation (native or forest plantation) that will suffer degradation. According to the climatic information provided in the Description Module, different types of most probable (within the corresponding ecological zone) vegetation are provided with their main characteristics according to the parameters outlined in the Description Module. Up to eight different vegetations are provided for the main groups, either natural vegetation type or plantation vegetation type (see Table DM-1). Users can fully describe four additional vegetation types (Specific Vegetation 1 to 4) corresponding more closely to the type of vegetation related to the project.

The distinction in “Native” and “Plantation” is justified by the fact that main characteristics (e.g. the growth rate of trees) strongly depend on management regime, therefore a distinction should be made between intensively (e.g., plantation forestry) and extensively (naturally re-growing stands with reduced or minimum human intervention) managed forests.

For each of the default vegetations proposed, the 5 pools are quantified according to the generic methodologies displayed above, but with specific characteristics for forest vegetation. The values affected to the five pools are explained in the previous chapter (deforestation module, description of vegetation).

7.3. Conversion details regarding forest state

In this part of the spreadsheet users can build the degraded systems, i.e. describe the type of vegetation concerned (using either the default categories presented above, or its own specific vegetation). Then users should indicate the initial state of the forest and identify its expected final states (without project and with project). Currently there are not international recognized methodologies to assess the forest degradation. The different available states within EX-ACT correspond to an average level of degradation, also expressed in terms of percentage of degraded area.

Available options of degradation are:

- None,
- Very low (10%),
- Low (20%)
- Moderate (40%)
- Large (60%); and
- Extrem (80%).

For example, 100 ha of non degraded forest becoming low degraded means that the new degraded system has the same behavior than 80 ha of non degraded forest. Another way to consider this degradation is to consider that the degraded forest at a certain level has lost the corresponding percentage of total biomass affecting all C pools. For instance 100 ha of "low degraded" forest store the equivalent of 80 % of the total C of a non degraded forest.

Users can also indicate if there is fire or not. The default value for the frequency of fire is set to 1 (i.e., one fire every year). It is however possible to change this frequency. The rate of 25% corresponds to the emissions of GHG due to the combustion of the soil carbon[26] and can be adjusted as needed.

7.4. Surface and GHG emissions

Users must insert here the data about initial forest area in hectare of forest/plantation associated with each degraded system described above. The dynamics are set by default to linear, but can be changed (see background part). More details regarding the implementation or not of the project and the associated dynamics is described in the background part. EX-ACT derives the area degraded by a degraded system. Based on these areas, vegetation characteristics and degradation level, the GHG balances in CO_2-Eq is calculated for the biomass, soil and fire pool.

The surface area considered in the module is also used to compute the matrix of change.

[26] This value comes from Moiseev and Filipchuck (2003) and can be adjusted by the user.

8. AFFORESTATION / REFORESTATION MODULE

Users are invited to read the general background and details on the description module before proceeding. Moreover, the module "Afforestation/reforestation" (A/R) is built using the same approach detailed in the "Deforestation Module". Users are invited to read the description on the deforestation module first as the text below refers to it.

8.1. Generalities[27]

The A/R Module is made up of 3 sections:

Figure 22: Definition of the vegetation

Type of Default forest/plantation proposed within the specified Climatic zone			Suggested Default Values per hectare (/ha)										
			Up to 20 year-old				After 20 year-old						
			Above-Ground Biomass Growth		Below-Ground Biomass growt		Above-Ground Biomass Grow		Below-Ground Biomass grov		Litter total	Dead Wood	Soil C
		Ecological Zone Ecol_Zone	tonnes dm	t C	tonnes dm	t C	tonnes dm	t C	tonnes dm	t C	t C	tC	tC
Natural Forest Type	Natural1	Tropical rain forest	10,00	4,70	3,70	1,74	3,10	1,46	1,15	0,54	3,65	0	47
	Natural2	Tropical moist deciduous forest	5,00	2,35	1,00	0,47	1,30	0,61	0,26	0,12	3,65	0	47
	Natural3	Tropical dry forest	2,40	1,13	1,34	0,63	1,80	0,85	1,01	0,47	3,65	0	47
	Natural4	Tropical shrubland	0,45	0,21	0,18	0,08	0,90	0,42	0,36	0,17	3,65	0	47
Plantation Type	Plantation1	Tropical rain forest	15,00	7,05	5,55	2,61	15,00	7,05	5,55	2,61	3,65	0	47
	Plantation2	Tropical moist deciduous forest	10,00	4,70	2,00	0,94	10,00	4,70	2,00	0,94	3,65	0	47
	Plantation3	Tropical dry forest	8,00	3,76	4,48	2,11	8,00	3,76	4,48	2,11	3,65	0	47
	Plantation4	Tropical shrubland	5,00	2,35	2,00	0,94	5,00	2,35	2,00	0,94	3,65	0	47
If you have your own data fill the information See IPCC 2006 Tables 4.9 and 4.10 for other values		Specific Vegetation1		0		0		0		0			
		Specific Vegetation2		0		0		0		0			
		Specific Vegetation3		0		0		0		0			
		Specific Vegetation4		0		0		0		0			

Figure 23: Conversion details

	Conversion details (Previous land use, use of fire before afforestation/reforestation,...)											Biomass of forests/plantation		
	Vegetation Type	Previous use before	Burnt befor	Default	Specific	Soil			CH4	N2O	Total	Annual Biomass Growtl		Litrer+dead
Name		afforestation/reforestation	conversioı	Biomass	Biomass	k_{soil}	Delta C	tCO2/yr	kg	kg	tCO2 eq	<=20yrs	>20yr	wood
A/R1	Plantation1	Degraded Land	NO	1		0,33	31,5	5,8	4,60	0,42	0,2	9,7	9,7	3,7
A/R2	Plantation2	Annual Crop	NO	5		0,48	24,4	4,5	13,50	3,50	1,4	5,6	5,6	3,7
A/R3	Plantation2	Perennial/Tree Crop (6-10 yrs)	NO	20,8		1,00	0,0	0,0	95,68	8,74	4,7	5,6	5,6	3,7
A/R4	Plantation1	Perennial/Tree Crop (>10 yrs)	NO	21		1,00	0,0	0,0	96,60	8,82	4,8	9,7	9,7	3,7
A/R5	Plantation1	Annual Crop	NO	5		0,48	24,4	4,5	13,50	3,50	1,4	9,7	9,7	3,7
A/R6	Plantation3	Grassland	NO	6,44		1,00	0,0	0,0	29,62	2,70	1,5	5,9	5,9	3,7
A/R7	Specific Vegetation1	Annual Crop	NO	5		0,48	0,0	0,0	13,50	3,50	1,4	0	0	0
A/R8	Specific Vegetation2	Annual Crop	NO	5		0,48	0,0	0,0	13,50	3,50	1,4	0	0	0
A/R9	Specific Vegetation3	Annual Crop	NO	5		0,48	0,0	0,0	13,50	3,50	1,4	0	0	0
A/R10	Specific Vegetation4	Annual Crop	NO	5		0,48	0,0	0,0	13,50	3,50	1,4	0	0	0

Figure 24: Surface and GHG emissions

GHG emissions															
Vegetation Type	Afforested or reforested Area (ha)					Area afforested (ha)		Biomass Gain		Biomass Loss		Soil		Total Balance	
	Start	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	Without	With
	t0	End	Rate	End	Rate			tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
A/R1	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R2	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R3	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R4	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R5	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R6	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R7	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R8	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R9	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
A/R10	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
												Deforestation Total		0	0

8.2. Definition of the Vegetation

The first part is dedicated to the description of the vegetation used in the afforestation or reforestation (regeneration or plantation of native species, or plantation of exotic species). According to the climatic information provided in the Description Module, different kinds of most common vegetation types in the corresponding ecological zone are provided with their main characteristics. Up to eight different vegetations are divided into two main groups:

[27] Material used to develop this module can be found in Volume 4 (AFOLU) of the NGGI-IPCC-2006, in Chapter 4 entitled "Forest Land", and particularly in Chapter 2 "Generic Methodology Applicable to Multiple Land-Use Categories

natural vegetation and plantations (see Table DM-1). As those default vegetation types might be too generic, users can fully describe four additional vegetation types (Specific Vegetation 1 to 4) corresponding more closely to the type of vegetation related to the project.

The distinction in "Native" and "Plantation" is justified by the fact that main characteristics (e.g. the growth rate of trees) strongly depend on management regime, therefore a distinction should be made between intensively (e.g., plantation forestry) and extensively (naturally re-growing stands with reduced or minimum human intervention) managed forests.

For each of the default vegetations proposed, information is quantified for the five pools according to the generic methodologies outlined above, but with specific characteristics for forest vegetation. Values of annual growth rates are given for the above ground and below ground biomass. But as NGGI-IPCC-2006 highlighted, it is important, in deriving estimates of biomass accumulation rates, to recognize that biomass growth rates will occur primarily during the first 20 years following changes in management, after which time the rates will tend towards a new steady-state level with little or no change unless further changes in management conditions occur.

Above ground biomass growth rate: The biomass growth rate values [28] for natural forest, EX-ACT retains either the value proposed or the central value when only a range is proposed. The values are given according to the continent and the ecological zone (Table A/R-1). When no specific numbers were available, the default value for a determined continent is proposed, this value corresponds to the default used for a full tier 1 approach Table 4.12[29]. Table A/R-1 reported default values for a system being more or less than 20 years.

[28] Derived from Table 4.9 of NGGI-IPCC-2006 (pages 4.57-4.58).

[29] Page 4.63 of NGGI-IPCC-2006.

Table A/R-1: Default aboveground biomass growth rate (tons d.m. ha^{-1} yr^{-1}) for default native vegetation type, according to location

	Africa	Asia (Continental)	Asia (Indian subcontinent)	Asia (Insular)	Middle East	Western Europe	Eastern Europe	Oceania	North America	Central America	South America
< 20-year old											
Tropical rain forest	**10.0**	**7.0**	**7.0**	**13.0**	7.0	7.0	7.0	7.0	**9.5**	**11.0**	**11.0**
Subtropical humid forest	5.0	**9.0**	**9.0**	**11.0**	5.0	5.0	5.0	5.0	**7.0**	**7.0**	**7.0**
Temperate oceanic forest	4.4	4.4	4.4	4.4	4.4	**2.3**	**2.3**	**3.5**	**15.0**	**5.7**	4.4
Boreal coniferous forest	1.0	**1.1**	**1.1**	**1.1**	1.0	**1.1**	**1.1**	1.0	**1.1**	1.0	1.0
Tropical mountain systems	**3.5**	**3.0**	**3.0**	**7.5**	1.0	1.0	1.0	1.0	**3.4**	**3.4**	**3.4**
Tropical moist deciduous forest	**5.0**	**9.0**	**9.0**	**11.0**	5.0	5.0	5.0	5.0	**7.0**	**7.0**	**7.0**
Subtropical dry forest	**2.4**	**6.0**	**6.0**	**7.0**	2.4	2.4	2.4	2.4	**4.0**	**4.0**	**4.0**
Temperate continental forest	4.0	**4.0**	**4.0**	**4.0**	4.0	**4.0**	**4.0**	4.0	**4.0**	4.0	4.0
Boreal tundra woodland	0.4	**0.4**	**0.4**	**0.4**	0.4	**0.4**	**0.4**	0.4	**0.4**	0.4	0.4
Tropical dry forest	**2.4**	**6.0**	**6.0**	**7.0**	2.4	2.4	2.4	2.4	**4.0**	**4.0**	**4.0**
Subtropical steppe	**1.2**	**5.0**	**5.0**	**2.0**	1.0	1.0	1.0	1.0	**4.0**	**4.0**	**4.0**
Temperate mountain systems	3.0	**3.0**	**3.0**	**3.0**	3.0	**3.0**	**3.0**	3.0	**3.0**	3.0	3.0
Boreal mountain systems	1.0	**1.1**	**1.1**	**1.1**	1.0	**1.1**	**1.1**	1.0	**1.1**	1.0	1.0
Tropical shrubland	**0.5**	**5.0**	**5.0**	**2.0**	1.0	1.0	1.0	1.0	**4.0**	**4.0**	**4.0**
Subtropical mountain systems	**3.5**	**3.0**	**3.0**	**7.5**	1.0	1.0	1.0	1.0	**3.4**	**3.4**	**3.4**
> 20-year old											
Tropical rain forest	**3.1**	**2.2**	**2.2**	**3.4**	7.0	7.0	7.0	7.0	**9.5**	**3.1**	**3.1**
Subtropical humid forest	5.0	**2.0**	**2.0**	**3.0**	5.0	5.0	5.0	5.0	**2.0**	**2.0**	**2.0**
Temperate oceanic forest	4.4	4.4	4.4	4.4	4.4	**2.3**	**2.3**	**3.5**	**15.0**	**5.7**	4.4
Boreal coniferous forest	1.0	**1.1**	**1.1**	**1.1**	1.0	**1.1**	**1.1**	1.0	**1.1**	1.0	1.0
Tropical mountain systems	**1.3**	**0.8**	**0.8**	**2.0**	1.0	1.0	1.0	1.0	**0.9**	**0.9**	**0.9**
Tropical moist deciduous forest	**1.3**	**2.0**	**2.0**	**3.0**	5.0	5.0	5.0	5.0	**2.0**	**2.0**	**2.0**
Subtropical dry forest	**1.8**	**1.5**	**1.5**	**2.0**	2.4	2.4	2.4	2.4	**1.0**	**1.0**	**1.0**
Temperate continental forest	4.0	**4.0**	**4.0**	**4.0**	4.0	**4.0**	**4.0**	4.0	**4.0**	4.0	4.0
Boreal tundra woodland	0.4	**0.4**	**0.4**	**0.4**	0.4	**0.4**	**0.4**	0.4	**0.4**	0.4	0.4

	Africa	Asia (Continental)	Asia (Indian subcontinent)	Asia (Insular)	Middle East	Western Europe	Eastern Europe	Oceania	North America	Central America	South America
Tropical dry forest	**1.8**	**1.5**	**1.5**	**2.0**	2.4	2.4	2.4	2.4	**1.0**	**1.0**	**1.0**
Subtropical steppe	**0.9**	**1.3**	**1.3**	**1.0**	1.0	1.0	1.0	1.0	**1.0**	**1.0**	**1.0**
Temperate mountain systems	3.0	**3.0**	**3.0**	**3.0**	3.0	**3.0**	**3.0**	3.0	**3.0**	3.0	3.0
Boreal mountain systems	1.0	**1.3**	**1.3**	**1.3**	1.0	**1.3**	**1.3**	1.0	**1.3**	1.0	1.0
Tropical shrubland	**0.9**	**1.3**	**1.3**	**1.0**	1.0	1.0	1.0	1.0	**1.0**	**1.0**	**1.0**
Subtropical mountain systems	**1.3**	**0.8**	**0.8**	**2.0**	1.0	1.0	1.0	1.0	**0.9**	**0.9**	**0.9**

* Values set in Bold were obtained in Table 4.9 and other values from Table 4.12 of NGGI-IPCC-2006

For the plantation type vegetation (Table A/R-2), all the values proposed are derived from the Table 4.12 (NGGI-IPCC-2006). It is highly recommended that users seek national/regional data on above-ground woody biomass growth rate, if possible. Moreover for plantation type vegetation, useful information may be found in Table 4.10 reproduced in Annex A/R Module: This table provides information of aboveground biomass growth rate in forest plantation by ecological zone and continent for a range of the principal subcategories of plantation e.g. Pinus sp., Eucalyptus sp., Tectona grandis, other Broadleaf, and sometimes taking into account the age of the plantation (>20 yrs or ≤ 20 years).

Table A/R-2: Default aboveground biomass growth rate (tons d.m. ha^{-1}) for default planted forest type (valid for all continent and all ages of plantation)

Plantation forest type	Above ground biomass t d.m.ha^{-1}
Tropical rain forest	15.0
Tropical moist deciduous forest	10.0
Tropical dry forest	4.4
Tropical shrubland	1.0
Subtropical humid forest	5.0
Subtropical dry forest	10.0
Subtropical steppe	8.0
Subtropical mountain systems	4.0
Temperate oceanic forest	0.4
Temperate continental forest	8.0
Temperate mountain systems	5.0
Boreal coniferous forest	3.0
Boreal tundra woodland	1.0
Boreal mountain systems	5.0
Tropical mountain systems	5.0

Below ground biomass: The generic method is used with a specific R ratio of below-ground biomass to above-ground biomass expressed in ton d.m. below-ground biomass, These coefficients are the same as for the Deforestation Module (see Table DM-4). The values correspond to default ratio reported in Table 4.4 (NGGI-IPCC-2006).

The default C content used for above and below ground biomass is 0.47

Litter, deadwood and soil carbon: They are treated in this Module exactly in the same way as in the Deforestation Module. Refer to the Deforestation Module for coefficients used.

8.3. Conversion details

In this part of the spreadsheet users have to build the Afforestation/Reforestation systems, i.e. provide information on the type of vegetation concerned, the previous vegetation and whether fire is used in the conversion to the other system, and identify the new land use.

Type of Vegetation: Users can either select one of the preset vegetation systems or use the specific system if defined in the first part.

Previous Land use: Users must indicate from the list of proposed systems which is the most appropriate used previously before the Afforestation or Reforestation. Available choices are: Annual Crop / Perennial/Tree Crop (<5yrs) / Perennial/Tree Crop (6-10 yrs) / Perennial/Tree Crop (>10 yrs) / Paddy Rice / Set Aside / Grassland / Degraded Land.
According to the choice, the corresponding default Biomass is proposed.

Proposed default biomass in t C before conversion are detailed in Table A/R-3.

Table A/R-3: Default biomass C stock (t C ha-1) for system present before A/R, for the different climatic zones

Climate Region	Annual Crop	Perennial/Tree Crop			Paddy Rice	Set Aside	Grassland	Degraded Land
		<5yrs	6-10 yrs	>10 yrs				
Boreal Dry	5.00	6.30	16.8	16.8	5.00	5.00	3.40	1
Boreal Moist	5.00	6.30	16.8	16.8	5.00	5.00	3.40	1
Cool Temperate Dry	5.00	6.30	16.8	31.5	5.00	5.00	2.60	1
Cool Temperate Moist	5.00	6.30	16.8	31.5	5.00	5.00	5.44	1
Warm Temperate Dry	5.00	6.30	16.8	31.5	5.00	5.00	2.44	1
Warm Temperate Moist	5.00	6.30	16.8	31.5	5.00	5.00	5.40	1
Tropical Montane Moist	5.00	5.40	9	9	5.00	5.00	3.48	1
Tropical Montane Dry	5.00	5.40	9	9	5.00	5.00	3.48	1
Tropical Dry	5.00	5.40	9	9	5.00	5.00	3.48	1
Tropical Moist	5.00	7.80	20.8	21	5.00	5.00	6.44	1
Tropical Wet	5.00	25.00	50	50	5.00	5.00	6.44	1

Values for Annual crops correspond to the proposed value[30] for default biomass carbon stocks present on land converted to cropland in the year following conversion. Paddy Rice is considered at the same level of Annual Crops. Set Aside Represents temporary set aside of annual cropland and therefore is also set at the same level as Annual Crop. Values for Grassland are derived from Table 6.4 (NGGI-IPCC-2006) using the default C content of 0.47. Degraded Land is set to 1, and can thus be used for areas where very little vegetation will be present. Values for Perennial are derived from Table 5.1 (Page 5.9, NGGI-IPCC-2006). Maximum values, i.e. Perennial System more than 10 years, is set using the default values

[30] Table 5.9 of NGGI-IPCC-2006.

indicated in Table 5.1[31] in column "Biomass C Loss" that represents the values at maturity according to main climatic zone. The maximum values are also used for younger systems according to the duration of the cycle indicated. For instance, for Tropical dry regions the cycle duration is set to 5 years, therefore Perennial Systems in the range 6-10 years are considered at the same level as older systems. Other values are calculated using the column annual growth rate and an average over the range of age considered.

Fire Use and emissions: If set to "yes" the corresponding emission factors associated with the vegetation are used, and applied to $M_{Biomass}$ defined as the sum of above ground, below ground and litter, but discounting Harvested Wood Product. The amount of CH_4 and N_2O are calculated in kg per GHG, and then the sum expressed in t CO_2 equivalent determined using the GWP indicated in the Description Module. The emission from burning individual GHG (N_2O or CH_4) is obtained using the generic method: $GHG_{fire} = M_{Biomass} \times C_F \times G_{ef}$

For this Module the factors C_F and G_{ef} used are detailed in Table A/R-4 below, and $M_{Biomass}$ corresponds to default biomass indicated previously. These values were set using Table 2.5 and 2.6.[32] Crop residues were estimated to represent 40% of Biomass for Annual and Paddy Rice, therefore CF coefficients were set to 0.4 to account for that.

Table A/R-4: C_F and G_{ef} used in A/R Module

	CF	Gef -CH4	Gef -N2O
Annual Crop	0.4	2.7	0.70
Perennial/Tree Crop (<5yrs)	0.8	2.3	0.21
Perennial/Tree Crop (6-10 yrs)	0.8	2.3	0.21
Perennial/Tree Crop (>10 yrs)	0.8	2.3	0.21
Paddy Rice	0.4	2.7	0.70
Set Aside	0.8	2.7	0.70
Grassland	0.8	2.3	0.21
Degraded Land	0.8	2.3	0.21

For soils, the estimation method is based on changes in soil organic C stocks over a finite period following changes in management that impact soil organic C, as described previously in the generic methodologies, and using the same values for the Deforestation Module (see Table DM-8). Additionally, a coefficient k_{soil} for Degraded Land was set arbitrarily to 0.33. These changes therefore have additional mitigation options as retained in other modules. For the croplands systems, the nominal values correspond to the coefficient F_{LU}.[33]

Then the change in soil C stock (over the reference period of 20 years) is computed and an annual coefficient in t CO_2 per ha is calculated to be used in the last step "Surface and GHG emissions".

[31] Page 5.9, by NGGI-IPCC-2006.

[32] NGGI-IPCC-2006.

[33] Reported by NGGI-IPCC-2006.

8.4. Surface and GHG emissions

Users must provide information on the changes in surface afforested or reforested with each A/R system described above. The dynamics are set by default to linear, but can be changed.[34] Based on areas indicated and also considering vegetation characteristics and details indicated in other parts the GHG balances in CO_2-Eq is calculated for the biomass and soil pool and the eventual emission due to fire.

The areas informed are also used to compute the matrix of change and some controls are indicated if one needs to complete related information in other modules.

9. NON FOREST LAND-USE CHANGE (NFLUC) MODULE

Users are invited to read Chapter 5, Description Module and the details on the description module before proceeding.

9.1. Generalities[35]

The Non Forest LUC Module is made up of 2 sections:

Figure 25: Description of land use changes

		Description of LUC	
Name	Your Name	Initial Land Use	Final Land Use
LUC-1	Ex: Rice to Tree	Paddy Rice	Perennial/Tree Crop
LUC-2		Annual Crop	Other
LUC-3		Degraded Land	Annual Crop
LUC-4		Other Land	Annual Crop
LUC-5		Perennial/Tree Crop (6-10 yrs)	Grassland
LUC-6		Set Aside	Perennial/Tree Crop
LUC-7		Paddy Rice	Set aside
LUC-8		Degraded Land	Paddy Rice
LUC-9		Grassland	Perennial/Tree Crop
LUC-10		Perennial/Tree Crop (<5yrs)	Grassland
LUC-11		Perennial/Tree Crop (6-10 yrs)	Paddy Rice
LUC-12		Perennial/Tree Crop (>10 yrs)	Other
LUC-13		Paddy Rice	Perennial/Tree Crop
LUC-14		Set Aside	Other
LUC-15		Annual Crop	Perennial/Tree Crop
LUC-16		Degraded Land	Perennial/Tree Crop

[34] See Chapter 3, EX-ACT background part. More details regarding the implementation or not of the project and the associated dynamics is described in the background part.

[35] Material used to develop this module can be found in the Volume 4 (AFOLU) of the NGGI-IPCC-2006 and particularly in Chapter 2 “Generic Methodology Applicable to Multiple Land-Use Categories”.

Figure 26: Land involved and corresponding GHG emissions

GHG emissions											
Vegetation Type		Area concerned by LUC				Biomass Change		Soil Change		Total Balance	
		Without Project		With Project		Without	With	Without	With	Without	With
		Area	Rate	Area	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
LUC-1	Ex: Rice to Tree	0	Linear	0	Linear	0	0	0	0	0	0
LUC-2		0	Linear	0	Linear	0	0	0	0	0	0
LUC-3		0	Linear	0	Linear	0	0	0	0	0	0
LUC-4		0	Linear	0	Linear	0	0	0	0	0	0
LUC-5		0	Linear	0	Linear	0	0	0	0	0	0
LUC-6		0	Linear	0	Linear	0	0	0	0	0	0
LUC-7		0	Linear	0	Linear	0	0	0	0	0	0
LUC-8		0	Linear	0	Linear	0	0	0	0	0	0
LUC-9		0	Linear	0	Linear	0	0	0	0	0	0
LUC-10		0	Linear	0	Linear	0	0	0	0	0	0
LUC-11		0	Linear	0	Linear	0	0	0	0	0	0
LUC-12		0	Linear	0	Linear	0	0	0	0	0	0
LUC-13		0	Linear	0	Linear	0	0	0	0	0	0
LUC-14		0	Linear	0	Linear	0	0	0	0	0	0
LUC-15		0	Linear	0	Linear	0	0	0	0	0	0
LUC-16		0	Linear	0	Linear	0	0	0	0	0	0

Other LUC total	0	0

9.2. Description of land use changes

The first sub-module is dedicated to the description of the land use before and after the change. For land use dealing with forestland, i.e. deforestation or afforestation/reforestation, users should use the specific Module. Initial and final land uses available to the users are Annual Crop, Perennial/Tree Crop, Paddy Rice, Set Aside, Grassland, Degraded Land and Other Land. In the case of Initial Land Use the Perennial/Tree Crop category is subdivided in Perennial/Tree Crop (<5 yrs), Perennial/Tree Crop (6-10 yrs), and Perennial/Tree Crop (>10 yrs). In the case of Final Land Use Other Land is subdivided in Other Land (Nominal) and Other Land (degraded). In total 72 different successions can be built.

For each change in land use, default values are given concerning the C stocks (Biomass and soil) for each category involved in the successions. Vegetation biomasses depend on the climatic zones.

Initial Land-use: Proposed default biomasses of initial land-use in t C before conversion are detailed in Table NFOLUC-1.

Table NFOLUC-1: Default biomass C stock (t C ha-1) for system present before the conversion, for the different climatic zones

Climate Region	Annual Crop	Perennial/Tree Crop			Paddy Rice	Set Aside	Grassland	Degraded Land
		<5yrs	6-10 yrs	>10 yrs				
Boreal Dry	5.00	6.30	16.8	16.8	5.00	5.00	3.40	1
Boreal Moist	5.00	6.30	16.8	16.8	5.00	5.00	3.40	1
Cool Temperate Dry	5.00	6.30	16.8	31.5	5.00	5.00	2.60	1
Cool Temperate Moist	5.00	6.30	16.8	31.5	5.00	5.00	5.44	1
Warm Temperate Dry	5.00	6.30	16.8	31.5	5.00	5.00	2.44	1
Warm Temperate Moist	5.00	6.30	16.8	31.5	5.00	5.00	5.40	1
Tropical Montane Moist	5.00	5.40	9.0	9.0	5.00	5.00	3.48	1
Tropical Montane Dry	5.00	5.40	9.0	9.0	5.00	5.00	3.48	1
Tropical Dry	5.00	5.40	9.0	9.0	5.00	5.00	3.48	1
Tropical Moist	5.00	7.80	20.8	21.0	5.00	5.00	6.44	1
Tropical Wet	5.00	25.00	50.0	50.0	5.00	5.00	6.44	1

“Other land” category is set to zero.

Values for annual crops correspond to the proposed value[36] for default biomass carbon stocks present on land converted to cropland in the year following conversion. Paddy Rice is considered at the same level of Annual Crop. Set Aside Represents temporary set aside of annual cropland and therefore is also set at the same level as Annual Crop. Values for Grassland are derived from Table 6.4 (NGGI-IPCC-2006) using the default C content of 0.47. Degraded Land is set to 1, and can thus be used for areas where very little vegetation will be present. Values for Perennial are derived from Table 5.1 (Page 5.9, NGGI-IPCC-2006). Maximum values, i.e. Perennial Systems more than 10 years, are set using the default values indicated in Table 5.1 (Page 5.9, NGGI-IPCC-2006) in the column “Biomass C Loss” that represents the values at maturity according to the main climatic zone.

The maximum values are also used for younger systems according to the duration of the cycle indicated. For instance, for Tropical dry regions the cycle duration is set to 5 years, therefore Perennial Systems in the range 6-10 years are considered at the same level as older systems. Other values are calculated using the column annual growth rate and an average over the range of age considered. Other land is set to zero and thus should be used to represent land use without vegetation.

Final land-use: Proposed default biomass in t C after conversion, is detailed in Table NFOLUC-2.

Table NFOLUC-2: Default biomass C stock (t C ha-1) for system implanted after deforestation for the different climatic zones

Climate Region	Annual Crop	Perennial/ Tree Crop	Paddy Rice	Set Aside	Grassland	Degraded	Other
Boreal Dry	5.00	2.10	5.00	5.00	4.00	1	0
Boreal Moist	5.00	2.10	5.00	5.00	4.00	1	0
Cool Temperate Dry	5.00	2.10	5.00	5.00	3.06	1	0
Cool Temperate Moist	5.00	2.10	5.00	5.00	6.39	1	0
Warm Temperate Dry	5.00	2.10	5.00	5.00	2.87	1	0
Warm Temperate Moist	5.00	2.10	5.00	5.00	6.35	1	0
Tropical Montane Moist	5.00	1.80	5.00	5.00	4.09	1	0
Tropical Montane Dry	5.00	1.80	5.00	5.00	4.09	1	0
Tropical Dry	5.00	1.80	5.00	5.00	4.09	1	0
Tropical Moist	5.00	2.60	5.00	5.00	7.57	1	0
Tropical Wet	5.00	10.00	5.00	5.00	7.57	1	0

Values for Annual and Perennial crops correspond to the proposed value[37] for default biomass carbon stocks present on land converted to cropland in the year following conversion. Paddy Rice is considered at the same level of Annual Crop. Set Aside Represents temporary set aside of annual cropland and therefore is also set at the same level as Annual Crop. Values for

[36] Table 5.9 of NGGI-IPCC-2006.

[37] Table 5.9 of NGGI-IPCC-2006.

Grassland are derived from Table 6.4[38] using the default C content of 0.47. Other is set to zero, and can thus be used for constructions, roads, parking lots or any kind of land use where no vegetation will be present.

Then the variation between initial and final biomass is computed in t CO_2.

Soil C stocks variation: For soils, the estimation method is based on maximum changes in soil organic C stocks for soil under initial and final vegetation. Maximum Soil C stocks are calculated by multiplying a relative factor depending on the vegetation with the nominal C stocks which depend on soil type and climate. For the nominal soil C estimates, the default values are based on default references for soil organic C stocks for mineral soils to a depth of 30 cm[39]. Default Values (Table NFOLUC-3) are provided using the IPCC simplified soil classification.

Table NFOLUC-3: Default C stocks for nominal mineral soils to a depth of 30 cm (t C.ha^{-1})

Climate Region	HAC Soils	LAC Soils	Sandy Soils	Spodic Soils	Volcanic Soils	Wetland Soils
Boreal Dry	68		10	117	20	146
Boreal Moist	68		10	117	20	146
Cool Temperate Dry	50	33	34		20	87
Cool Temperate Moist	95	85	71	115	130	87
Warm Temperate Dry	38	24	19		70	88
Warm Temperate Moist	88	63	34		80	88
Tropical Montane Moist	65	47	39		70	86
Tropical Montane Dry	38	35	31		50	86
Tropical Dry	38	35	31		50	86
Tropical Moist	65	47	39		70	86
Tropical Wet	44	60	66		130	86

The relative factors[40] are based on the factors given by NGGI-IPCC-2006 for croplands systems[41] and Grassland[42]. These factors were fixed to the nominal values, where. The value given for a system is nominally managed, i.e. non-degraded and sustainably managed but without significant management improvements. Specific options of management and inputs that impact the soil C stocks in the newly implanted systems are treated in the *ad hoc* corresponding module. For instance, if a grassland system is set after deforestation, the C stock is unchanged (nominal value is set to 1), but in the Grassland module users can change the management of this specific grassland management system where initial state is fixed to nominal value (i.e. non degraded in this case). These changes therefore have additional mitigation options as retained in other modules. For the croplands systems, the

[38] NGGI-IPCC-2006.

[39] Table 2.3 in NGGI-IPCC-2006.

[40] Table NFOLUC-4.

[41] Table 5.5 pages 5.17-5.18 of NGGI-IPCC-2006.

[42] Table 6.2 page 6.16 of NGGI-IPCC-2006

nominal values correspond to the coefficient F_{LU} reported by NGGI-IPCC-2006. Degraded and Other (degraded) systems are set to 50% of the annual crop system.

Table NFOLUC-4: Relative factor used to compute the C stock for soil under the initial or final vegetation

Climate Region	Annual Crop	Perennial/ Tree Crop	Paddy Rice	Set Aside	Grass land	Other (nominal)	Other (degraded)
Boreal Dry	0.80	1.00	1.10	0.93	1.00	1.00	0.40
Boreal Moist	0.69	1.00	1.10	0.82	1.00	1.00	0.35
Cool Temperate Dry	0.80	1.00	1.10	0.93	1.00	1.00	0.40
Cool Temperate Moist	0.69	1.00	1.10	0.82	1.00	1.00	0.35
Warm Temperate Dry	0.80	1.00	1.10	0.93	1.00	1.00	0.40
Warm Temperate Moist	0.69	1.00	1.10	0.82	1.00	1.00	0.35
Tropical Montane Moist	0.64	1.00	1.10	0.88	1.00	1.00	0.32
Tropical Montane Dry	0.64	1.00	1.10	0.88	1.00	1.00	0.32
Tropical Dry	0.58	1.00	1.10	0.93	1.00	1.00	0.29
Tropical Moist	0.48	1.00	1.10	0.82	1.00	1.00	0.24
Tropical Wet	0.48	1.00	1.10	0.82	1.00	1.00	0,24

According to C stocks calculated under initial and final vegetation, EX-ACT calculates a coefficient k_{soil} used to estimate the C stocks variation associated with the corresponding succession. The validity timeframe for this coefficient is limited to 20 years.

9.3. Surface and GHG emissions

Users must inform the changes in surface with each successive system described above. The dynamics are set by default to linear, but can be changed (see background part). More details regarding the implementation or not of the project and the associated dynamics is described in the background part. Based on areas indicated and also considering vegetation characteristics and details indicated in other parts, the GHG balances in CO_2-Eq is calculated for the biomass and soil pool.

Data on land use (hectares) is also used to compute the land use matrix.

10. CROPLAND: ANNUAL MODULE

10.1. Generalities[43]

The Annual Module is made up of 2 sections:

[43] Material used to develop this module can be found in Chapter 8 "Agriculture" of volume "Mitigation" of the fourth Assessment Report of the IPCC (Smith et al., 2007), and in Chapter 2 of NGGI-IPCC-2006 "Generic Methodology Applicable to Multiple Land-Use Categories".

Figure 27: Definition of the annual systems and management practices

	Your description	User-defined practices	Name	Rate in tC/ha/yr	Improved agro- -nomic practices	Nutrient management	NoTillage/residues management	Water management	Manure application	Residue/Biomass Burning	t dm/ha
Reserved system A1	from Deforestation	NO			?	?	?	?	?	NO	10
Reserved system A2	Converted to A/R	NO			?	?	?	?	?	NO	10
Reserved system A3	Annual From OLUC	NO			?	?	?	?	?	NO	10
Reserved system A4	Converted to OLUC	NO			?	?	?	?	?	NO	10
Annual System1	Current system *	YES	Equilibrium	0	* A conservative approach is to consider this system at equilibrium or decreasing					YES	10
Annual System2		NO			?	?	?	?	?	NO	10
Annual System3		NO			?	?	?	?	?	NO	10
Annual System4		NO			?	?	?	?	?	NO	10
Annual System5		NO			?	?	?	?	?	NO	10
Annual System6		NO			?	?	?	?	?	NO	10
Annual System7		NO			?	?	?	?	?	NO	10
Annual System8		NO			?	?	?	?	?	NO	10
Annual System9		NO			?	?	?	?	?	NO	10
Annual System10		NO			?	?	?	?	?	NO	10

Figure 28: Area involved and corresponding GHG emissions

Mitigation potential												
Vegetation	Areas					Soil CO2 mitigated		CO2eq emitted from Burni		**Total Balance**		**Difference**
Type	Start	**Without project**		**With Project**		Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate					tCO2	tCO2	tCO2
System A1	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A2	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A3	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A4	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System2	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System3	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System4	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System5	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System6	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System7	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System8	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System9	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Annual System10	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0
Total Syst 1-10	0	0		0								
						Agric. Annual Total				0	0	0

10.2. Definition of the Annual System

The four First rows are reserved for:

- Newly implemented systems after deforestation (system A1) or from conversion of other land use systems (system A3), and for
- Annual systems that are converted either to plantation (system A2) or other Land-used (Systems A4).

These systems must be built only if in the project there is conversion from or to annual systems. The following lines concern Annual systems remaining annual systems with or without project implementation.

The "Annual System 1" is dedicated to a system that is traditionally used in the BAU option. In most cases as such systems have been implemented for long period of time, it is conservative to consider that the system is in equilibrium and no significant soil C changes occur. However, users can consider that the system is still losing or gaining C providing its own C rates of tC/ha/year (positive or negative).

For the other implemented systems, users can select for each system whether different management practices are implemented. 5 different default options are available[44]:

- Improved agronomic practices
- Nutrient management
- No-tillage and residues management
- Water Management
- Manure application

[44] Detailed explanation of the meaning of each practice can be found in Smith et al, 2007.

Note that some practices may present some overlapping. Some descriptions of the options are briefly given below.

- **Improved agronomic practices**: all practices that may increase yields and thus generate higher residues. Examples of such practices reported by Smith et al. (2007) are, using improved crop varieties, extending crop rotations, and rotations with legumes crops.
- **Nutrient management**: application of fertilizer, manure, and biosolids, improving either the efficiency (adjusting application rate, improving timing, location…) or diminishing the potential losses (slow release fertilizer form or nitrification inhibitors).
- **Tillage/residue management**: adoption of practices with less tillage intensity ranging from minimum tillage to no-tillage and with or without residues maintenance on the field.
- **Water management**: enhanced irrigation measures that can lead to an increase in the productivity (and hence of the residues).
- **Manure application**: improving nutrient source using manure or Biosolids.

Some of the practices may result in concomitant gain in terms of C sequestration, reduction of N_2O and C sources but also emissions increases, e.g. increase N_2O potential emissions associated with increases on external N inputs. The emissions or reduction of N_2O and CH_4 are not incorporated in default values and thus concern only the potential of C sequestration. Those factors depend on simplified climatic classification and are reported in Table Annual-1.

Table Annual-1: Annual mitigation potentials using only CO_2 effect ($tCO_2\ ha^{-1}\ yr^{-1}$) in each climate region for management categories implanted in EX-ACT

Management category	Simplified climatic classification			
	Cool Dry	Cool Moist	Warm Dry	Warm Moist
Improved agronomic practices	0.29	0.88	0.29	0.88
Nutrient management	0.26	0.55	0.26	0.55
Tillage/residues management	0.15	0.51	0.33	0.70
Water management	1.14	1.14	1.14	1.14
Manure application	1.54	2.79	1.54	2.79

All those coefficients represent annual soil carbon change rate for a 20-year time horizon in the top 30 cm of the soil.

Final emissions factors reported by Smith et al. (2007) are higher when considering non-CO_2 emissions (Table Annual-2). In order to avoid overly optimistic estimates and to maintain a conservative approach, only the mitigation effect linked with CO_2 was retained.

Table Annual-2: Annual net mitigation potentials including non-CO_2 GHG (tCO_2-eq ha^{-1} yr^{-1}) in each climate region for management categories

Management category	Simplified climatic classification			
	Cool Dry	Cool Moist	Warm Dry	Warm Moist
Improved agronomic practices	0.39	0.98	0.39	0.98
Nutrient management	0.33	0.62	0.33	0.62
Tillage/residues management	0.17	0.53	0.35	0.72
Water management	1.14	1.14	1.14	1.14
Manure application	1.54	2.79	1.54	2.79

Users also can define their own management category, entitled user-defined practices, and add a specific mitigation potential (in t C ha^{-1} yr^{-1}). If users want to consider the annual net mitigation potentials including non-CO_2 given in Table Annual-2, this can be done under the "user-defined practices". Note that the user-defined category has a priority on the default category to calculate the overall potential even if the value given is lower than default values.

Then a representative mitigation potential is determined as the maximum potential of all selected management practices. This approach is very conservative and supposed to be the best choice because there is evidence in the literature that some measures are not additive when applied simultaneously. If users want to use the sum of individual potential, this can be done under the user-specific option.

Users should also indicate if residues or biomass are burnt. A default amount of 10t DM per ha is proposed but can be replaced by a more specific or precise value. Emissions from biomass burning are calculated based on the generic methods proposed in section 2.4[45] presented in Generic methods. The combustion factor is set to 0.8 and the emissions factors are respectively 0.07 g N_2O and 2.7 g CH_4 per kg^{-1} dry matter burnt.

Users may also enter the yield of each annual crop in t/ha/yr. This information will be used in the value chain module, to calculate emissions per tons of product. Help is provided in the "yield sheet", which gives the evolution of yields for major crops over different regions.

10.3. Surface and GHG emissions

Users must provide data about the changes in surface with each successive system described above. The dynamics are set by default to linear, but can be changed (see background part). More details regarding the implementation or not of the project and the associated dynamics are described in the background part.

Based on areas indicated and considering also vegetation characteristics and details indicated in other parts the GHG balances in CO_2-Eq is calculated for the biomass and soil pool.

Note that total for systems 1-10, i.e. Annual crop remaining Annual crop must be the same at the beginning and at the end (with or without project).

[45] See page2.40-2.43 of NGGI-IPCC-2006.

Data on land use (hectares) is also used to compute the land use matrix.

11. CROPLAND: PERENNIAL MODULE

11.1.Generalities[46]

Figure 29: Definition of the perennial systems and management practices

	Your description	Residue/Biomass Burning	Interval (yr)	tonnes dm/ha	Aboveground Biomass Growth rate Default	Specific	Belowground Biomass Growth rate Default	Specific	Soil Effect Default t CO2/ha/yr	User default available	tCO2/ha/yr	CH4 kg	N2O kg	CO2eq t
Reserved system P1	From Deforestation	NO	1	10	2,1		0		0,7	NO		0	0	0,0
Reserved system P2	Converted to A/R	NO	1	10	0		0		0,7	NO		0	0	0,0
Reserved system P3	OLUC to Perennial	NO	1	10	2,1		0		0,7	NO		0	0	0,0
Reserved system P4	Perennial to OLUC	NO	1	10	0		0		0,7	NO		0	0	0,0
Perennial Syst 1		NO	1	10	0		0		0,7	NO		0	0	0,0
Perennial Syst 2		NO	1	10	0		0		0,7	NO		0	0	0,0
Perennial Syst 3		NO	1	10	0		0		0,7	NO		0	0	0,0
Perennial Syst 4		NO	1	10	0		0		0,7	NO		0	0	0,0
Perennial Syst 5		NO	1	10	0		0		0,7	NO		0	0	0,0

Figure 30: Surface and GHG emissions

Mitigation potential														
Vegetation Type	Areas					CO_2 mitigated from Biomass		CO_2 mitigated from Soil		CO_2eq emitted from Burnir		**Total Balance**		**Difference**
	Start t0	**Without project** End	Rate	**With Project** End	Rate	Without	With	Without	With	Without	With	Without tCO_2	With tCO_2	tCO2eq
System P1	0	*0*	*Immediate*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
System P2	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
System P3	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
System P4	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Perennial Syst 1	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Perennial Syst 2	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Perennial Syst 3	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Perennial Syst 4	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Perennial Syst 5	0	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Total Syst 1-5	0	0		0										
									Agric. Annual Total			**0**	**0**	**0**

11.2. Definition of the Perennial System

The four first rows are reserved for a) newly implemented systems after deforestation (System P1) or from conversion of other land use systems (System P3), and for b) Annual systems that are converted either to plantation (system P2) or other Land-used (Systems P4). These systems must be informed only if in the project there is conversion from or to Perennial systems. The following lines concern Perennial systems remaining Perennial systems with or without project implementation.

Users should indicate if residues or biomasses are burnt and indicate the interval (in year) of fire occurrence. The default biomass is set to 10 t DM per ha and the interval is set to 1, i.e., one episode of residue burning each year.

Default above and below ground biomass growth rates are given, but users can indicate their own or specific values.

Default Below ground biomass growth rate is set to zero due to missing default coefficients. Above ground biomass growth is set using IPCC default from table 5.1[47]: 2.1 t C ha^{-1} yr^{-1} for

[46] Material used to develop this module can be found in Chapter 8 "Agriculture" of volume "Mitigation" of the fourth Assessment Report of the IPCC (Smith et al., 2007), and in Chapter 2 of NGGI-IPCC-2006 "Generic Methodology Applicable to Multiple Land-Use Categories".

[47] page 5.9 in Chapter 5 Cropland of NGGI-IPCC-2006.

all Temperate climates, 1.8 t C ha^{-1} yr^{-1} for Tropical dry, 2.6 t C ha^{-1} yr^{-1} for Tropical moist and 10 t C ha^{-1} yr^{-1} for Tropical wet. Default for Temperate climate is also used for Boreal climate. Tropical montane is set arbitrarily to the lower value of Tropical systems i.e. 1.8t C ha^{-1} yr^{-1}. For all Perennial systems remaining Perennial systems, and systems converted to plantation or other land-use, the default above and below ground growth rates are set to zero because it is considered that systems are near equilibrium. Users can use their own values if they consider that systems are still growing.

Perennial systems (e.g. agro-forestry) can also store carbon C in soil. Default C storages correspond to values indicated for agro-forestry systems, i.e. 0.15 t CO_2-eq ha^{-1} $yr^{-1}$for Cool Dry regions, 0.51 t CO_2-eq ha^{-1} yr^{-1} for Cool Moist Regions, 0.33 t CO_2-eq ha^{-1} yr^{-1} for Warm Dry regions and 0.70t CO_2-eq ha^{-1} yr^{-1} for Warm Moist regions. It is recommended using more specific values if available.

Emissions from biomass burning are calculated based on the generic methods proposed in section 2.4 (see page 2.40-2.43 of NGGI-IPCC-2006) presented in Generic methods. The combustion factor is set to 0.8 and the emissions factors are respectively 0.21 g N_2O and 2.3 g CH_4 per kg^{-1} dry matter burnt.

Users may also enter the yield of each perennial crop in t/ha/yr. This information will be used in the value chain module, to calculate emissions per tons of product. Help is provided in the “yield sheet”, which gives the evolution of yields for major crops over different regions.

11.3. Surface and GHG emissions

Users must provide information on the changes in the surface area with each successive system described above. The dynamics are set by default to linear, but can be changed.[48]

Based on areas indicated and considering also vegetation characteristics and details indicated in other parts the GHG balances in CO_2-Eq is calculated for the biomass and soil pool.

Note that total for systems 1-10, i.e. perennial system remaining perennial system must be the same at the beginning and at the end (with or without project).

The areas informed are also used to build the matrix of change.

12. CROPLAND: IRRIGATED RICE MODULE

12.1. Generalities

Material used to develop this module can be found in Volume 4 (AFOLU)[49] for GHG emissions for biomass burning[50] and Part 5.5 for methane emission from rice cultivation[51].

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[48] See Chapter 3, EX-ACT background part. More details regarding the implementation or not of the project and the associated dynamics are also described.

[49] NGGI-IPCC-2006, Part 5.2.4.

The “Rice Module” concerns only flooded (permanently or part of the year) rice fields. Non flooded rice, i.e. upland rice or pure rain-fed rice is considered an annual crop and must therefore be treated in the “Annual Module”

GHG covered by the “Rice Module” are (i) methane (CH_4) emission produced from anaerobic decomposition of organic matter and (ii) non-CO_2 GHG emissions (CH_4 and N_2O) from Biomass burning when occurring. CO_2 emissions from biomass burning do not have to be considered since the carbon release during the combustion is assumed to be reabsorbed by the vegetation during the next growing season. The N_2O emissions from N-fertilizer applied in rice fields is treated in the “Inputs Module”

12.2. Details regarding the calculation and proposed default values

Methane emission from rice cultivation

Calculations are based on equations 5.1 and 5.2 of NGGI-IPCC-2006 with coefficients proposed for the Tier 1 approach. Methane emissions for one hectare of a determined rice system are estimated by multiplying daily emission factors by cultivation period of rice:

$$CH_4\text{-Rice System}_i = EF_i \times t_i$$

Where :

CH_4 = annual methane emission from rice cultivation, in kg CH_4 per ha per year.
EF_i = a daily emission factor for Rice $System_i$, in kg CH_4 per ha per day.
t = cultivation period of rice for Rice $System_i$

EFi incorporates a baseline emission factor multiplied by scaling factors to adjust for the principal various conditions that are known to influence the methane emission from rice cultivation. Baseline emission factor corresponds to continuously flooded field during the rice cultivation period, and no flooded field for less than 180 days prior to rice cultivation, and without organic amendments. The tier 1 default IPCC baseline $EF_{Baseline}$ is 1.30 kg CH_4 ha^{-1} day^{-1}. [52] This factor is corrected by multiplying three specific factors accounting for the flooding patterns before (EF_{before}) and during (EF_{during}) the cultivation period, and the use of organic amendments (EF_{OA}):

$$EF_i = EF_{Baseline} \times EF_{before} \times EF_{during} \times EF_{OA}$$

The scaling factors were derived from Table 5.12 and 5.13 respectively for EF_{before} and EF_{during}. (see Table RM-1).

[50] pages 5.24- 5.25 of NGGI-IPCC-2006.

[51] Pages 5.44-5.53 of NGGI-IPCC-2006.

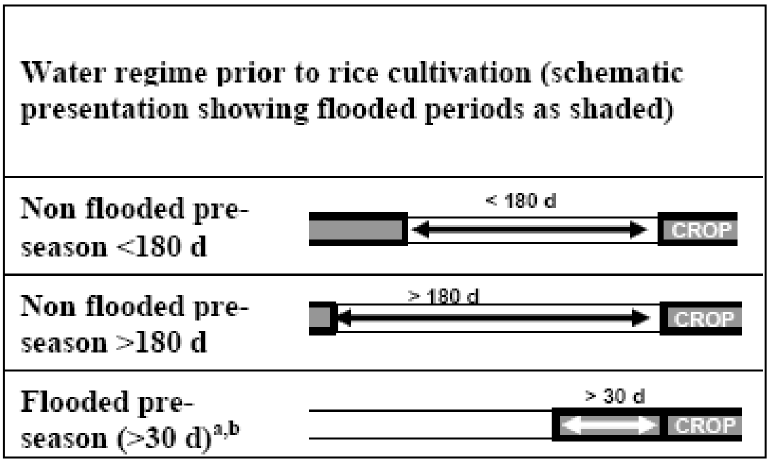
[52] This factor was calculated using Yan et al., 2005.

Table RM-1: Default scaling factor for water regimes before and during the cultivation period

Period considered	Water regime	Scaling factor generic name	Scaling factor value
Before	Non flooded pre-season < 180 days	EFbefore	1
Before	Non flooded pre-season > 180 days	EFbefore	0.68
Before	Flooded pre-season > 30 days	EFbefore	1.90
During	Irrigated - Continuously flooded	EFduring	1
During	Irrigated - Intermittently flooded	EFduring	0.56
During	Rainfed and deep water	EFduring	0.27

In the Rice Module a figure (given in Table 5.13) is reproduced in order to help the users in the meaning of the different water regimes before the cultivation period (see Figure 31below)

Figure 31: Figure illustrating the different water regime before the cultivation period



Concerning the water regime during the cultivation period, the 3 categories cover the following situations:

- **Irrigated – Continuously flooded**: fields have standing water throughout the rice growing season and may only dry out for harvest (end-season drainage).
- **Irrigated – Intermittently flooded:** Fields have at least one aeration period of more than 3 days during the cropping period, no difference is made here for single or multiple aeration. The default scaling factor proposed (0.56) is the average of the value proposed for both these cases, respectively 0.60 and 0.52.
- **Rainfed and deep water**: Fields are flooded for a significant period of time and water regime depends solely on precipitation. It includes the following subcases: (i) regular rainfed (the water level may rise up to 50cm during the cropping season), (ii) drought prone (drought periods occur during every cropping season), and (iii) deep water rice (Floodwater rises to more than 50cm for a significant period of time during the cropping season). The scaling factor used in the RM is the aggregated value proposed for these 3 subcases (i.e. 0.27), because the factors reported for the 3 subcases are relatively similar

(respectively 0.28, 0.25 and 0.31) and different from the coefficient proposed for the irrigated cases.

In total 9 different rice systems can be built concerning the different water regimes with corresponding emissions ranging from 0.24 to 2.47 $CH_4.ha^{-1}.day^{-1}$, i.e. a ratio maximum/minimum of 10. Thus, users should carefully provide information on the water managements before and during the cultivation period of the rice systems, because a small change can bring about quite different results!

Regarding organic amendment (compost, farmyard manure, green manure and rice straw) the EF_{OA} scaling factor is calculated using Equation 5.3 and default values proposed in Table 5.14.[53]

$$EF_{OA} = (1 + R_{OA} \times CF_{OA})^{0.59}$$

Where:

EF_{OA} = scaling factor for both type and amount of organic amendment applied.

R_{OA} = application rate of organic amendment, in dry weight for straw and fresh weight for others ton ha^{-1}. A default value of 5.5 t (DM of straw of fresh weight of other material) is proposed, but the recommendation is to replace this value with more specific information if available. The default values of 5.5 correspond to the proposed default values for agricultural (post harvest field burning) residues for rice in Table 2.4 [54]entitled “fuel (dead organic matter plus live biomass) biomass consumption values (tons dry matter ha-1) for fires in a range of vegetation types”.

CF_{OA} = conversion factor for organic amendment (in terms of its relative effect with respect to straw applied shortly before cultivation). Seven default values are proposed to the users according to the type and management of the residues or organic amendment (Table RM-2 below). Straw application means that straw is incorporated into the soil; it does not include the case that straw is just placed on the soil surface (no proposed specific factor in NGGI-IPCC-2006)

Table RM-2: Default conversion factor for different types of organic amendment

Option proposed in the Rice Module	Corresponding CFOA
Straw burnt	0
Straw exported	0
Straw incorporated shortly (<30d) before cultivation)	1.00
Straw incorporated long (>30d) before cultivation)	0.29
Compost	0.05
Farm yard manure	0.14
Green manure	0.50

[53] NGGI-IPCC-2006.

[54] NGGI-IPCC-2006.

12.3. Non-CO_2 GHG emissions (CH_4 and N_2O) from Biomass burning

Non-CO_2 GHG emissions from biomass burning are based on the generic method presented for all Biomass in chapter 2.4 of Volume 4.[55] Amount of GHG emitted is determined using the following equation:

$$GHG_{fire} = M_{Biomass} \times C_F \times G_{ef}$$

Where:

GHG_{fire} = amount of GHG emissions from fire, kg of each GHG, (CH_4, N_2O) ha^{-1}.
M = mass of fuel available for combustion, tons DM ha^{-1}.
C_F = combustion factor, dimensionless.
G_{ef} = emission factor, kg GHG.t^{-1} dry matter burnt.

For M a default value of 5.5 t DM of straw is proposed, but the recommendation is to replace this value with more specific information if available. The default values of 5.5 t DM correspond to the proposed default values for agricultural (post harvest field burning) residues for rice in Table 2.4[56] entitled "fuel (dead organic matter plus live biomass) biomass consumption values (tons dry matter ha-1) for fires in a range of vegetation types". $M_{Biomass}$ corresponds to R_{OA} coefficient in the case of trash residues (see above). C_F corresponds to the proportion of prefire fuel biomass consumed by fire, it is set to 0.8 using the combustion factor proposed for rice residues in Table 2.6.[57] Gef is set to 0.07 kg.t^{-1} DM for N_2O and 2.7 kg.t^{-1} DM for CH_4, using the default values proposed for the agricultural residues in Table 2.5.[58]

Then the total amount is calculated in kg CO_2-eq using the GWP retained by users (see Module Description). For the default value of 5.5 DM of rice straw the amount of non-CO_2 released is therefore equivalent to $5.5 \times 0.8 \times 0.07 = 0.308$ kg N_2O plus $5.5 \times 0.8 \times 2.7 = 11.88$ kg CH_4, i.e., considering the official GWP for CDM project, 0.345t CO_2-eq.

12.4. Description of the Rice Module

Two different tables are composed for the Rice Module, the first one is for users to describe the different rice systems present within the project boundaries, the second one is for users to identify the surface change both with and without the project implementation and the dynamic of change[59].

[55] NGGI-IPCC-2006.
[56] NGGI-IPCC-2006.
[57] NGGI-IPCC-2006.
[58] NGGI-IPCC-2006.
[59] See Chapter 3. EX-ACT.

Figure 32: Building the different Rice systems

	Your description	Cultivation period (Days)	Water Regime: During the cultivation Period	Water Regime: Before the cultivation period need help	Organic Amendment type (Straw or other)	rate tonne	Specific C change Delta C* tCO2eq/ha/yr
Reserved system R1	from Deforestation	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Reserved system R2	converted to A/R	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Reserved system R3	from OLUC	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Reserved system R4	Rice to OLUC	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice1		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice2		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice3		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice4		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice5		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice6		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice7		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice8		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice9		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	
Rice10		150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5,5	

The first two lines are reserved to be used in conjunction with (i) the deforestation module if the deforested area is converted to flooded (or paddy) rice (first line of the table), or (ii) in case of conversion of flooded rice field in Afforested or Reforested area (second line of the table). The following 10 lines can be used to build the different systems providing information on:

- The length in day of the rice cultivation period; users can find useful information at www.irri.org/science/ricestat and www.faostat.fao.org . In particular, a rice crop calendar by country is available at http://www.irri.org/science/ricestat/data/may2008/WRS2008-AppendixTable04.pdf (see Figure 33).

Figure 33: Extract of rice crop calendar provided by IRRI

Appendix Table 4. Rice crop calendar, by country.

CROP AND COUNTRY	Planting	Harvest	Bulk of harvest
ASIA			
Bangladesh			
Aus	Apr	Jul-Sep	Aug
Transplanted aman	Jul-Aug	Nov-Jan	Dec
Broadcasted aman	Apr	Late Oct-Dec	Nov
Boro	Dec	Apr-May	May
Cambodia			
Main	Jun-Jul	Dec-Jan	
Second	Dec-Jan	Mar	
China, PR			
Early crop	Feb-May	Jun-Jul	Jul
Intermediate[a]	Mar-May	Aug-Oct	Sep
Late rice	Jun-Jul	Oct-Nov	
Northern	Mid-Apr to Mid-Jun		Sep

- The water management regime and the information concerning the organic amendment. In total, 9 different water regimes can be built, combined with 7 options for the organic amendment, i.e. a total of 63 different rice systems.
- Users can inform eventual specific C change (in t CO_2-eq ha^{-1} yr^{-1}) positive value corresponds to an increase of soil organic carbon). The validity timeframe for this coefficient is limited to 20 years.

- Users can also enter the yield in t/ha/yr. This information will be used in the value chain module, to calculate emissions per tons of product. Help is provided in the "yield sheet", which gives the evolution of yields for major crops over different regions.

Figure 34: Information on the changes (surface and dynamics)

Areas (ha) of the different options					
	Start	Without Project		With Project	
Type	t0	End	Rate	End	Rate
System R1	0	0	Linear	0	Linear
System R2	0	0	Linear	0	Linear
System R3	0	0	Linear	0	Linear
System R4	0	0	Linear	0	Linear
Rice1	0	0	Linear	0	Linear
Rice2	0	0	Linear	0	Linear
Rice3	0	0	Linear	0	Linear
Rice4	0	0	Linear	0	Linear
Rice5	0	0	Linear	0	Linear
Rice6	0	0	Linear	0	Linear
Rice7	0	0	Linear	0	Linear
Rice8	0	0	Linear	0	Linear
Rice9	0	0	Linear	0	Linear
Rice10	0	0	Linear	0	Linear
Total Systems 1-10	0	0		0	

Users must enter the changes in surface associated with each rice system described previously. The dynamics are set by default to linear, but can be changed.[60] The last line provides alert error if the total for systems 1 to 10 changes over time.

The tools will automatically calculate the corresponding amount of emissions (positive values) or emissions avoided (negative values) for each rice system. All values are calculated and reported in t CO_2-eq:

[60] See Chapter 3. EX-ACT.

Figure 35: Emissions from the irrigated rice cultivation

Change over the period						
CH4 emitted (tCO2eq)		Straw burning		Total		Difference
All period		t CO2 eq		t CO2 eq		tCO2eq
Without	With	Without	With	Without	With	
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
			Total	0,0	0,0	0,0

13. GRASSLAND MODULE

13.1. Generalities [61]

This Module calculates GHG balance associated with soil C stock changes and periodic burning of the grasslands.

The Grassland Module is built according to 2 parts:

Figure 36: Definition of the Grassland systems and management practices

Description of Grassland type, their management and areas (ha)													
Name of the Systems		Initial state	Final State of the grassland		Fire used to manage				Soil Carbon Stock (after 20 yrs)			Delta Soil C*	
					Without project		With project		Cstart	Cend without	Cend with	Without	With
Default	Your name		Without Project	With Project	Fire*	Interval (yr)	Fire*	Interval (yr)	t C/ha	t C/ha	tC/ha	tCO2eq/ha/yr	
Reserved system G1	from Deforestation	Non degraded	Non degraded	Non degraded	NO	5	NO	5	63.00	63.00	63.00	0.00	0.00
Reserved system G2	converted to A/R	Non degraded	Non degraded	Non degraded	NO	5	NO	5	63.00	63.00	63.00	0.00	0.00
Reserved system G3	From OLUC	Non degraded	Non degraded	Non degraded	NO	5	NO	5	63.00	63.00	63.00	0.00	0.00
Reserved system G4	Grassland to OLUC	Non degraded	Non degraded	Non degraded	NO	5	NO	5	63.00	63.00	63.00	0.00	0.00
Grass-1		Select state	Select state	Select state	NO	5	YES	5	0.00	0.00	0.00	0.00	0.00
Grass-2		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-3		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-4		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-5		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-6		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-7		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-8		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-9		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00
Grass-10		Select state	Select state	Select state	NO	5	NO	5	0.00	0.00	0.00	0.00	0.00

[61] Material used to develop this module can be found in Chapter 6 "*Grassland*" of the Volume 4 (AFOLU) of the NGGI-IPCC-2006, and in Chapter 2 of NGGI-IPCC-2006 "*Generic Methodology Applicable to Multiple Land-Use Categories*".

Figure 37: Surface and GHG emissions

Default		Start	Without project		With Project		Soil C variations (tCO2eq		Total CO2 eq from fire		Total CO2eq		Difference
		t0	End	Rate	End	Rate	Without	With	Without	With	Without	With	tCO2eq
System G1	from Deforestation	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	**0**
System G2	converted to A/R	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	**0**
System G3	From OLUC	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	**0**
System G4	Grassland to OLUC	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	**0**
Grass-1		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-2		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-3		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-4		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-5		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-6		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-7		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-8		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-9		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Grass-10		*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	**0**
Total Syst 1-10		0											
									Grassland total		0	0	**0**

13.2. Definition of the Grassland System

The first four lines are reserved for a) newly implemented grasslands after deforestation (System G1) or from conversion of other land use systems (System G3), and for b) Grassland systems that are converted either to plantation (system G2) or other Land-used (Systems G4). These systems must be informed only if in the project there is conversion from or to Grassland systems. The following lines concern Grassland systems that remain Grassland systems with or without project implementation.

Users should indicate the state of the grassland and identify the initial and the final state (without project and with project) if there is a change of management. Available options are:

- Severely Degraded
- Moderately Degraded
- Improved without inputs management, and
- Improved with inputs improvement

Users should also identify the fire occurrence and interval (in year) of occurrence with or without the project. The default value for fire interval occurrence is set to 5, i.e. burning will occurs every 5 years.[62] Briefly degraded grassland category implies a major long-term loss of productivity and vegetation cover, due to severe mechanical damage to the vegetation and/or severe soil erosion. Moderately degraded grassland category represents overgrazed or moderately degraded grassland, with somewhat reduced productivity (relative to the native or nominally managed grassland) and receiving no management inputs. Improved grassland category gathers grasslands which are sustainably managed with moderate grazing pressure and that receive at least one improvement (e.g., fertilization, species improvement, irrigation). The improved category with input improvement applies to improved grassland where one or more additional management inputs/improvements have been used.

Users may also enter the yield for both situations (with and without the project) in t/ha/yr. This information will be used in the value chain module, to calculate emissions per tons of product. Help is provided in the software “yield sheet”, which gives the evolution of yields for major crops in different regions.

[62] These options correspond to those described by NGGI-IPCC-2006.

13.3. Details regarding the calculation and proposed default value

Soil (column G): : The soil C estimates are based on default references for soil organic C stocks for mineral soils to a depth of 30cm as previously described in generic methodologies above. The estimation method is based on changes in soil organic C stocks over a finite period following changes in management that impact on soil organic C, as described previously in the generic methodologies. According to information provided, EX-ACT calculates a coefficient Delta C_{soil} used to estimate the C stocks variation according to the change in the grassland management. The coefficients Delta Csoil are based on the relative factors k_{soil} given by NGGI-IPCC-2006 for Grassland.[63] Note that these factors in the case of the four reserved grassland systems are in addition to nominal values used for grassland in the corresponding Module.[64]

Delta C_{soil} is determined as the difference between reference C stocks according to the management condition, over a reference period of 20 years. Those C stocks are calculated from the nominal C stock that corresponds to information provided in the description module (dominant soil type and climate). Carbon Stock for severely degraded grassland is obtained by multiplying nominal C stock with 0.7 for all regions. Carbon Stock for moderately degraded grassland is obtained by multiplying nominal C stock with 0.95 for Temperate and Boreal regions, 0.97 for all tropical regions and 0.96 For Tropical montane regions. Carbon Stock for Improved degraded grassland is obtained by multiplying nominal C stock with 1.14 for Temperate and Boreal regions, 1.17 for all tropical regions and 1.16 for Tropical montane regions. Additionally improved grassland with inputs improvements are subsequently multiplied by 1.11.

Corresponding Delta C_{soil} obtained is only valid for the first 20 years of change.

Fire emissions: The emission from burning of individual GHG (N_2O or CH_4) is obtained using the generic method. For Grassland systems default above ground biomass is set according to the climate region (Table GM-1).

Table GM-1: Default aboveground biomass stocks present on grassland

Climatic regions	Biomass (t DM ha-1)
Boreal (Dry and Wet)	1.7
Cool Temperate Dry	1.7
Cool Temperate Moist	2.7
Warm Temperate Dry	1.6
Warm Temperate Moist	2.7
Tropical Montane (Moist and Dry)	2.3
Tropical Dry	2.3
Tropical Moist	6.2
Tropical Wet	6.2

[63] See Table 6.2 page 6.16 of NGGI-IPCC-2006.

[64] Deforestation, A/R and NFOLUC modules.

The combustion factor is set to 0.77 and the emissions factors are respectively 0.21 g N_2O and 2.3 g CH_4 per kg^{-1} dry matter burnt.

13.4. Surface and GHG emissions

Users must provide information on the changes in the surface area for each grassland system described above. By default, the dynamics are set to linear, but can be changed.[65] Based on areas indicated and also considering management characteristics and details indicated in the rest of the grassland module the GHG balances in CO_2-Eq is calculated for the change in soil C stock and emissions from burning. Note that the total for systems 1-10, i.e. grassland system remaining grassland system must be the same at the beginning and at the end (with or without project).

The areas informed are also used to build the matrix of change.

14. ORGANIC SOILS MODULE

14.1. Generalities[66]

This Module calculates GHG balance associated with the management of organic soils. It allows users to consider patches of organic soils across a landscape defined mostly by another soil type. According to FAO, soils are classified as "organic soils" when they satisfied the following statements (1 and 2, or 1 and 3)[67]:

[65] See Chapter 3. EX-ACT. More details regarding the implementation feasibility of the project or not and the associated dynamics.

[66] Material used to develop this module can be found in Chapter 7 "Wetlands" of the Volume 4 (AFOLU) of the NGGI-IPCC-2006.

[67] FAO. 1998. World Reference Base for Soil Resources. World Soil Resources Reports 84. FAO, Rome. 88pp. (ISBN 92-5-104141-5).

Figure OM-1: Definition of organic soils

1) Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20cm must have 12 percent or more organic carbon when mixed to a depth of 20cm.

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 i) at least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay; or ii) at least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay; or iii) an intermediate, proportional amount of organic carbon for intermediate amounts of clay.

Source: FAO, 1998.

The Organic soils Module is built according to 4 parts:

Figure 38: Emissions from loss of C associated with drainage of organic soils

Emissions from loss of C associated with drainage of organic soils

Type of Land use	Emission factors (tonnes C ha-1 yr-1)			Surface of organic soils concerned (ha)					Emission (tCO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start	Without Project		With Project		Start	End		All Period		
										Without	With	Without	With	
Managed Forest	1.36		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Annual	20.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Perennial	1.36		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Grassland	5.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0

Figure 39: On-site CO2 emissions from peatlands undergoing active peat extraction

On-site CO2 emissions from peatlands undergoing active peat extraction

Type of Peat	Emission factors (tonnes C ha-1 yr-1)			Surface of organic soils concerned (ha)					Emission (tCO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start	Without Project		With Project		Start	End		All Period		
										Without	With	Without	With	
Nutrient-poor peat	2.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Nutrient Rich	2.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0

Figure 40: On site CO2 emissions from peat use

On-site N2O emissions from peatlands undergoing active peat extraction

Type of Peat	Emission factors (kg N2O-N ha-1 yr-1)			Surface of organic soils concerned (ha)					Emission (tCO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start	Without Project		With Project		Start	End		All Period		
										Without	With	Without	With	
Nutrient-poor peat	0.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Nutrient Rich	3.60		YES	0	0	Linear	0	Linear	0	0	0	0	0	0

Figure 41: On-site N2O emissions from peatlands undergoing active peat extraction

On site CO2 emissions from peat use (energy use, horticultural use"..)

Type of Peat	C fraction (tonnes C (tonne air-dry peat)-1)			Air-dry weight of extracted peat, tonnes yr-1 (If you have volume of Peat use conversion factor on the right -->)					Emission (tCO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start	Without Project		With Project		Start	End		All Period		
										Without	With	Without	With	
Nutrient-poor peat	0.3		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Nutrient Rich	0.34		YES	0	0	Linear	0	Linear	0	0	0	0	0	0

14.2. Emissions from loss of C associated with drainage of organic soils

Drainage is a practice used in agriculture and forestry to improve site conditions for plant growth. This tool allows users to calculate the impact of the drainage of organic soils on four types of land uses : managed forest, annual, perennial, grassland[68].

Inputs of organic matter can exceed decomposition losses under anaerobic conditions, which are common in undrained organic soils, and considerable amounts of organic matter can accumulate over time. Carbon stored in organic soils will readily decompose when conditions become aerobic following soil drainage. The basic methodology to assess stock changes is to stratify managed organic soils by climate region and assign a climate specific annual C loss rate. Land areas are multiplied by emission factors. C Loss rates vary by climate, with drainage under warmer conditions leading to faster decomposition rates.

Wetland drainage, especially peatland, results in an increase in CO_2 emissions due to increased oxidation of soil organic material, an increase in N_2O emissions and a possible reduction of CH_4 emissions that occur in un-drained organic soils. However there is currently no methodology to assess CH_4 emissions. Thus they are not taken into account in EX-ACT.

Users should indicate the surface of organic soils that is drained in the initial and final state (future with and without project).

Emissions are calculated by multiplying an emission factor by the area concerned, and converted in CO_2eq.

Table OM-1: Emission factors for drained organic soils in t of C ha^{-1} yr^{-1}

Climate zone	Managed forest	Cultivated soils	Grassland	Perennials
Boreal dry	0.16	5	0.25	0.16
Boreal moist	0.16	5	0.25	0.16
Cool temperate dry	0.68	5	0.25	0.68
Cool temperate moist	0.68	5	0.25	0.68
Warm temperate dry	0.68	10	2.5	0.68
Warm temperate moist	0.68	10	2.5	0.68
Tropical montane dry	1.36	20	5	1.36
Tropical montane moist	1.36	20	5	1.36
Tropical dry	1.36	20	5	1.36
Tropical moist	1.36	20	5	1.36
Tropical wet	1.36	20	5	1.36

68 The emissions factors for drained organic soils come from the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU), Table 4.6, table 5.6, and table 6.3

14.3. On-site CO2 emissions from peatlands undergoing active peat extraction

This section covers emissions from peatlands undergoing active peat extraction. Use of peat is widely distributed; about half is used for energy; the remainder for horticultural, landscape, industrial waste water treatment, and other purposes.[69]

Peat extraction starts with vegetation clearing, which prevents further carbon sequestration, so only CO_2 emissions are considered. They are obtained by multiplying an emission factor by the area concerned.[70]

Table OM-2: Emission factors for land managed for peat extraction, by climate zone in t of C ha^{-1} yr^{-1}

Climate zone	Emission factor	Uncertainty
Boreal and Temperate		
- Nutrient poor	0.2	0 to 0.63
- Nutrient rich	1.1	0.03 to 2.9
Tropical	2	0.06 to 7.0

Two kinds of peats are provided within EX-ACT; i) the nutrient-poor, and ii) the nutrient-rich peats, knowing that higher emissions are associated with nutrient-rich peats.

Nutrient-poor bogs predominate in boreal regions, while in temperate regions, nutrient-rich fens and mires are more common. Types of peatlands can be inferred from the end-use of peat: sphagnum peat, dominant in oligotrophic (nutrient-poor) bogs (acidic wetland that receive water exclusively from stifled flow of nutrient-poor rainwater), is preferred for horticultural uses, while sedge peat, more common in minerotrophic (nutrient rich) fens (waterlogged habitat that tend to be alkaline and nourished by mineral-rich surface and groundwater), is more suitable for energy generation. Boreal countries that do not have information on areas of nutrient-rich and nutrient-poor peatlands should use the emission factor for nutrient-poor peatlands. Temperate countries that do not have such data should use the emission factor for nutrient-rich peatlands. Only one default factor is provided for tropical regions, so disaggregating peatland area by soil fertility is not necessary for tropical countries using the Tier 1 method.

Users should indicate which area of peatland is going to be extracting from the initial to the final situation (with and without project).

[69] International Peat Society, 2004.

[70] cf. Table OM-2 and table 7.4 of the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU).

14.4. On site CO_2 emissions from peat use

Once the peat is extracted, it can be used for different purposes that may lead to additional emissions, depending on the quantity of peat extracted.

Emissions are calculated by multiplying a conversion factor with the quantity extracted per year, and converted in CO_2eq. By default, the conversion factors proposed by the IPCC are 0.34 tC/t air dry peat for tropical humus climate zone, 0.4 for nutrient-rich boreal and temperate climate zones, 0.45 for nutrient-poor boreal and temperate climate.[71]

Users should indicate this air-dry weight of extracted peat in tonne per year. If users only have this data in volume, a box on the right side of the screen called conversion factor is proposed. Thus users can enter the volume and get the information required in tonne.

14.5. On-site N_2O emissions from peatlands undergoing active peat extraction

More than CO_2 emissions, the active extraction of peat leads to emit N_2O. The method to estimate N_2O emissions from drained wetlands is similar to that described for drained organic soils for agriculture or forestry, but emission factors are generally lower. The default methodology only considers nutrient-rich peatlands. The tool automatically accounts the surface indicated in the previous part (On-site CO_2 emissions from peatlands undergoing active peat extraction) multiplied by an emission factor[72]. The IPCC only provides default emission factors for nutrient-rich organic soils in boreal and temperate climate zone equals to 1.8 kg N_2O-N ha^{-1} $year^{-1}$ and another one for tropical climate equals to 3.6 kg N_2O-N ha^{-1} $year^{-1}$. The emissions in nutrient-poor organic soils in boreal and temperate climate are neglected.

15. LIVESTOCK MODULE

15.1. Generalities

Material used to develop this module can be found in Volume 4 (AFOLU) of the NGGI-IPCC-2006, Chapter 10 “Emissions from Livestock and Manure Management”, and from Chapter 8 of the Fourth Assessment Report from working group III of IPCC[73] for specific technical mitigation options not covered in NGGI-IPCC-2006.

GHG covered by the “Livestock Module” are (i) methane (CH_4) emissions from enteric fermentation, (ii) methane emissions from manure management, (iii) nitrous oxide emissions from manure management and also (iv) some methane additional technical mitigation from livestock.

[71] cf. Table 7.5 of the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU).

[72] cf. Table 7.6 of the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU).

[73] Smith et al., 2007.

15.2. Methane emissions from enteric fermentation

Figure 42: CH_4 emissions from enteric fermentation

Methane emissions from enteric fermentation				Head Number					Emission (t CO2eq) per year			Total Emission (tCO2eq)		
	IPCC factor	Specific factor	Default Factor	Start	Without Project		With Project		Start	End		All Period		Difference
Choose Livestocks:				t0	End	Rate	End	Rate		Without	With	Without	With	
Dairy cattle	40		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Other cattle	31		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Buffalo	55		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Sheep	5		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Swine (Market)	1,5		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Swine (Breeding)	1,5		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Goats	5		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Camels	46		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Camels	46		YES	0	0	Linear	0	Linear	0	0	0	0	0	0
User Defined- Specified value --------------->			NO	0	0	Linear	0	Linear	0	0	0	0	0	0
User Defined- Specified value --------------->			NO	0	0	Linear	0	Linear	0	0	0	0	0	0
								Sub-Total L	0	0	0	0	0	0

[l1]

EX-ACT uses the Tier 1 method so that only animal population data (in addition to information already provided in the software description module) is needed to estimate the emissions. Users can always use their own emission factors if available. To fill the information users should as a first step divide the livestock population into subgroups. It is recommended to use annual averages estimated with consideration for the impact of production cycles and seasonal influences on population numbers.

Six main categories of livestock are fixed, therefore there is a specific line to calculate methane emissions from Dairy Cattle, Other Cattle (all other non-dairy cattle are included in this category and must be summarised), Buffalo, Sheep, Swine (market) and Swine (breeding). The category Swine (market) corresponds to animals produced for meat which are slaughtered before maturity (between 80-110 kg usually) whereas Swine (breeding) are bigger. In case users do not have the necessary information, consider all animals as Swine (market).

In addition users may choose up to 3 different animal categories from the following choices: Goats, Camels, Horses, Mules and Asses, Poultry, Deer and Alpacas. Finally two lines are available for user-defined livestock not covered previously.

Here, Dairy Cattle category corresponds to mature cows that are producing milk in commercial quantities for human consumption. This definition corresponds to the dairy cow population reported in the FAO Statistical Yearbook[74]. Low productivity, multi-purpose cows should be considered as other cattle

The amount of methane from enteric fermentation is calculated based on the generic method, i.e. multiplying an emission factor per animal with the corresponding animal numbers. For cattle, both Dairy and Other subgroups, the emission factor (Table LM-1) is detailed by continent based on Table 10.11[75] that also provides more details on the regional characteristics used to derive these values, and also takes into account the animals' average milk production, with animals divided into subcategories…. For instance, for Africa and Middle East regions it is considered that:

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[74] http://www.fao.org/economic/ess/syb/en/

[75] NGGI-IPCC-2006.

- Commercialised dairy sector are based on grazing with low production per cow;
- Most cattle are multi-purpose, providing draft power and some milk within farming regions;
- Some cattle graze over very large areas;
- Cattle are smaller than those found in most other regions;
- Other Cattle includes multi-purpose cows, bulls, and young;
- For Dairy Cattle the average milk production is 475 kg head^{-1} yr^{-1}.

Users may include two additional pieces of information:

Figure 43: Additional information required in the livestock module

PLEASE SPECIFY INFORMATION BELOW IF AVAILABLE

Country "Type"	*Not specified*
Mean Annual Temperature (MAT*) in °C	

Alternatively, users should leave the default option "not specified" and in this case EX-ACT will automatically use the "developing" coefficient. The country "type" will affect methane emissions from enteric fermentation only for "sheep" and "swine". The country type will also affect the CH_4 and N_2O emissions from manure management (see sections below).

Users can also indicate the Mean Annual Temperature (MAT) in °C. If no value is provided EX-ACT uses the following default values according to the main climate indicated in the Description Module: -5°C for "Boreal", 5°C for "Cool Temperate", 14°C for "Warm Temperate", 22°C for "Tropical Montane" and 24°C for "Tropical". MAT will affect the CH_4 and N_2O emissions from manure management (see sections below).

Table LM-1: Methane emissions factors by continent for Dairy and Other Cattle, in kg CH_4 head^{-1} yr^{-1}

Continent	Dairy	Other
North America	121	53
Western Europe	109	57
Eastern Europe	89	58
Oceania	81	60
Central America	63	56
South America	63	56
Asia (Continental)	61	47
Asia (Insular)	61	47
Africa	40	31
Middle East	40	31
Asia (Indian Subcontinent)	51	27

For other livestock most of the emissions factors indicated for the tier 1 approach are the same for all countries, except for Sheep and Swine where the factors vary for developed and developing countries. The differences in the emission factors are driven by differences in feed intake and feed characteristic assumptions. EX-ACT decides to separate Developed and Developing countries even if the coefficients may be the same for most livestock categories. Table LM-2 reported corresponding emission factors. For poultry, IPCC does not provide emission factor for enteric fermentation, due to the lack of data. However, poultry is one of the most important meat sources in many countries and there are large poultry flocks in many territories. Therefore it is suggested that the value provided by the French Environmental Agency[76] is used for developed countries and the value by Wang and Huang 2005[77] from Taiwan for developing countries mostly situated in non-temperate areas.

Table LM-2: Methane emissions factors by country type for different livestock categories, in kg CH4 head-1 yr-1

Category	Developed	Developing
Buffalo	55	55
Sheep	8	5
Goats	5	5
Camels	46	46
Horses	18	18
Mules and Asses	10	10
Poultry	0.08	$1.38.10^{-4}$
Deer	20	20
Alpacas	8	8
Swine	1	1.5

It is highly recommended that users seek regional or national coefficients. Table LM-3 reported some more specific values from scientific literature.

[76] ADEME 2010, Emission factor guide, v6.1; chap 6 agriculture, p.30
[77] Shu-Yin Wang and Da-Ji Huang 2005 Assessment of Greenhouse Gas Emissions from Poultry Enteric Fermentation (Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 6 : 873-878), adapted by Colomb.

Table LM-3: Specific methane emissions factors from enteric fermentation reported in published articles for different livestock categories and regions, in kg CH_4 head^{-1} yr^{-1}

Category	Country or region	Enteric Emission factor		Ref
		Mean	Range	
Dairy cattle	China	65.3	39.9-78.5	Zhou et al., 2007
Non-dairy cattle	China	54.2	34.9-59.7	Zhou et al., 2007
Buffalo	China	72.9	48.0-87.6	Zhou et al., 2007
Sheep	China	5.3	3.1-7.4	Zhou et al., 2007
Goats	China	4.6	2.9-6.7	Zhou et al., 2007
Cattle	East Africa	33.2	26-40	Herrero et al., 2008
Cattle	Southern Africa	32.7	26-40	Herrero et al., 2008
Cattle	West Africa	29.1	21-36	Herrero et al., 2008
Cattle	Central Africa	30.4	23-37	Herrero et al., 2008
Cattle	North Africa and The Horn	30.1	21-38	Herrero et al., 2008
Cattle	Africa, Arid grazing systems	23	21-26	Herrero et al., 2008
Cattle	Africa, Humid grazing systems	30	27-33	Herrero et al., 2008
Cattle	Africa, Temperate grazing systems	36	34-40	Herrero et al., 2008
Cattle	Africa, Mixed rainfed arid systems	27	25-30	Herrero et al., 2008
Cattle	Africa, Mixed humid systems	33	32-34	Herrero et al., 2008
Cattle	Africa, Mixed rainfed temperate systems	37	36-38	Herrero et al., 2008
Broiler	Taiwan	1.6 10-5	-	Yang et al., 2003

Users should then insert the mean annual head per category at the beginning, with and without the project and choose the dynamics. Results provide the corresponding emissions in t CO_2-eq.

15.3. Methane emissions from manure management

Figure 44: CH_4 emissions from manure management

Methane emissions from manure management				Head Number					Emission (t CO2eq) per year			Variation of Emission (tCO2eq)		
	IPCC	Specific	Default	Start	Without Project		With Project		Start	End		All Period		Difference
Choose Livestocks:	factor	factor	Factor	t0	End	Rate	End	Rate		Without	With	Without	With	
Dairy cattle	1		YES	500	500	Linear	1000	Linear	10,5	10,5	21	0,0	52,5	52,5
Other cattle	1		YES	500	500	Linear	0	Linear	10,5	10,5	0	0,0	-52,5	-52,5
Buffalo	1		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
Sheep	0,15		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
Swine (Market)	1		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
Swine (Breeding)	1		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
Horses	1,64		YES	100	100	Linear	0	Linear	3,444	3,444	0	0,0	-17,2	-17,2
Mules and Asses	0,9		YES	1000	1000	Linear	0	Linear	18,9	18,9	0	0,0	-94,5	-94,5
Camels	1,92		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
User Defined- Specified value -------------->			NO	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
User Defined- Specified value -------------->			NO	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
								Sub-Total L-2	43,344	43,344	21	0,0	-111,7	-111,7

Users do not need to give any information if they want to use the default IPCC coefficients. The livestock categories, including those chosen or provided by users, are copied from the table for methane emissions from enteric fermentation.[78] These emissions correspond to CH4 produced during the storage and treatment of manure (including both dung and urine) and from manure deposited on pasture. CH4 emissions from manure management depend on the amount produced and the portion that decomposes in anaerobic conditions. The temperature and the retention time of the storage unit highly affects the amount of CH4 produced. When manure is handled as a solid or when it is deposited on pastures, it tends to decompose under more aerobic conditions and less CH4 is produced.

EX-ACT uses the Tier 1 method based on default emission factor by region and by average mean annual temperature (MAT). These coefficients are from Table 10.14 of NGGI-IPCC-2006 for Cattle, Swine and Buffalo. For other animals, data comes from Table 10.15 of NGGI-IPCC-2006. The principal characteristics retained to derive these coefficients can be found in the Tables 10.14 and 10.15, and more details are available in Tables 10A-4 to 10A-9 of Annex 10A-2, chapter 10, in NGGI-IPCC-2006. For instance, for Africa it is considered that most livestock manure is managed as a solid on pastures and ranges, and that a small, but significant fraction is burned as fuel. The uncertainty associated with these factors is about 30%. Values used in EX-ACT are reported in Tables LM-4 through LM-4 below.

[78] Details about calculations are in section 10.4 of Chapter 8 of NGGI-IPCC-2006.

Table LM-4: Manure management methane emissions factors for Dairy Cattle according to the MAT, in kg CH_4 head^{-1} yr^{-1}

Region	≤10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥28
North America	48	50	53	55	58	63	65	68	71	74	78	81	85	89	93	98	105	110	112
Western Europe	21	23	25	27	29	34	37	40	43	47	51	55	59	64	70	75	83	90	92
Eastern Europe	11	12	13	14	15	20	21	22	23	25	27	28	30	33	35	37	42	45	46
Oceania	23	24	25	26	26	27	28	28	28	29	29	29	29	29	30	30	31	31	31
South America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
Central America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
Africa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Middle East	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
Asia (Continental)	9	10	10	11	12	13	14	15	16	17	18	20	21	23	24	26	28	31	31
Asia (Insular)	9	10	10	11	12	13	14	15	16	17	18	20	21	23	24	26	28	31	31
Asia (Indian Subcontinent)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6

Table LM-5: Manure management methane emissions factors for Other Cattle according to the MAT, in kg CH4 head-1 yr-1

Region	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28
North America	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Western Europe	6	7	7	8	8	10	11	12	13	14	15	16	17	18	20	21	24	25	26
Eastern Europe	6	6	7	7	8	9	10	11	12	13	14	15	16	17	18	19	21	23	23
Oceania	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
South America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Central America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Africa	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Middle East	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asia (Continental)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asia (Insular)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asia (Indian Subcontinent)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Table LM-6: Manure management methane emissions factors for Buffalo according to the MAT, in kg CH4 head-1 yr-1

Region	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28
North America	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Western Europe	5	5	5	6	7	8	8	9	9	10	11	12	13	14	15	16	17	5	5
Eastern Europe	5	6	6	7	8	8	9	10	11	11	12	13	15	16	17	19	19	5	6
Oceania	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
South America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1
Central America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1
Africa	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Middle East	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4
Asia (Continental)	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Asia (Insular)	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Asia (Indian Subcontinent)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table LM-7: Manure management methane emissions factors for Market Swine according to the MAT, in kg CH4 head-1 yr-1

Region	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28
North America	10	11	11	12	12	13	13	14	15	15	16	17	18	18	19	20	22	23	10
Western Europe	6	6	7	7	8	9	9	10	11	11	12	13	14	15	16	18	19	21	6
Eastern Europe	3	3	3	3	3	4	4	4	4	5	5	5	6	6	6	7	10	10	3
Oceania	11	11	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13	11
South America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1
Central America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1
Africa	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Middle East	1	1	1	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	1
Asia (Continental)	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	7	2
Asia (Insular)	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	7	2
Asia (Indian Subcontinent)	2	2	3	3	3	3	3	3	4	4	4	4	4	5	5	5	6	6	2

Table LM-8: Manure management methane emissions factors for Breeding Swine according to the MAT in kg CH4 head-1 yr-1

Region	<10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	>28
North America	19	20	21	22	23	24	26	27	28	29	31	32	34	35	37	39	41	44	19
Western Europe	9	10	10	11	12	13	14	15	16	17	19	20	22	23	25	27	29	32	9
Eastern Europe	4	5	5	5	5	6	7	7	7	8	8	9	9	10	11	12	16	17	4
Oceania	20	20	21	21	22	22	23	23	23	23	23	24	24	24	24	24	24	24	20
South America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1
Central America	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1
Africa	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Middle East	1	1	1	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	1
Asia (Continental)	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	7	2
Asia (Insular)	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	7	2
Asia (Indian Subcontinent)	2	2	3	3	3	3	3	3	4	4	4	4	4	5	5	5	6	6	2

Table LM-9: Manure management methane emissions factors for other livestock according to the MAT and country type, in kg CH_4 head^{-1} yr^{-1}

Category	Developed Country			Developing country		
	MAT<15	15<MAT<25	MAT>25	MAT<15	15<MAT<25	MAT>25
Sheep	0.19	0.28	0.37	0.1	0.15	0.2
Goats	0.13	0.2	0.26	0.11	0.17	0.22
Camels	1.58	2.37	3.17	1.28	1.92	2.56
Horses	1.56	2.34	3.13	1.09	1.64	2.19
Mules and Asses	0.76	1.1	1.52	0.6	0.9	1.2
Poultry	0.03	0.03	0.03	0.01	0.02	0.01
Deer	0.22	0.22	0.22	0.22	0.22	0.22
Alpacas						

Poultry corresponds to dry Layers for Developed Country.

When possible it is recommended that users seek more specific emission factors. Some additional coefficients are provided below to illustrate other available EF for CH4 emissions from manure management, either for other animals or for specific country/region.

Table LM-10: Examples of more specific emissions factors for manure management, in kg CH4 head-^{1} yr-^{1}

Category/animal	Subcategory	Country	EF	Reference
Dairy cattle	Crossbred	India	3.3 ± 0.16	Gupta et al., 2007
Dairy cattle	Indigenous	India	2.7 ± 0.13	Gupta et al., 2007
ND cattle	0-1 year	India	0.8 ± 0.04	Gupta et al., 2007
ND cattle	Adult-Crossbred	India	2.3 ± 0.11	Gupta et al., 2007
ND cattle	Adult-Indigenous	India	2.8 ± 0.14	Gupta et al., 2007
Dairy buffalo		India	3.3 ± 0.06	Gupta et al., 2007
Turkeys		Developed countries	0.09	NGGI-IPCC-2006
Ducks	MAT< 15°C	Developed countries	0.02	NGGI-IPCC-2006
Ducks	MAT > 15°C	Developed countries	0.03	NGGI-IPCC-2006
Broilers		Developed countries	0.02	NGGI-IPCC-2006
Deer			0.22	NGGI-IPCC-2006
Rabbits			0.08	NGGI-IPCC-2006

ND= non-dairy

Calculations are then carried out according to information about numbers of animals per category that have previously been identified from the beginning, and forecasted with and without the project and the choosing of dynamics. Results provide the corresponding emissions in t CO_2-eq.

15.4. Nitrous oxide emissions from manure management

Figure 45: N_2O emissions from manure management

Nitrous Oxide emissions from manure management

				Annual amount of N manure* (t N per year)					Emission (t CO2eq) per year			Variation of Emission (tCO2eq)		
	IPCC	Specific	Default	Start	Without Project		With Project		Start	End		All Period		Difference
Choose Livestocks:	factor	factor	Factor	t0	End	Rate	End	Rate		Without	With	Without	With	
Dairy cattle	0,01		YES	30,1	30,1	Linear	60,2	Linear	93	93	187	0,0	466,7	466,7
Other cattle	0,01		YES	19,9	19,9	Linear	0,0	Linear	62	62	0	0,0	-308,3	-308,3
Buffalo	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0,0	0,0	0,0
Sheep	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0,0	0,0	0,0
Swine (Market)	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0,0	0,0	0,0
Swine (Breeding)	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0,0	0,0	0,0
Horses	0,01		YES	4,0	4,0	Linear	0,0	Linear	12	12	0	0,0	-61,9	-61,9
Mules and Asses	0,01		YES	21,8	21,8	Linear	0,0	Linear	68	68	0	0,0	-338,3	-338,3
Camels	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0,0	0,0	0,0
User Defined- Specified value -------------->			NO			Linear		Linear	0	0	0	0,0	0,0	0,0
User Defined- Specified value -------------->			NO			Linear		Linear	0	0	0	0,0	0,0	0,0
see equation 10.30								Sub-Total L-3	235,061205	235,0612	186,6975	**0,0**	**-241,8**	**-241,8**

Users will not need to provide any data if he wants to use the default IPCC coefficients. The livestock categories, including those chosen or provided by users, are copied from the table for methane emissions from enteric fermentation and also used in CH4 emissions from manure management.[79] These emissions correspond to N2O produced, directly or indirectly, during the storage and treatment of manure (the solids and liquids). Calculations are based on Tier 1 approach that consists in multiplying the total amount of N excretion by species category by a default emission factor.

The annual excretion rate is calculated based on equation 10.30 page 10.57 of NGGI-IPCC-2006.

$$N_{ex} = N_{rate} \times TAM \times 365 / 1000$$

Where

N_{ex} = annual N excretion for a determined livestock category, kg N animal^{-1} yr^{-1};
N_{rate} = default N excretion rate (kg N (1000 kg Animal mass)$^{-1}$ day^{-1};
TAM = Typical animal mass for livestock category, kg animal^{-1}

N_{rate} are derived from Table 10.19.[80] Coefficients used by EX-ACT are reported in Table LM-11 for cattle, buffalo and swine and Table LM-12 for other animals by continent.

[79] Details about calculations can be encountered in section 10.5 of Chapter 8 of NGGI-IPCC-2006.

[80] NGGI-IPCC-2006.

Table LM-11: Default Nitrogen Excretion rate for cattle, buffalo and swine, in kg N (1000 kg Animal mass)-[1] day-[1]

Region	Dairy Cattle	Other Cattle	Buffalo	Market Swine	Breeding Swine
North America	0.44	0.31	0.32	0.50	0.24
Western Europe	0.48	0.33	0.32	0.68	0.42
Eastern Europe	0.35	0.35	0.32	0.74	0.46
Oceania	0.44	0.50	0.32	0.73	0.46
South America	0.48	0.36	0.32	1.64	0.55
Central America	0.48	0.36	0.32	1.64	0.55
Africa	0.60	0.63	0.32	1.64	0.55
Middle East	0.70	0.79	0.32	1.64	0.55
Asia (Continental)	0.47	0.34	0.32	0.50	0.24
Asia (Insular)	0.47	0.34	0.32	0.50	0.24
Asia (Indian Subcontinent)	0.47	0.34	0.32	0.50	0.24

Table LM-12: Default Nitrogen Excretion rate for other animals, in kg N (1000 kg Animal mass)$^{-1}$ day^{-1}

Region	Sheep	Goats	Camels	Horses	Mules and Asses	Poultry
North America	0.42	0.45	0.38	0.30	0.30	0.83
Western Europe	0.85	1.28	0.38	0.26	0.26	0.83
Eastern Europe	0.90	1.28	0.38	0.30	0.30	0.82
Oceania	1.13	1.42	0.38	0.30	0.30	0.82
South America	1.17	1.37	0.46	0.46	0.46	0.82
Central America	1.17	1.37	0.46	0.46	0.46	0.82
Africa	1.17	1.37	0.46	0.46	0.46	0.82
Middle East	1.17	1.37	0.46	0.46	0.46	0.82
Asia (Continental)	1.17	1.37	0.46	0.46	0.46	0.82
Asia (Insular)	1.17	1.37	0.46	0.46	0.46	0.82
Asia (Indian Subcontinent)	1.17	1.37	0.46	0.46	0.46	0.82

Default TAM values are provided in Tables 10A-4 to 10A-9 in Annex 10.A.2 of NGGI-IPCC-2006. Table LM-13 reported values for cattle, buffalo and swine by continent, and Table LM-14 for other animals but by country type (developing or developed) as is indicated in NGGI-IPCC-2006.

Table LM-13: Default typical animal mass (TAM) for cattle, buffalo, and swine, kg animal^{-1}

Region	Dairy Cattle	Other Cattle	Buffalo	Market Swine	Breeding Swine
North America	604	389	380	46	198
Western Europe	600	420	380	50	198
Eastern Europe	550	391	380	50	180
Oceania	500	330	380	45	180
South America	400	305	380	28	28
Central America	400	305	380	28	28
Africa	275	173	380	28	28
Middle East	275	173	380	28	28
Asia (Continental)	350	319	380	28	28
Asia (Insular)	350	319	380	28	28
Asia (Indian Subcontinent)	275	110	295	28	28

Table LM-14: Default typical animal mass (TAM) for other animals, kg animal^{-1}

Region	Sheep	Goats	Camels	Horses	Mules and Asses	Poultry
Developed	49	39	217	377	130	2
Developing	28	30	217	238	130	1

Once the quantity of annual N excretion for a determined livestock category is known it must be multiplied by a coefficient of emission. This coefficient is set arbitrarily to 0.01 except for pasture where it is set to 0.02. This factor ranges from 0 to 0.1 according to the manure management (see Table 10.21[81]). This value (0.01) is the default number given for different management, i.e., (i) composting in windrows with regular turning for mixing and aeration, (ii) cattle and swine deep bedding without mixing and (iii) Aerobic treatment with natural aeration system. Most other management systems have a lower emission factor: 0.002 for pit storage below animal confinements, 0.005 for Aerobic treatment with forced aeration systems, liquid/slurry system (manure is stored as excreted or with some minimal water addition), and solid storage, 0.006 for composting "in-Vessel" and in "Static Pile". Anaerobic digester systems are considered as having negligible emission and are set to zero. Only 3 systems presented a higher emission factor: Dry lot (EF = 0.02), Cattle and swine deep bedding with active mixing (0.07) and Composting in intensive windrow. It is highly recommended that users use a more specific factor than the default provided.

Indirect emissions due to volatilisation of N from manure management are not accounted for. Even considering the highest coefficients in equations 10.26 and 10.27 (i.e. FracGasMS set to 100% and EF4 set to 0.01) of NGGI-IPCC-2006, the contribution of indirect emissions would be one tenth of direct emissions.

The time spent in pastures enables users to calculate the share of dejection that is managed, and the share goes directly into the field. The share that is managed by the farmer emits N_2O

[81] NGGI-IPCC-2006.

during dejection management[82], and then when it is spread onto the field as an organic fertilizer (Inputs sheet, line 28). As organic fertilizers can be imported or exported, the value needs to be reported (and possibly modified) in the "Input sheet". The value of organic N available from livestock dejection is provided in the Livestock sheet, line 72; be aware of the loss of N during dejection management. For the share of dejections left in pasture, N_2O emissions are accounted for in Livestock[83].

The default value for the time spent in pastures comes from the IPCC Tables in Annex 10.A.2.

It is recognised here that in the next version of EX-ACT, the improvement of N_2O emissions from manure management should be a priority!

15.5. Additional Technical Mitigation

Figure 46: Mitigation measures for the livestock

			Percent of head with practices (0% =none;100%=all)					Emission (t CO2eq) per year			Variation of Emission (tCO2eq)		
			Start	Without Project		With Project		Start	End		All Period		Difference
Livestocks	Dominant Practice*	Factor	t0	End	Rate	End	Rate		Without	With	Without	With	
Dairy cattle	Feeding practices	0,040	0%	0%	Linear	33%	Linear	0,00	0,00	-14,14	0,0	-212,1	-212,1
	Specific Agents	0,010	0%	0%	Linear	33%	Linear	0,00	0,00	-3,53	0,0	-53,0	-53,0
	Management-Breedi	0,010	0%	0%	Linear	34%	Linear	0,00	0,00	-3,64	0,0	-54,6	-54,6
	No Option	0,000	100%	100%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
Other cattle	Feeding practices	0,030	0%	0%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
	Specific Agents	0,010	0%	0%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
	Management-Breedi	0,010	0%	0%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
	No Option	0,000	100%	100%	Linear	100%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
Buffalo	Feeding practices	0,030	0%	0%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
	Specific Agents	0,006	0%	0%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
	Management-Breedi	0,015	0%	0%	Linear	0%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
	No Option	0,000	100%	100%	Linear	100%	Linear	0,00	0,00	0,00	0,0	0,0	0,0
Sheep	Feeding practices	0,020	0%	0%	0,0	0%	0,0	0,00	0,00	0,00	0,0	0,0	0,0
	Specific Agents	0,001	0%	0%	0,0	0%	0,0	0,00	0,00	0,00	0,0	0,0	0,0
	Management-Breedi	0,001	0%	0%	0,0	0%	0,0	0,00	0,00	0,00	0,0	0,0	0,0
	No Option	0,000	100%	100%	0,0	100%	0,0	0,00	0,00	0,00	0,0	0,0	0,0
							Sub-Total L-4	0,0	0,0	-21,3	**0,0**	**-319,7**	-319,7

Methane emissions are affected by a number of factors including the animal traits (e.g. age, bodyweight, and genetics) and environmental parameters (e.g. temperature) but also feed quality. Therefore, mitigation options would have to address those last drivers. Smith et al.[84] reviewed the mitigation potentials linked mostly with animal and feed factors and reported that they could be categorised more precisely into improved feeding practices, use of specific agents or dietary additives, and longer term management changes and animal breeding. Concerning feeding practices, Smith et al.[85] showed that the use of more concentrates commonly increases CH_4 emission on an animal basis, but since it also increases performance (milk and meat), the end result is an overall reduction of CH_4 emissions per unit of product (litre of milk or kg of meat). Moreover, the enrichment of the diet with concentrates is more efficient with complementary practices related to management (e.g. younger slaughter age for beef animals) or feeding (oil seeds addition). Another alternative consists in the use of additives (ionophores, propionate precursors, condensed tannins) that directly affect methanogenesis inside the rumen, but these options may be limited due to existing barriers

[82] Livestock sheet, lines ;54;56;58;60;62;64;65:69.

[83] Lines 53;55;57;59;61;63.

[84] Smith et al., 2007.

[85] Smith et al., 2007.

regarding their use (for instance ionophores are banned in the European market), their cost, or adverse effects in meat conversion rates. Choice of the animal might be of prime importance. Additional technical mitigation options for 4 animal categories are therefore considered using default coefficients (expressed in % of reduction) provided by Smith et al.[86] and reported in Table LM-15 and LM-16 below.

Table LM-15: Percentage of reduction in CH4 emission due to the adoption of additional technical practices for Cattle

Region	Animal category and technical options					
	Dairy cattle			Other cattle		
Region	Feeding Practices	Specific Agents	Management-Breeding	Feeding Practices	Specific Agents	Management-Breeding
North America	16.0	11.0	3.0	11.0	9.0	3.0
Western Europe	18.0	8.0	4.0	12.0	4.0	3.0
Eastern Europe	11.0	4.0	4.0	6.0	4.0	3.0
Oceania	22.0	8.0	5.0	14.0	8.0	3.0
South America	6.0	3.0	2.0	3.0	2.0	3.0
Central America	3.0	2.0	1.0	2.0	1.0	2.0
Africa	1.0	0.3	0.4	1.0	0.4	0.6
Middle East	1.0	0.3	0.4	1.0	0.4	0.6
Asia (Continental)	7.3	1.7	1.7	3.3	3.0	3.3
Asia (Insular)	6.0	1.0	1.0	3.0	2.0	2.0
Asia (Indian Subcontinent)	4.0	1.0	1.0	3.0	1.0	1.0

Smith et al.,[87] do not report coefficients according to the same regions that are used in EX-ACT. Some assumptions were made: coefficients for the Middle East regions were set equal to the ones reported for Africa. For Asia (Insular), Asia (India Subcontinent) values are supposed to be the same as for the South Eastern and Southern Agro-Ecological Zones. Finally, the coefficients for Asia (Continental) correspond to the average of values reported for East, West and Central Agro-Ecological Zones.

Values for Buffalo (Table LM-16) were set considering the average of values reported for Dairy and No Dairy cattle.

[86] Smith et al., 2007.
[87] Smith et al., 2007.

Table LM-16: Percentage of reduction of CH4 emission due to the adoption of additional technical practices for Buffalo and other cattle

Region	Animal category and technical options					
	Buffalo			Other cattle		
Region	Feeding practices	Specific Agents	Management-Breeding	Feeding Practices	Specific Agents	Management-Breeding
North America	4.5	0.7	2.5	4.0	0.4	0.3
Western Europe	4.5	0.7	2.5	4.0	0.4	0.3
Eastern Europe	4.5	0.7	2.5	3.0	0.4	0.3
Oceania	4.5	0.7	2.5	6.0	0.4	0.4
South America	4.5	0.7	2.5	2.0	0.1	0.2
Central America	4.5	0.7	2.5	2.0	0.1	0.2
Africa	4.5	0.7	2.5	1.0	0.0	0.6
Middle East	4.5	0.7	2.5	1.0	0.0	0.6
Asia (Continental)	10.0	1.1	0.4	2.3	0.1	0.3
Asia (Insular)	4.5	0.7	2.5	2.0	0.1	0.1
Asia (Indian Subcontinent)	3.0	0.6	1.5	2.0	0.1	0.1

Users should indicate the percentage at the beginning and at the end (with or without project) of the herd that uses one or other technical mitigation options. The dynamic of changes should also be informed. By default, 100% of the herd of each category is set with no additional mitigation option.

16. INPUTS MODULE

16.1. Generalities

Material used to develop this module can be found in Volume 4 (AFOLU) of the NGGI-IPCC-2006 in Chapter 11 “N_2O emissions from managed soils, and CO_2 emissions from lime, urea application, and from Lal (2004) for embodied GHG emissions associated with the use of agricultural chemicals in farm operations.

GHG covered by the “Inputs Module” are (i) carbon dioxide emissions from lime application, (ii) carbon dioxide emissions from urea application, (iii) nitrous oxide emissions from N application on managed soils (except manure management treated in Livestock Module) and also (iv) emissions (in CO_2 equivalent) from production, transportation storage and transfer of agricultural chemicals.

16.2. Carbon dioxide emissions from Lime application

Figure 47:CO2 emissions from lime application

Type of lime	IPCC factor	Specific factor	Default Factor	Amount of Lime in tonnes per year: Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Emission (t CO2eq) per year: Start	End: Without	End: With	Variation of Emission (tCO2eq) Change of the period: Without	Change of the period: With	Difference
Limestone	0,12		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
Dolomite	0,13		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
Not precised	0,125		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
								Sub-Total I-1	0	0	0	0,0	0,0	0,0

Liming corresponds to the addition of carbonates to soils in the form of either calcic limestone or dolomite. Those additions lead to CO_2 emissions when carbonates lime dissolve.

CO_2 emissions are calculated using default emissions factors provided by IPCC guidelines, i.e., 0.12 for limestone and 0.13 for dolomite. CO_2 emissions are obtained by multiplying the emission factor with the quantities of each type of carbonates applied. When users do not know the type of lime used, it can select the third line of the table that uses an average emission factor. Users may also specify their own emissions factor that must by definition be less than the default emission factor, because that default factor corresponds to the carbonate carbon content of the materials.

Calculations are then done for the quantities' information concerning the beginning, and forecast with and without the project and the dynamics chosen. Results provide the corresponding emissions in t CO_2-eq.

16.3. Carbon dioxide emissions from Urea Application

Figure 48: CO2 emissions from urea application

	IPCC factor	Specific factor	Default Factor	Amount of Urea in tonnes per year: Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Emission (t CO2eq) per year: Start	End: Without	End: With	Variation of Emission (tCO2eq) Change of the period: Without	Change of the period: With	Difference
Urea	0,2		YES	0	0	Linear	0	Linear	0	0	0	0,0	0,0	0,0
								Sub-Total I-2	0	0	0	0,0	0,0	0,0

The addition of urea ($CO(NH_2)_2$) to the soils leads to a loss of CO_2. The amount of CO_2 released is based on the amount of urea fertilization (in ton urea) multiplied by the default coefficient 0.2 that corresponds to the equivalent of C content of urea on a weight basis. Users may also specify their own emissions factor that must by definition be less than the default emission factor.

Calculations are then carried out based on the quantities of urea applied at the beginning, with and without the project, and the dynamics chosen. Results provide the corresponding emissions in t CO_2-eq.

16.4. N_2O emissions from N application on managed soils

This section excludes the N_2O emissions from the dejections (which contain N) left in pasture because it is already covered in the specific Livestock Module.

Figure 49: N2O emissions from N application

Type of input	IPCC factor	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate	With Project 0	With Project Rate	Start	End Without	End With		Without	With	Difference
Urea	0,01		YES	0	0	Linear	0	Linear	0,0	0,0	0,0		0	0	0
N Fertiliser (other than Urea)	0,01		YES	0	0	Linear	0	Linear	0,0	0,0	0,0		0	0	0
N Fertiliser in non-upland Rice*	0,003		YES	0	0	Linear	0	Linear	0,0	0,0	0,0		0	0	0
Sewage	0,01		YES	0	0	Linear	0	Linear	0,0	0,0	0,0		0	0	0
Compost	0,01		YES	0	0	Linear	0	Linear	0,0	0,0	0,0		0	0	0
*N fertilizer from upland rice should be included above (N fertilizer)								Sub-Total I-3	0,0	0,0	0,0	#	0,0	0,0	0

This section covers the direct N_2O emissions, i.e. N_2O emissions directly linked with increased nitrification and denitrification rate due to increase in available N. The following sources are covered: Chemical N fertilizer, N fertilizer in non-upland rice systems (i.e., flooded rice systems), sewage and organic fertilizers. Emissions are calculated based on the amount of N applied and an emission factor associated with the type of input (Table I-1). Organic fertilizers from animals (e.g., manure) produce N_2O emissions in the building during storage, and in the field when spread. The storage phase is accounted for in the "livestock sheet" whereas for the field stage the amount of organic N fertilizer (from animal and the rest) needs to be defined by users in the "input sheet", line 28.

The value for urea is automatically reported from above (CO_2 from urea application).

Table I.1. Default emission factors used to compute N_2O emissions (adapted from Table 11.1 of NGGI-IPCC-2006)

Type of input	Default value
Chemical N fertilizer and Urea	0.01
N fertilizer in non-upland rice	0.003
Sewage	0.01
Organic fertilizer	0.01

Indirect emissions may arise from the N application, but uncertainties are very high and the origins may be from an N source outside the geographical limit of the project, e.g. N_2O emissions associated with N deposition from chemical industries. Thus these emissions were not included. Users can include indirect emission when using a specific factor that would be the sum of direct and indirect effect. For instance, it is considered by default that 0.1 kg of N is volatilized in the form of NH_3 or NOx per kg of N from synthetic fertilizer applied. This re-deposition of N having the same emission factor (0.01 kg N-N_2O per kg N applied) - the default emission factor corresponding to both direct and indirect emissions, would thus be increased by 10%, i.e. 0.011. This variation is small compared to the uncertainty range of the default emission factors: 0.003 to 0.03 for mineral fertilizer. Thus it is highly recommended for users to consider more specific emission factors when available.

16.5. Emissions from production, transportation, storage and transfer of agricultural chemicals

Figure 50: CO2 emissions from the production and distribution of chemical inputs

Type of input**	Default factor*	Specific factor	Default Factor	Start	Without Project		With Project		Start	End		Total Emission		Difference
				t0	End	Rate	End	Rate		Without	With	Without	With	
Urea	4,8		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
N Fertiliser (other than Urea)	4,8		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
N Fertiliser in non-upland Rice*	4,8		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Phosphorus synthetic fertilizer	0,7		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Potassium synthetic fertilizer	0,6		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Limestone (Lime)	0,6		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Dolomite (Lime)	0,6		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Generic Lime	0,6		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Herbicides (Pesticides)	23,1		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Insecticides (Pesticides)	18,7		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
Fungicides (Pesticides)	14,3		YES	0	0	Linear	0	Linear	0,0	0,0	0,0	0	0	0
								Sub-Total I-4	0,0	0,0	0,0	0,0	0,0	0

* from Lal (2004) Table 5 - central value -tCO2/t product
** tonnes of N, P2O5, K2O and CaCO3

This section covers the embedded GHG emissions associated with the production, transportation storage and transfer of agricultural chemicals. IPCC guidelines do not provide such coefficients or indicators because emissions associated with the life cycle of these products are already computed within each sector (Energy, Industries…) and subsector (transportation…). This section uses the central value of the range of estimates reviewed by Lal.[88]

Table I.2. GHG emissions factors associated with the use of inputs

Type of Input	Equivalent C-Emission (Lal, 2004) (kg C-eq / kg product)	Emission coefficient used by EX-ACT (t CO_2-eq per tons of product)
Nitrogen-fertilizers	1.3 ± 0.3	4.77
Phosphorus-Fertilizer	0.2 ± 0.06	0.73
Potassium-fertilizer	0.15 ± 0.06	0.55
Lime	0.16 ± 0.11	0.59
Herbicides	6.3 ± 2.7	23.10
Insecticides	5.1 ± 3.0	18.70
Fungicides	3.9 ± 2.2	14.30

Calculations are then carried out for the information of quantities of chemical N fertilizer and Lime provided in previous sections concerning the beginning, and forecast with and without the project and the dynamics chosen. In this subsection users should provide the amount in tons of product for the P and K fertilizers and in tons of active ingredients for the xenobiotics used. Final calculations provide the corresponding emissions in t CO_2-eq.

17. Other Investment Modules

Material used to develop this module came from different sources according to the specificity of the sector covered: Energy related emissions can be found in Volume 1 (Energy) of the NGGI-IPCC-2006, in the "Bilan Carbone" used by French AFD and from the International

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88 Lal, 2004.

Energy Agency. Default values associated with the installations of irrigation systems are from Lal (2004).

GHG covered by the "Investment Module" are (i) GHG emissions associated with electricity consumption, (ii) GHG emissions associated with fuel consumption, (iii) GHG emissions associated with installation of irrigation systems and (iv) GHG emissions associated with building of infrastructure.

17.1. GHG emissions associated with electricity consumption

Two different options are provided for users to compute GHG emissions linked to electricity consumption: option 1 is based on the total amount of electricity expressed in MWh whereas option 2 considers the annual consumption at the beginning of the project and at the end of the implementation phase with or without the project. Users can combine the 2 options according to the level of information available.

Figure 51: Emissions from electricity consumption

Origin of Electricity	Please select the country of origin		
Default values (T CO2 / MWh)	YES	0,000	

Losses of electricity during transportation
10%

OPTION 1 (Based on Total Electricity consumption over the whole duration of the project)

Total Electricity Consumption (MWh)		Associated tCO2eq
Without Project	0	0,0
With Project	0	0,0

OPTION 2 (Based on Annual Electricity consumption at the beginning and according to dynamic changes)

Annual Electricity Consumption (MWh/yr)					Emission (t CO2eq)	
Start	Without Project		With Project		All Period	
t0	End	Rate	End	Rate	Without	With
0	*0*	*Linear*	*0*	*Linear*	0	0

OPTION1 + OPTION2	Sub-Total Without	*0,0*	Sub-Total With	*0,0*	*Difference*	*0,0*

The default GHG emissions (in CO_2-eq) provided depend on the origin of the electricity consumed by the project. It is not necessarily the country where the project is developed. For instance, a project located near the border of a determined country may use the energy from a neighbouring country. Users will have to inform the amount and the origin of the electricity consumed.

The emissions' factors are from the Electricity Information Database from the International Energy Agency (IEA) and reported by the U.S. Department of Energy.[89] These factors correspond to the average for the years 1999-2002. User may use their own coefficients providing a specific value.

[89] Form EIA-1605, 2007, Appendix F. Electricity Emission Factors.

Table Inv-1: GHG emissions associated with Electricity consumption according to its origin

Region	CO_2 (tons/MWh)	Region	CO_2 (tons/MWh)	Region	CO_2 (tons/MWh)
OECD		Non-OECD Europe and Eurasia	0,513	Africa	0,683
Canada	0.223	Albania	0.051	Algeria	0.752
Mexico	0.593	Armenia	0.230	Angola	0.386
Austria	0.197	Azerbaijan	0.613	Benin	0.683
Belgium	0.289	Belarus	0.326	Botswana	0.683
Czech Republic	0.604	Bosnia-Herzegovina	0.770	Cameroon	0.016
Denmark	0.358	Bulgaria	0.492	Congo	0.683
Finland	0.239	Croatia	0.513	Côte d'Ivoire	0.408
France	0.083	Estonia	0.774	DR Congo	0.004
Germany	0.539	FYR of Macedonia	0.773	Egypt	0.436
Gibraltar	0.870	Georgia	0.137	Eritrea	0.736
Greece	0.887	Kazakhstan	1.293	Ethiopia	0.011
Hungary	0.437	Kyrgyzstan	0.102	Gabon	0.311
Iceland	0.001	Latvia	0.513	Ghana	0.150
Ireland	0.699	Lithuania	0.165	Kenya	0.393
Italy	0.525	Malta	0.904	Libya	1.146
Luxembourg	0.387	Republic of Moldova	0.513	Morocco	0.809
Netherlands	0.479	Romania	0.426	Mozambique	0.683
Norway	0.005	Russia	0.351	Namibia	0.683
Poland	0.730	Serbia and Montenegro	0.786	Nigeria	0.372
Portugal	0.511	Slovenia	0.369	Senegal	0.892
Slovak Republic	0.297	Tajikistan	0.038	South Africa	0.911
Spain	0.443	Turkmenistan	0.858	Sudan	0.540
Sweden	0.048	Ukraine	0.345	Togo	0.683
Switzerland	0.022	Uzbekistan	0.497	Tunisia	0.608
Turkey	0.584	Central and South America	0.204	United Republic of Tanzania	0.108
United Kingdom	0.475	Argentina	0.317	Zambia	0.007
Australia	0.924	Bolivia	0.401	Zimbabwe	0.683
Japan	0.417	Brazil	0.093	Other Africa	0.431
Korea	0.493	Chile	0.333	Middle East	0.743
New Zealand	0.159	Colombia	0.157	Bahrain	0.876
Non-OECD Asia	0.809	Costa Rica	0.015	Cyprus	0.851
Bangladesh	0.625	Cuba	1.104	Iraq	0.744
Brunei Darussalam	0.830	Dominican Republic	0.771	Islamic Republic of Iran	0.598
China (including Hong Kong)	0.839	Ecuador	0.256	Israel	0.839
Chinese Taipei	0.631	El Salvador	0.302	Jordan	0.775
Dem. People's Republic of Korea	0.630	Guatemala	0.418	Kuwait	0.790
India	0.999	Haiti	0.347	Lebanon	0.754
Indonesia	0.722	Honduras	0.290	Oman	0.856
Malaysia	0.528	Jamaica	0.819	Qatar	0.862
Myanmar	0.456	Netherlands Antilles	0.793	Saudi Arabia	0.816
Nepal	0.013	Nicaragua	0.650	Syria	0.655
Pakistan	0.482	Panama	0.286	United Arab Emirates	0.760
Philippines	0.526	Paraguay	0.000	Yemen	1.029
Singapore	0.731	Peru	0.148		
Sri Lanka	0.384	Trinidad and Tobago	0.751		
Thailand	0.583	Uruguay	0.055		
Vietnam	0.417	Venezuela	0.251		
Other Asia	0.469	Other Latin America	0.584		

A default addition of 10% is accounted for due to losses during transportation. This coefficient may be adapted if necessary.

17.2. GHG emissions associated with Fuel consumption

Two different options are also provided for users to compute GHG emissions linked with fuel consumption: option 1 (only for Gasoil/Diesel and Gasoline) is based on the total amount whereas option 2 retains annual consumption at the beginning and at the end. The default factor for Gasoil/diesel is 2.63 tCO_2 per m^3 and 2.85 for gasoline.[90]

For propane and butane, IPCC does not provide emission factors, thus the ones provided by the Swiss Government have been used[91]. Concerning wood energy, the emission of CO_2 is not accounted for. Indeed, the growing trees remove carbon dioxide from the atmosphere during photosynthesis and store the carbon in plant structures. When the biomass is burned, the carbon released back to the atmosphere will be recycled into the next generation of growing plants; therefore the overall impact is neutral. What is accounted is the CH_4 and N_2O produced, that result from the combustion process.

Figure 52: emissions from fossil fuels consumption

OPTION 1 (Based on Total consumption over the whole duration of the project)

Total Liquid Fuel Consumption (m3)	Gasoil/Diesel	Gasoline	Associated tCO2eq
Without Project	0	0	0
With Project	0	0	0

OPTION 2 (Based on Annual Fuel consumption at the beginning and according to dynamic changes)

Type of Fuel	Default value t CO2 /m3	Specific Value	Default Factor	Annual Fuel Consumption (m3/yr) Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Emission (t CO2eq) All Period Without	Emission (t CO2eq) All Period With
Gasoil/Diesel	2,63		YES	0	0	Linear	0	Linear	0	0
Gasoline	2,85		YES	0	0	Linear	0	Linear	0	0
Gas (LPG/ natural)	1,69		YES	0	0	Linear	0	Linear	0	0
Propane	1,53		YES	0	0	Linear	0	Linear	0	0
Butane	1,76		YES	0	0	Linear	0	Linear	0	0
User defined		0,517	NO	0	0	Linear	0	Linear	0	0
	t CO2/t dry matter			Annual Consumption in t dry matter						
Wood	0,01		YES	0	0	Linear	0	Linear	0	0

OPTION1 + OPTION2	Sub-Total Without	0,0	Sub-Total With	0,0	Difference	0,0

It should be noted that fuel consumption associated with inputs transportation is already embodied in “Input Module”

Option 2 proposes also GHG emissions for LPG/ natural gas, Propane and Butane and for wood.

17.3. GHG emissions associated with the installation of irrigation systems

Installing or improving water management may be part of the project, thus the aim of this section is to account for emissions associated with the installation of irrigation systems reported in Table Inv-2.[92]

[90] These coefficients were derived from data reported in Table 3.3.1 of NGGI-IPCC-2006 for off-road transportation.
[91] Emission factors of CO2, from swiss GHG inventory. Octobre 2011 http://www.bafu.admin.ch/klima/09570/index.html?lang=fr

[92] EX-ACT used default emissions reviewed by Lal (2004).

Table Inv-2: Default GHG emissions for installation of irrigation systems

System	GHG emissions in kgCO_2-eq/ha
Surface without IRSS*	34
Surface with IRSS*	90
Solid set sprinkle	445
Permanent sprinkle	130
Hand moved sprinkle	60
Solid roll sprinkle	85
Centre-pivot sprinkle	79
Traveller sprinkle	62
Trickle	311

IRSS = Irrigation runoff return system

roject.

Figure 53: emissions due to irrigation

Installation of irrigation system	surface (ha)	Type of irrigation syster	Associated tCO2eq
Without Project	0	Hand moved sprinkle	0,0
With Project	0	Hand moved sprinkle	0,0
		Difference	*0,0*

17.4. GHG emissions associated with construction

The project may require additional constructions (building to store fertilizers or seeds...). This submodule allows users to account for GHG emissions associated with construction. [93]
Table Inv-3 reports the default coefficient retained by EX-ACT.

[93] Default values are from the tools developed by AFD (Agence Française de Développement. See: AFD Carbon Footprint at :*http://www.afd.fr/jahia/Jahia/lang/en/home/DemarcheRSE_AFD/Bilan_Carbone*

Table Inv-3: Default GHG emissions for building of infrastructure

Type	GHG emissions in kgCO_2-eq/m^2
Housing (concrete)	436
Agricultural Buildings (concrete)	656
Agricultural Buildings (metal)	220
Industrial Buildings (concrete)	825
Industrial Buildings (metal)	275
Garage (concrete)	656
Garage (metal)	220
Offices (concrete)	469
Offices (metal)	157
Other (concrete)	550
Other (metal)	220
Road for medium traffic (concrete)	319
Road for medium traffic (asphalt)	73
Road for Intense traffic (concrete)	458
Road for Intense traffic (asphalt)	147

Users should provide the type (chosen from a list of available options) and surface concerned with and without the project.

Figure 54: emissions from the construction of infrastructures

Type of construction or infrastructure	Default value t CO2 /m2	Specific Value	Default Factor	surface (m2)		Emission (t CO2eq)	
				Without	With	Without	With
Industrial Buildings (concrete)	0,825		YES			0,0	0,0
Agricultural Buildings (metal)	0,220		YES			0,0	0,0
Agricultural Buildings (metal)	0,220		YES			0,0	0,0
Agricultural Buildings (metal)	0,220		YES			0,0	0,0
Industrial Buildings (concrete)	0,825		YES			0,0	0,0
Road for medium trafic (concrete)	0,319		YES			0,0	0,0
Road for medium trafic (asphalt)	0,073		YES			0,0	0,0

18. Results Modules

18.1. Generalities

All calculations carried out in the EX-ACT tool are reported in two specific modules called "**Gross results**" and "**Balance**".

The first "Gross results" module presents the gross fluxes for all accounted GHG expressed in eq-CO_2, for both scenarios, without and with project, plus de gross fluxes per year of accounting for both scenarios. In actual fact the "Balance" module presents the difference between those two scenarios through the expression of the carbon balance and more accurate results. The "Gross results" module follows exactly the same structure than the "Balance" module presented below.

The "Balance" Module is made up of 4 sections:

Figure 55: General context summary

Project Summary
Name
Continent
Climate
Dominante Soil T

Area (Initial state in ha)		
Forest/Plantation		0
Cropland	Annual	0
	Perennial	0
	Rice	0
Grassland		0
Other Land	Degraded	0
	Other	0
Organic soils/peatlands		0

Duration of the Project (years)	
Implementation	0
Capitalisation	0
Total	0
Total Area	
Mineral soils	0
Organic soils	0
Total Area	**0**

Figure 56: Affectation of the different carbon balances

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq	CO2 Biomass	CO2 Soil	N2O	CH4	Per phase of the project Implement.	Per phase of the project Capital.	Mean per year Total	Mean per year Implement.	Mean per year Capital.
Deforestation	0	0	0	0	0	0	0	0	0	0
Forest Degradation	0	0	0	0	0	0	0	0	0	0
Afforestation and Reforestation	0	0	0	0	0	0	0	0	0	0
Non Forest Land Use Change	0	0	0	0	0	0	0	0	0	0
Agriculture										
Annual Crops	0	0	0	0	0	0	0	0	0	0
Agroforestry/Perennial Crops	0	0	0	0	0	0	0	0	0	0
Irrigated Rice	0	0	0	0	0	0	0	0	0	0
Grassland	0	0	0	0	0	0	0	0	0	0
Organic soils and peatlands	0	--	0	0	0	0	0	0	0	0
Other GHG Emissions		CO2 (other)								
Livestock	0	---		0	0	0	0	0	0	0
Inputs	0	0		0	---	0	0	0	0	0
Other Investment	0	0		---	---	0	0	0	0	0
Final Balance	0	0	0	0	0	0	0	0	0	0
In % of Emission without project:	0,0%									
Result per ha	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Figure 57: Graphical representation of the project's components impacts

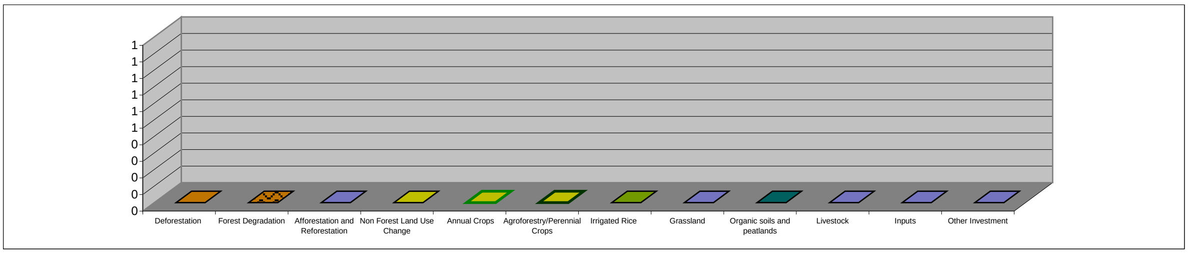


Figure 58: Estimations of the uncertainty level

		%
*	Low uncertainty	10
**	Moderate uncertainties	20
***	High uncertainties	33
****	Very high uncertainty	50

Indication of the level of uncertainty expected

Components of the Project	Main approach used	CO2 Biomass	CO2 Soil	N2O	CH4	CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	Tier 1	***	****	**	**	0	0	0	0
Forest Degradation	Tier 1	***	****	---	---	0	0	---	---
Afforestation and Reforestation	Tier 1	***	****	**	**	0	0	0	0
Non Forest Land Use Change	Tier 1	***	****	**	**	0	0	0	0
Agriculture									
Annual Crops	Tier 1	**	****	**	**	0	0	0	0
Agroforestry/Perennial Crops	Tier 1	****	****	**	**	0	0	0	0
Rice	Tier 1	**	****	**	**	0	0	0	0
Grassland	Tier 1	**	****	**	**	0	0	0	0
Organic soils and peatlands	Tier 1	--	****	****	****	--	0	0	0
Other GHG Emissions		CO2 (other)				CO2 (other)			
Livestock	Tier 1	---		***	***	---		0	0
Inputs	Tier 1	***		***	---	0		0	---
Other Investments	Tier 1	***		---	---	0		---	---

Problem of permanency may arise

Total uncertainty	0
Global level of uncertainty (%)	0

18.2. General context summary

The main information provided within the “Description Module” is presented in the top left table of the two “Gross results” and “Balance” Modules. It includes the name of the appraised project, the continent, the dominant climate, and the soil chosen by users. In the table in the middle, there is a summary of total land cover of the initial state of the project. The duration of the project appraisal is reported in the right table, as well as the total area of interest.

18.3. Affectation of the different carbon balances

The calculated figures are first presented in the two Results Modules for each possible project’s components.

Within the “Balance” Module, the global C-balance (all GHG accounted in tCO_2eq) per component is reported in the first column. If a result is positive, it means that the component of the project creates a source of GHG: the situation with project is emitting more than the situation without project. Whereas, if a result is negative, it means that the component of the project creates a sink of GHG: the situation with project is emitting less than the situation without project.

In the second column the previous result for each component is affected depending on the different kind of GHG responsible for it (CO_2 in biomass or soil, N_2O and CH_4).

The third column represents the C-balance for each component per phase of appraisal of the project (implementation and capitalization). The last column shows the C-balance for each component per year.

Figure 59: Figure 15: Schematic representation of results provided in the "Balance" Module

Components	Total Carbon results per component	Carbon results per type of emissions per component	Carbon results per phase per component	Carbon results per year per component

At the end, a line is dedicated for the global C-balance (sum of all activities) and the result is again given per type of GHG, per phase, and per year. Another line gives the global C-balance per hectare (using the total area appearing at the top of the "Result Module"), and per type of GHG, phase and year.

Within the "Gross results" Module, the first column corresponds to the gross GHG fluxes accounted for the scenario without project, and the second column to the ones accounted for the scenario with project. The last column reflects the previous fluxes for both scenarios per year of accounting.

Figure 60: Schematic representation of results provided in the "Gross results" Module

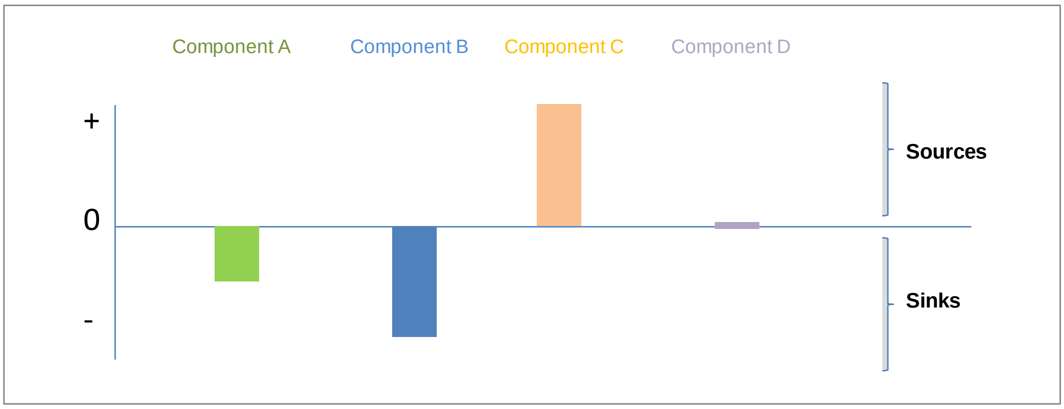
Components	Carbon results for the **without project** scenario per component	Carbon results for the **with project** scenario per component	Carbon results per year per component	
			without	with

18.4. Graphical representation of the project impacts

In order to obtain a better visibility of the results per component, each Results Module provides a graphical representation of the components impacts. It allows users to achieve comparisons between the component's potential that acts positively or negatively on Climate Change mitigation. The graphic below represents the different sources and sinks for each module. In the "Gross results" Modules, two bars are indicated per component (one for the gross fluxes in the without project scenario and one for the with project scenario) whereas in the "Balance" Module only one bar corresponding to the C-balance (difference between the two scenarios) is represented.

As an example to interpret the graphical representation in the "Balance" module, the following Figure 17 indicates that four components have been appraised. Components A and B are net sinks, whereas components C and D are sources in comparison to the situation without project. The project's component that contributes most positively to Climate Change mitigation is the component B. And the less efficient component in terms of mitigation is component C. In the "Gross results" Module, there would be two bars per component instead of one, describing the effect of both scenarios separated for each component. It is worth noticing that the results provided in the "Balance" module are obtained in comparison to the baseline scenario. A sink represented in the "Balance" module does not always mean that the activity implemented with the project is "good" for mitigation. This sink can also represent an activity that is less emitting than the activity implemented without project. For example, there could be deforestation in both scenarios, but on a smaller area in the situation with project. The reduced deforestation in the situation with project leads to a sink as the scenario with project emits less than the baseline, while deforesting creates a source of GHG emissions. This is why the “Gross Results” is also proposed to users to be able to understand what is exactly happening in each scenario.

Figure 61: Schematic representation of results chart provided



18.5. Estimations of uncertainty level

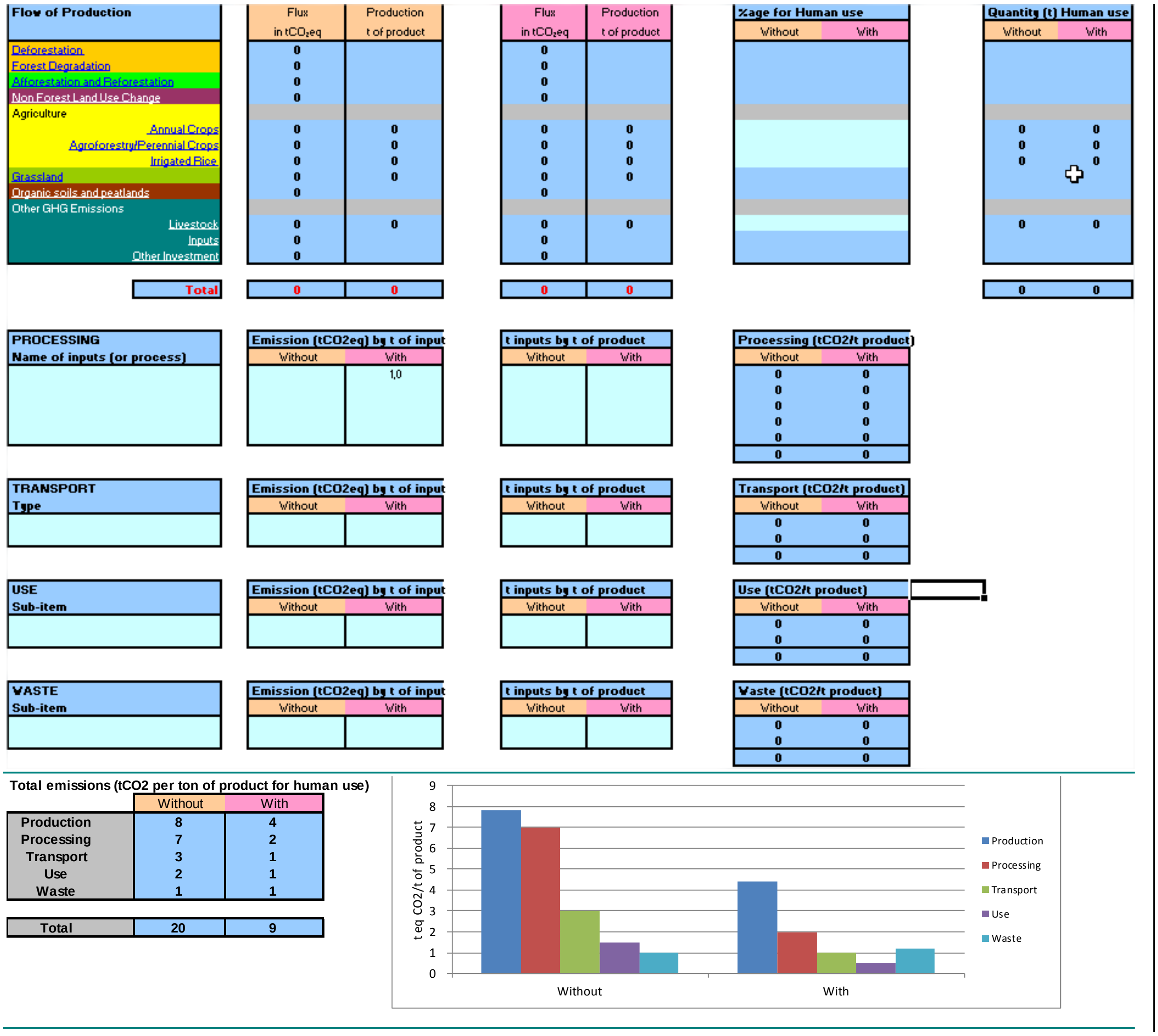
Within the “Balance” Module, a table is provided about the level of uncertainty, after the graphical representation of the results. As mentioned previously, EX-ACT calculations are based on either default coefficients (Tier 1 approach) or values provided by users (Tier 2 approach). A single project may use a combination of both approaches. It is thus extremely difficult to provide uncertainties associated with the final values provided by EX-ACT. Most default coefficients are associated with low to extremely large uncertainties. The table provides indications of the minimum level of uncertainty that users may expect, based on expert opinion. Different categories have been created, in order to reflect the level of uncertainties (low uncertainty, moderate uncertainties, high uncertainties, very high uncertainties). Going from Tier 1 to Tier 2 decreases the category of uncertainties, as Tier 2 uses more precise values.

The rough level of uncertainty is affected per type of accounted GHG. At the end a final estimation of the total level of uncertainty is given in t of eq-CO_2, as well as in percent.

18.6. Value chain

To better link GHG emissions and food production, it is now possible to include the level of food production of assessed projects in the calculator. The aim is to obtain a value in t eq CO_2 per ton of human food. Yields must be entered in each agricultural production sheet (annual, perennial, rice and livestock). Special attention is required for projects with multiple productions (e.g., crops, meat, milk) as EX-ACT adds together the tonnage of different kinds of products, regardless of their properties (proteins, calories, vitamins etc.). Therefore users must be very careful when interpreting these results. The share of production dedicated to human consumption is necessary to take into account that large quantities of cereals are used for animal feed and not for human food. Users must enter the emissions for the transformation process, transport, use and waste, following a life cycle approach. No default values are provided here due to the high variability of situations. The idea is to give an overview of this topic; however the tool does not pretend to replace specific life cycle softwares.

Figure 62: the value chain module



18.7. Other environmental indicators

A complementary sheet proposes different environmental criteria. Users do not have to fill in any new data. These indicators provide a first glance on the impact of the project on water consumption and biodiversity. The module only aims at highlighting the risk of trade-off between GHG mitigation measures and other sustainability criteria.

Figure 63: Calculation of complementary indicators

OTHER INDICATORS

Area Irrigated (ha)

	Start	End	
	t0	Without Pr.	With Pr.
Irrigated Rice	0	0	0
Annual crop	0	0	0
Total	0	0	0

Area Burnt (totally or partially)

	Cumulated areas burnt	
	Without Pr.	With Pr.
From deforestation	0	0
From degradation	0	0
Plantation	0	0
Other LUC	0	0
Annual	0	0
Perennial	0	0
Irrigated Rice	0	0
Grass	0	0
Total	0	0

Forest Degraded (ha)

Total area potentially subject to degradation (ha)	0

	Start	End	
	t0	Without Pr.	With Pr.
Area with degradatior	0	0	0
% of the area degrade	0,0	0,0	0,0
mean level of degradation (%)	0,0	0,0	0,0

19. CONCLUSION

These technical guidelines describe the structure of the EX-ACT tool, detail its scientific background to make users understand the logic of the tool and the results of its calculation to estimate carbon-balance within ex ante projects and investment programmes.
Two levels of analysis are available, the one through default values mostly related to the IPCC methodology, and the one through specific data owned by users that have to be quoted as references.

The EX-ACT tool allow estimating how many forestry and agricultural projects, programmes or sector strategies can mitigate climate change by reducing or sequestrating GHG. The estimation of the carbon balance can also guide the project design process and the decision making on funding aspects regarding project activities with higher benefits. It reflects which cropping practises, livestock and forestry management are expected to have significant response to tackle climate change in agriculture development projects, developing synergies between climate change and resilience of vulnerable smallholders.

20. EASYPOL LINKS

Readers can see other related material

EASYPol Module 101, ***EX-ACT: EX-ante Appraisal Carbon-Balance Tool*** **(Version 4)** and **Brochure**.

See all EX-ACT resources in EASYPol under the Resource package, ***Investment Planning for Rural Development - EX-Ante Carbon-Balance Appraisal of Investment Projects***

21. READERS' NOTES

21.1. Related documents

Readers can see other documents related to the topic:

Bernoux M., Branca G., Carro A., Lipper L., Smith G., Bockel L., 2010. Ex-Ante Greenhouse Gas Balance of Agriculture and Forestry Development Programs. *Sci. Agric. (Piracicaba, Braz.), v.67, n.1, p 31-40, January/February 2010.*

Bockel, L., 2009. *Climate Change and Agricultural Policies, How to Mainstream Climate Change Adaptation and Mitigation into Agriculture Policies*, for the FAO Policy Learning Programme 2009.

FAO. 2009. *Food Security and Agricultural Mitigation in Developing countries: Options for Capturing Synergies*.

22. FURTHER REFERENCES

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Herrero M., Thornton P.K., Kruska R., Reid R.S.. 2008. Systems Dynamics and the Spatial Distribution of Methane Emissions from African Domestic Ruminants to 2030. *Agriculture, Ecosystems and Environment 126, 122–137.*

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Smith, P.; Martino, D.; Cai, Z.; Gwary, D.; Janzen, H.H.; Kumar, P.; Mccarl, B.; Ogle, S.; O'mara, F.; Rice, C., Scholes, R.J.; Sirotenko, O. 2007. Agriculture. Chapter 8. In Climate *Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, (B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, .A. Meyer, Eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

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Yang S.S., Liu C.M., Liu Y.L. 2003. Estimation of Methane and Nitrous Oxide Emission from Animal Production Sector in Taiwan During 1990–2000. *Chemosphere 52,1381–1388*

Zhou J.B., Jiang M.M., Chen G.Q. 2007. Estimation of Methane and Nitrous Oxide Emission from Livestock and Poultry in China During 1949–2003. *Energy Policy 35, 3759–3767*