



The EX-Ante
Carbon-
balance Tool



EASYPol
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ANALYTICAL TOOLS

EASYPol MODULE 101

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

Technical Guidelines for Version 3

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) [Tool](#); (ii) [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](#)



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

Technical Guidelines for Version 3

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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 ₂ O	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 CH₄ and N₂O emissions expressed in t CO₂e 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 to identify the mitigation impacts of various investment project options, and thus provide an additional criterion for consideration in project selection. These technical guidelines for using EX-ACT aim at providing the user with the details of 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 the user with an explanation of 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-CO₂/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 references¹. 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 (IPCC 2006, thereafter named NGGI-IPCC-2006) 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 in finding 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 (CO₂ 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 details 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, except if specified, use a Tier 1 approach with a stock-difference method for emission of CO₂ (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.

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*.

- **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 necessary².
- **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 (Table 2.3 of NGGI-IPCC-2006). When Soil Organic C changes over time (land use change or management change), it is assumed 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.

It could be highlighted that 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)

² 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).

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 N₂O and CH₄ emissions, the generic approach considers multiplying an emission factor for a specific gas or source category with activity data related to the emission source (it can be area, animal numbers or mass unit). Emissions of N₂O and CH₄ are either associated with a specific land use category or subcategory (e.g. CH₄ emission from rice), or are estimated at project aggregated data (e.g. emissions from livestock and N₂O emission from fertilizers).

Emissions from biomass burning for all kind 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 (N₂O or CH₄) for one hectare is obtained as follow:

$$\text{GHG}_{\text{fire}} = M_{\text{Biomass}} \times C_{\text{F}} \times G_{\text{ef}}$$

Where:

GHG_{fire} = amount of GHG from fire, kg of each GHG e.g., CH₄ or N₂O.

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.

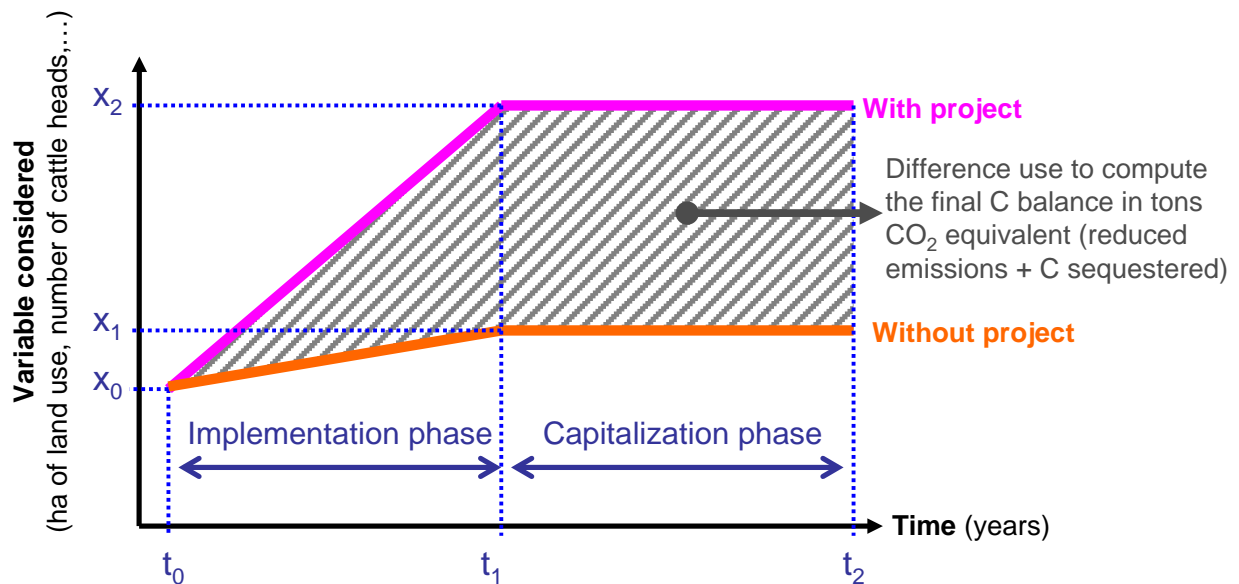
3. EX-ACT

3.1. The logic behind the EX-ACT tool

When performing an ex-ante analysis the user 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.

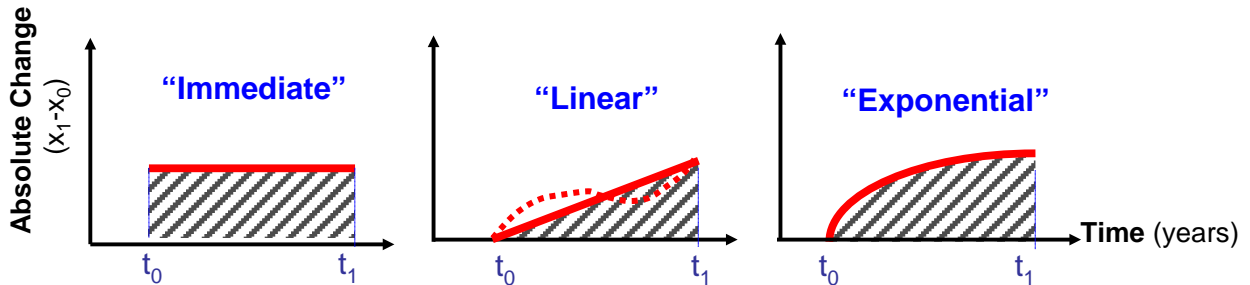
The user can set two different time periods for the project, one referred to as the implementation phase (i.e. the active phase of the project commonly corresponding to the investment phase), and the other as the capitalization phase (i.e. a period where project benefits are still occurring as a consequence of the activities performed during the implementation phase). The user 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 fig. 1).

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



3.2. Dynamics of change

The software allows the user to take into account different dynamics of change. Default dynamics adopted and represented here are linear, but the advanced users have the possibility to 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 farmers will employ fertilizer on an additional 100 ha for the first year resulting in an amount of GHG release for the 5 years being:

$$\text{Total}_{\text{Immediate}} = 100 \times 5 \times \text{EF}.$$

Under the “Linear” dynamic, which is the default dynamic proposed, the 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: $\text{Total}_{\text{Linear}} = 0.5 \times (100 \times 5 \times \text{EF})$. The exponential case represents an intermediary situation. The rate of change is faster at the beginning. The exponential approximation is defined by the equation $\Delta(t) = \Delta_{\text{max}} (1 - e^{-kt})$, with $\Delta_{\text{max}} = (x_1 - x_0)$, and k is set in order to have $\Delta(t_1) = 99\%$ of Δ_{max} . It can be shown that therefore $\text{Total}_{\text{exponential}} = 0.78 \text{ Total}_{\text{Immediate}}$.

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 (see NGGI-IPCC-2006 for details). The tool retains the approach 2 as a basis (cf. sections 3.3 and 3.3.1 of NGGI-IPCC-2006), 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).

Screenshot of the matrices with and without projection of the different changes compiled from the other modules.

Mineral soils <i>Without Project</i>		FINAL							Total Initial	
		Forest/ Plantation	Cropland			Grassland	Other Land			
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 Land	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 <i>With Project</i>		FINAL							Total Initial	
		Forest/ Plantation	Cropland			Grassland	Other Land			
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 Land	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 practice 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; the reader may refer to section 3.5 of NGGI-IPCC-2006 for more details.

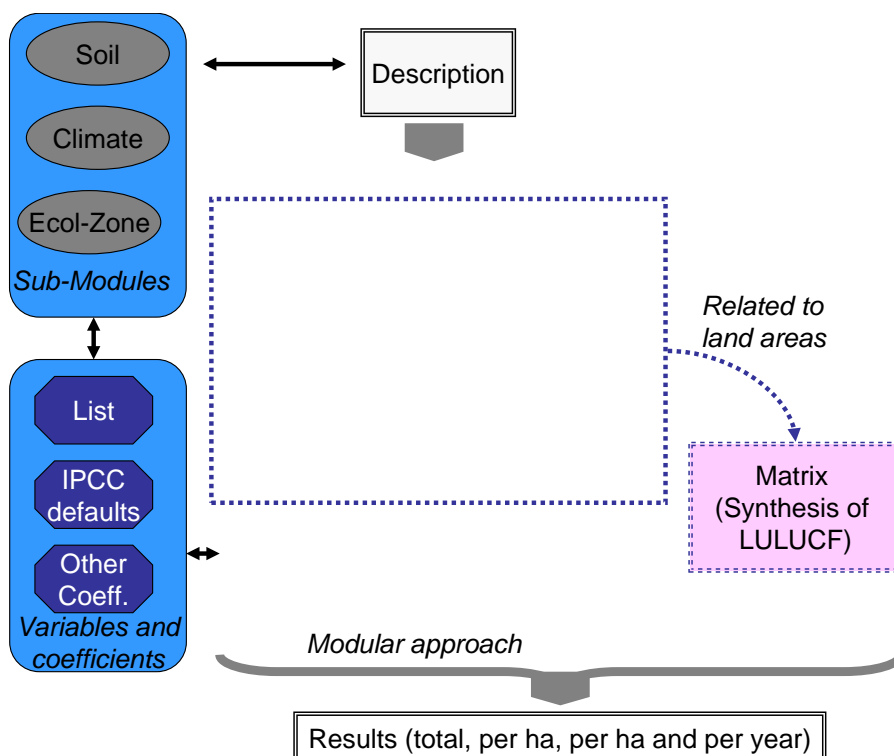
Additionally to change in land-use categories, the EX-ACT tool also considers the management practices, or the change of practices, inside categories, when the practice can influence the GHG balance (e.g. tillage intensity for croplands, level of inputs...).

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).

- general description of the project (geographic area, climate and soil characteristics, duration of the project);
- 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
- computation of C-balance with and without the project using IPCC default values and – when available – ad-hoc coefficients.

Figure 3: Structure of the tool



EX-ACT is organised according to 20 spreadsheets, also named as Modules, where the user 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 4: Screen shot of EX-ACT



The colours used make reference to determined action requested or information about links to specific part: baseline, project...

Figure 5: Colours used and their broad significance for the user

Colour used	Meaning
	Request an action from the user: either choose from a predetermined list, or fill with a value
	Default value proposed, can be changed if necessary
	No action requested, already calculated or copied from original information
	Related to the Baseline
	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 the user 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 the user wants 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 impacts on climate change mitigation. In this manner, the user should be able to list the different modules he 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, the user 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 precised methodology 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

projection to have more or less uncertainty. 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 allow for estimating the project impacts against this ‘without-project’ reference scenario (“business as usual”).

That should help to answer the criteria of conditionality often asked to present a “carbon” project, putting forward what additional impacts the project can bring.

If the user attempts 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 project³ 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 process⁴. Approval is given by Designated National Authorities.

The main objective is to describe the most plausible baseline scenario (UNFCCC⁵) including the most credible options of land use, possible land use changes and main management practises 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.

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 for checking the different references used, consequently calculation 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...)

³ Going through the CDM Process. <http://www.undp.org/energy/docs/cdmchapter2.pdf>

⁴ Clean Development Mechanism Website: <http://cdm.unfccc.int/EB/index.html>

⁵ <http://cdm.unfccc.int/UserManagement/FileStorage/W9RY2SX45CMGK3QT16ZFPUED7IBN0V>

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 user's 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 for verifying that the tool has been used in a proper manner, and collecting data about mitigation activities implemented worldwide, thus helping to build database regarding mitigation potential in AFOLU sector

5. DESCRIPTION MODULE

It contains 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 as precisely as possible the climate.

The user 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 calculation will only need the first piece of information, or also the moisture regime, whereas other calculations may particularly require the MAT, e.g. the CH₄ emissions from manure management.

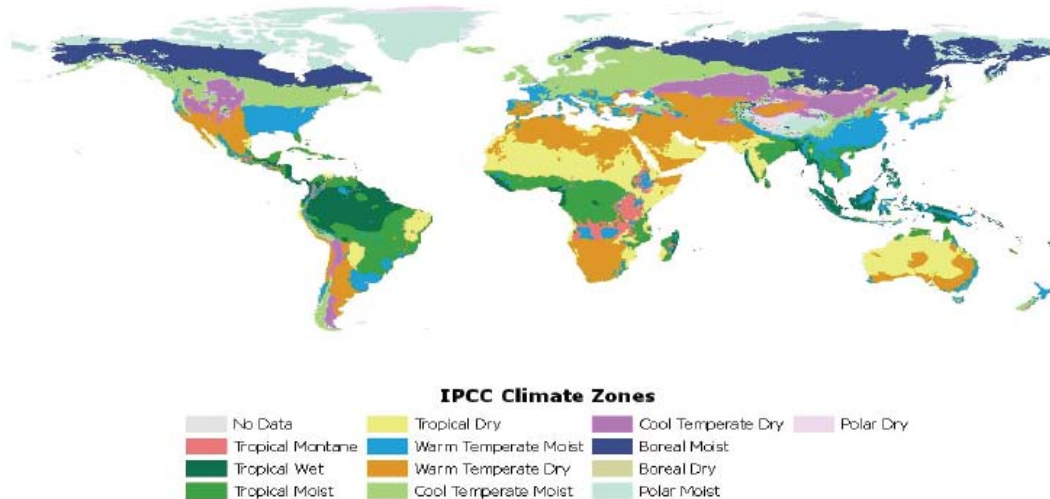
EX-ACT offers some help (maps, tables) and links to find additional information. In this case, the climate sub-module provides some help with different levels of complexity.

Climate sub-module content:

This sub-module provides the following help:

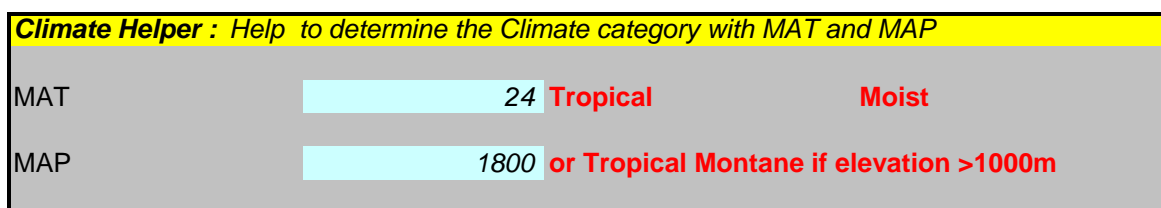
- A visual representation of the IPCC climate zones

Figure 6: Representation of IPCC climate Zone⁶



- 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 the user should provide⁷.

Figure 7: The climate helper tool



- 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 (LocClim is available for download

⁶ Source: Figure 3A.5.1 “Delineation of major climate zones, updated from the NGGI-IPCC-2006, Volume 4, Chapter 3 Page 3.38.

⁷ 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).

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>. This software will help the user to estimate the MAP and MAT of the project based on its location.

Figure 8: Screenshot of the different FAO resources provided to the 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 the advanced user, 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 (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

- **Dominant Soil type:** The user 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

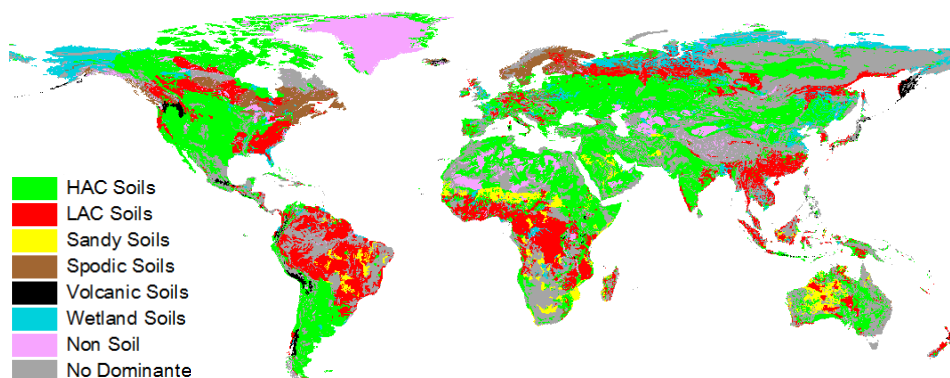
- Base - WRB - classification includes Aerosols; in US Department of Agriculture - USDA -classification includes Psamments).
- **Spodic Soils** are soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols).
 - **Volcanic Soils** derived from volcanic 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).

Soil Sub-module Content

This sub-module provides the following information:

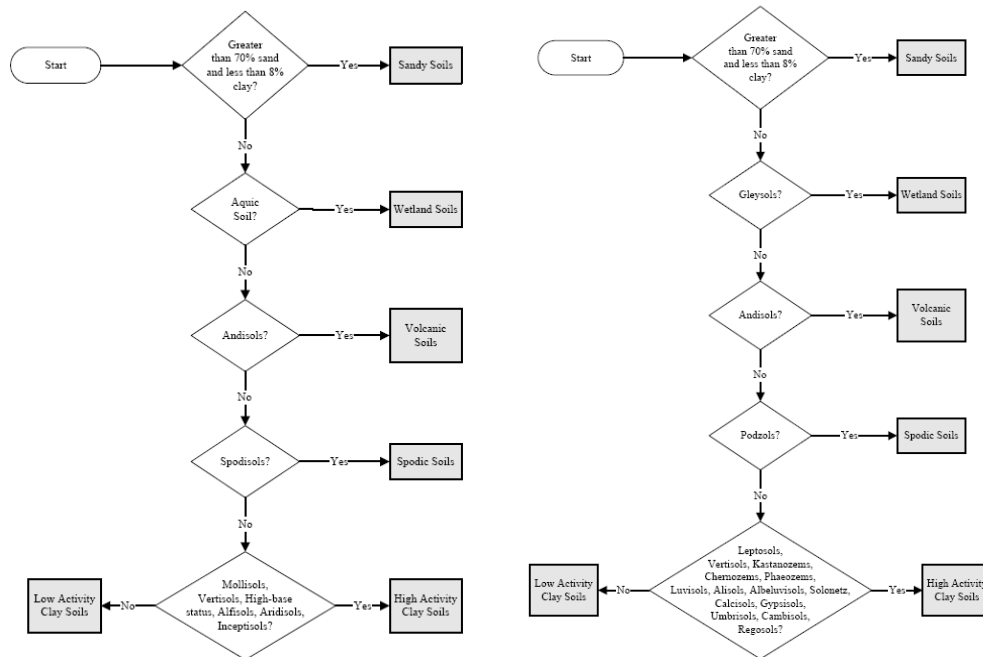
- A tentative map of the distribution of the IPCC soil categories using the FAO soil maps and the decision tree provided by the NGGI-IPCC-2006.

Figure 9: Tentative map of the distribution of the dominant soil type using IPCC classification



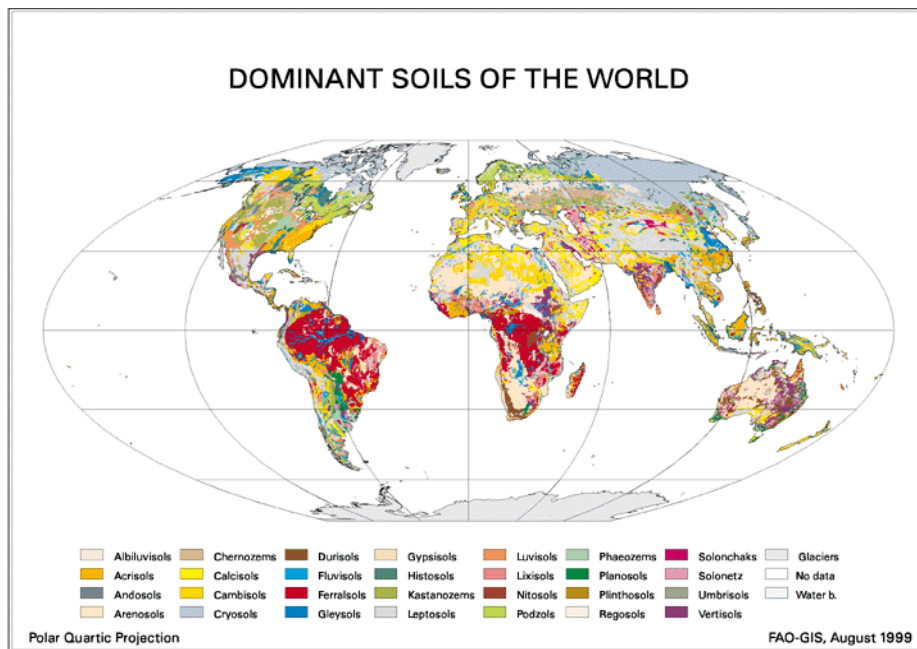
- A reproduction of the decision tree from NGGI-IPCC-2006 used to obtain corresponding IPCC classification using either the USDA or the FAO-WRB soil classification.

Figure 10: Classification scheme for mineral soil types based on World Reference Base for Soil Resources (WRB) classification (left) and USDA taxonomy (right)⁸



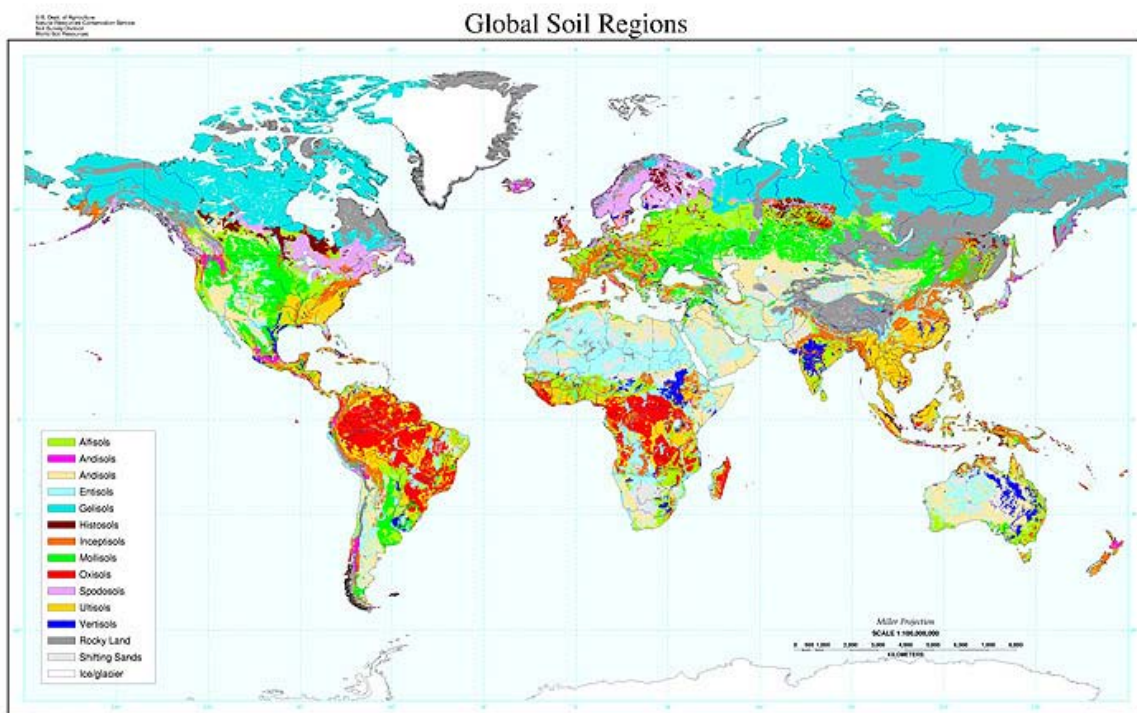
⁸ A reproduction of the dominant WRB Reference Soil Groups as based on the FAO-Unesco Soil Map of the World available at <http://www.fao.org/ag/agl/agll/wrb/wrbmaps/htm/domsol.htm>

Figure 11: Dominant Soils of the World (FAO-WRB classification)



- A reproduction of the dominant soil order of the US soil Taxonomy classification (<http://soils.cals.uidaho.edu/soilORDERS/i/worldorders.jpg>)

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



- **Duration of the Project:** The user 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 are still occurring 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.
- **Modules:** EX-ACT is made up of different modules which can be used to simulate the impact of project activities on the C balance. The user will only have to use the 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

Figure 13: Components of the project and corresponding EX-ACT modules

6. DEFORESTATION MODULE

The user is invited to read the general background and the details on the description module before proceeding.

6.1. Generalities⁹

The Deforestation Module is made up of 3 sections:

- 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	t C	t C			
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	0	0	0	0	0	0	0	0	0	0
Specific Vegetation2	0	0	0	0	0	0	0	0	0	0	0	0
Specific Vegetation3	0	0	0	0	0	0	0	0	0	0	0	0
Specific Vegetation4	0	0	0	0	0	0	0	0	0	0	0	0

- Conversion details

Name	Vegetation Type	Conversion details (Harvest wood product exported before the conversion, use of fire, final use after conversion)				Losses (positive value) and gain (negative value) per ha									
		HWP before		Fire use		Final Use after deforestation	Biomass	Biomass		Soil			CH4	N2O	Total
		tonne	t C exported	yes/no	% released		t 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

⁹ 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”

- Surface and GHG emissions

GHG emissions Vegetation type	Forested Area (ha)				Area deforested (ha)		Biomass loss		Biomass gain		Soil		Fire		Total Balance	
	Start to	Without Project		With Project		Without	With	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	
		End	Rate	End	Rate											
Defor. 1	0	0	Linear	0	Linear	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	
Defor. 3	0	0	Linear	0	Linear	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	
Defor. 5	0	0	Linear	0	Linear	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	
Defor. 7	0	0	Linear	0	Linear	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	
Defor. 9	0	0	Linear	0	Linear	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	
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 vegetations are provided for the main groups, either natural vegetation type or plantation vegetation type (Table DM-1). The user has the facility to fully describe four additional vegetation types (Specific Vegetation 1 to 4).

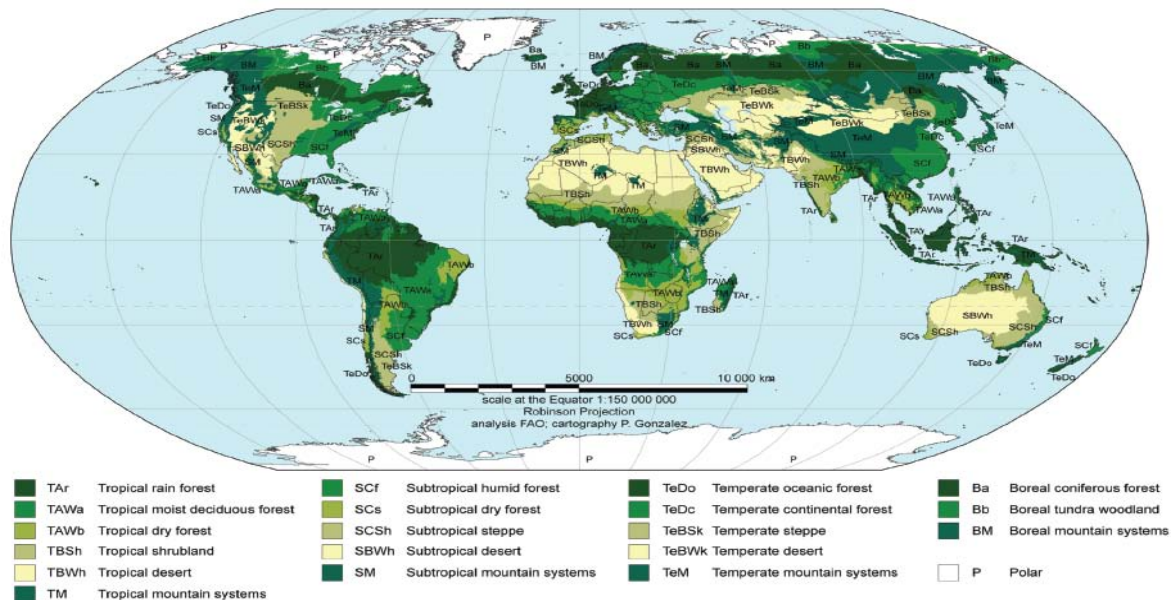
Table DM-1: Name of the vegetation (natural or plantation type) according to the Ecological Zone

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			

The user has the possibility to go to the map of the Global Ecological zone reproduced in the Ecol_Zone Sub-Module

Figure 14: 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 (pages 4.53-4.54 of NGGI-IPCC-2006) 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. 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 the user considers more precise values if possible, particularly for plantation type vegetation. For this purpose, useful information may be encountered 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). 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 given in Table 2.2 (page 2.27 of NGGI-IPCC-2006) by climate zone, Table DM-5 below summarized values proposed.

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 the user that wants to provide specific information using amount of litter expressed in dm; it is recommended considering the default carbon fraction of dry matter for litter of 0.37 (page 2.23 of NGGI-IPCC-2006).

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 (N₂O or CH₄) 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., CH₄ or N₂O.

$M_{Biomass}$ = 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).

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

HWP: User 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 CH₄ and N₂O are calculated in kg per GHG, and the sum expressed in t CO₂ 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 (Table 5.9 of NGGI-IPCC-2006) 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 (Table 5.5 pages 5.17-5.18 of NGGI-IPCC-2006) and Grassland (Table 6.2 page 6.16 of NGGI-IPCC-2006). 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 the user has the possibility to 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 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

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

An annual coefficient in t CO₂ per ha is calculated to be used in the last step “Surface and GHG emissions”.

6.4. Surface and GHG emissions

User 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 CO₂-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 the user needs to complete related information in other modules.

7. FOREST DEGRADATION MODULE

The user is 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:

- Definition of the vegetation

Type of Default forest/plantation proposed within the specified Climatic zone			Suggested Default Values per hectare (ha) for corresponding non-degraded forest								Biomass Sub Total tC
Ecological Zone	Go to Map		Above-Ground Biomass		Below-Ground Biomass		Litter	Dead Wood	Soil C		
			tonnes dm	t C	tonnes dm	t C	t C	tC	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	Specific Vegetation 2	Specific Vegetation 3	Specific Vegetation 4						
		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

- Conversion details regarding forest state

Sequence Type	Vegetation Type concerned	Initial State		Final State Without Project		Final State WithProject		Biomass			Soil (variation in 20 yrs)			Delta C Soil*	
		Degradation		Degradation		Degradation		Initial tC	Without tC	With tC	Initial tC	Without tC	With tC	Without tCO2	With tCO2
		Level	%	Level	%	Level	%								
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

- Surface and GHG emissions

GHG emissions													
Sequence Type	Degraded Forest Area (ha)						Biomass variation		Soil		Total Balance		Difference tCO2
	Start t0	Without Project		With Project		Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2		
		End	Rate	End	Rate								
Veget.1	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.2	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.3	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.4	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.5	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.6	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.7	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.8	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.9	0	Linear	0	Linear	0	0	0	0	0	0	0	0	
Veget.10	0	Linear	0	Linear	0	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). The user has the ability to 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 the user will have to 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.

7.4. Surface and GHG emissions

User 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 CO₂-Eq is calculated for the biomass and soil pool.

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

8. AFFORESTATION/ REFORESTATION MODULE

The reader is 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”. The reader is invited to read the description on the deforestation module first as the text below makes reference to it.

8.1. Generalities¹⁰

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

- Definition of the vegetation

Type of Default forest/plantation proposed within the specified Climatic zone				Suggested Default Values per hectare (ha)											
Natural Forest Type	Ecological Zone	Ecological Zone	Ecological Zone	Up to 20 year-old				After 20 year-old				Litter total	Dead Wood	Soil C	
				Above-Ground Biomass	Growth	Below-Ground Biomass	grow	Above-Ground Biomass	Grow	Below-Ground Biomass	grow				
				tonnes dm	tC	tonnes dm	tC	tonnes dm	tC	tonnes dm	tC	tC	tC	tC	
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	
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	Specific Vegetation2	Specific Vegetation3	Specific Vegetation4
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

- Conversion details

Name	Conversion details (Previous land use, use of fire before afforestation/reforestation,...)				Soil			CH4	N2O	Total	Biomass of forests/plantation			
	Vegetation Type	Previous use before afforestation/reforestation	Burnt before conversio	Default Biomass	Specific Biomass	k _{soil}	Delta C				tCO2/yr	kg	kg	tCO2 eq
													<=20yrs	>20yr
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

¹⁰ 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

- Surface and GHG emissions

GHG emissions Vegetation Type	Afforested or reforested Area (ha)						Area afforested (ha)		Biomass Gain		Biomass Loss		Soil		Total Balance		
	Start t0	Without Project			With Project			Without	With	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2
		End	Rate	End	Rate	End	Rate										
A/R1	0	0	Linear	0	Linear	0	0	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	0	0
A/R3	0	0	Linear	0	Linear	0	0	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	0	0
A/R5	0	0	Linear	0	Linear	0	0	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	0	0
A/R7	0	0	Linear	0	Linear	0	0	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	0	0
A/R9	0	0	Linear	0	Linear	0	0	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	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: natural vegetation and plantations (see Table DM-1). As those default vegetation types might be too generic, the user has the ability to 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: These values derived from table 4.9 of NGGI-IPCC-2006 (pages 4.57-4.58) 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 (page 4.63 of NGGI-IPCC-2006). Table A/R-1 reported default values for a system being more or less than 20 years.

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 of NGGI-IPCC-2006. It is highly recommended that the user seeks 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 of 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 the user will have to build the Afforestation/Reforestation systems, i.e. inform the type of vegetation concerned, the previous vegetation and if fire is used in the conversion to the other system, and also identify the new land use.

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

Previous Land use: The user 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 (Table 5.9 of NGGI-IPCC-2006) 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. 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) of NGGI-IPCC-2006. Maximum values, i.e. Perennial System more than 10 years, is set using the default values indicated in Table 5.1 (Page 5.9 of NGGI-IPCC-2006) 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 of individual GHG (N_2O or CH_4) is obtained using the generic method: $\text{GHG}_{\text{fire}} = M_{\text{Biomass}} \times C_F \times G_{\text{ef}}$

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. Crop residues were estimated to represent 40% of Biomass for Annual and Paddy Rice, therefore C_F coefficients were set to 0.4 to account for that.

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

	C_F	$G_{\text{ef}} - \text{CH}_4$	$G_{\text{ef}} - \text{N}_2\text{O}$
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} reported by NGGI-IPCC-2006.

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”.

8.4. Surface and GHG emissions

User must inform 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 (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 CO₂-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

The reader is invited to read the general background and the details on the description module before proceeding.

9.1. Generalities¹¹

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

- Description of land use changes

Name	Your Name	Description of LUC	
		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

- Land involved and corresponding GHG emissions

GHG emissions											
Vegetation Type	Area concerned by LUC	Area concerned by LUC				Biomass Change		Soil Change		Total Balance	
		Without Project		With Project		Without	With	Without	With	Without	With
		Area	Rate	Area	Rate	tCO ₂	tCO ₂	tCO ₂	tCO ₂	tCO ₂	tCO ₂
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	0	0	0	0

¹¹ 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”.

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, user 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 (Table 5.9 of NGGI-IPCC-2006) 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. 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 of 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 of NGGI-IPCC-2006) in column “Biomass C Loss” that represent 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 (Table 5.9 of NGGI-IPCC-2006) 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.

Then the variation between initial and final biomass is computed in t CO₂.

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 depends 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 (Table 2.3 in NGGI-IPCC-2006). 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 (Table NFOLUC-4) are based on the factors given by NGGI-IPCC-2006 for croplands systems (Table 5.5 pages 5.17-5.18 of NGGI-IPCC-2006) and Grassland (Table 6.2 page 6.16 of NGGI-IPCC-2006). 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 the user has the possibility to 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 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

User 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 CO₂-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. Generalities¹²

The Annual Module is made up of 2 sections:

- Definition of the annual systems and management practices

	Your description	User-defined practices Name Rate in tC/ha/yr	Improved agro- nomic practice:management	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 OLU	NO	?	?	?	?	?	NO	10
Reserved system A4	Converted to OLU	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

- Area involved and corresponding GHG emissions

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

¹² 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”.

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 at equilibrium and no significant soil C changes are occurring. But, anyway, the user 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, the user has the ability to select for each system whether different management practices are implemented. 5 different default options are available:

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

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 N₂O and C sources but also emissions increases, e.g. increase N₂O potential emissions associated with increases on external N inputs. The emissions or reduction of N₂O and CH₄ 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 CO₂ effect (tCO₂ 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-CO₂ emissions (Table Annual-2). In order to avoid overly optimistic estimates and to maintain a conservative approach, only the mitigation effect linked with CO₂ was retained.

Table Annual-2: Annual net mitigation potentials including non-CO₂ GHG (tCO₂-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

The user also has the possibility to define its own management category, entitled user-defined practices, and add a specific mitigation potential (in t C ha⁻¹ yr⁻¹). If the user wants to consider the annual net mitigation potentials including non-CO₂ given in Table Annual-2, this can be done under the “user-defined practices”. Note that the user-defined category has priority on 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 the user wants to use the sum of individual potential, this can be done under the user-specific option.

The user should also indicate if residues or biomass are burnt. A default amount of 10 t 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 (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 0.07 g N₂O and 2.7 g CH₄ per kg⁻¹ dry matter burnt.

10.3. Surface and GHG emissions

User 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 CO₂-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).

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

11. CROPLAND: PERENNIAL MODULE

11.1. Generalities¹³

- Definition of the perennial systems and management practices

	Your description	Residue/Biomass tonnes dm/ha			Aboveground Biomass Growth rate		Belowground Biomass Growth rate		Soil Effect Default t CO ₂ /ha/yr	User default available		CH ₄ kg	N ₂ O kg	CO ₂ eq t
		Burning	Interval (yr)		Default	Specific	Default	Specific		tCO ₂ /ha/yr	tCO ₂ /ha/yr			
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

¹³ 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”.

- Surface and GHG emissions

Mitigation potential														
Vegetation Type	Areas					CO ₂ mitigated from Biomass		CO ₂ mitigated from Soil		CO ₂ eq emitted from Burnt		Total Balance		Difference tCO ₂ eq
	Start t0	Without project		With Project		Without	With	Without	With	Without	With	Without tCO ₂	With tCO ₂	
	End	Rate	End	Rate										
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 1) newly implemented systems after deforestation (System P1) or from conversion of other land use systems (System P3), and for 2) 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 the user can indicate its 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 (page 5.9 in Chapter 5 Cropland of NGGI-IPCC-2006): 2.1 t C ha⁻¹ yr⁻¹ for 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. 1.8 t 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. User can use its own values if it is considered 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 CO₂-eq ha⁻¹ yr⁻¹ for Cool Dry regions, 0.51 t CO₂-eq ha⁻¹ yr⁻¹ for Cool Moist Regions, 0.33 t CO₂-eq ha⁻¹ yr⁻¹ for Warm Dry regions and 0.70t CO₂-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 N₂O and 2.3 g CH₄ per kg⁻¹ dry matter burnt.

11.3. Surface and GHG emissions

User 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 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 CO₂-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) of the NGGI-IPCC-2006, Part 5.2.4 for GHG emissions for biomass burning (pages 5.24- 5.25 of NGGI-IPCC-2006) and Part 5.5 for methane emission from rice cultivation (pages 5.44-5.53 of NGGI-IPCC-2006).

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 (CH₄) emission produced from anaerobic decomposition of organic matter and (ii) non-CO₂ GHG emissions (CH₄ and N₂O) from Biomass burning when occurring. CO₂ 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 N₂O 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:

$$\text{CH}_4\text{-Rice System}_i = \text{EF}_i \times t_i$$

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 $_i$

EF_i 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 $\text{EF}_{\text{Baseline}}$ is $1.30 \text{ kg CH}_4 \text{ ha}^{-1} \text{ day}^{-1}$ (This factor was calculated using Yan et al., 2005). This factor is corrected by multiplying three specific factors accounting for the flooding patterns before ($\text{EF}_{\text{before}}$) and during ($\text{EF}_{\text{during}}$) the cultivation period, and the use of organic amendments (EF_{OA}):

$$\text{EF}_i = \text{EF}_{\text{Baseline}} \times \text{EF}_{\text{before}} \times \text{EF}_{\text{during}} \times \text{EF}_{\text{OA}}$$

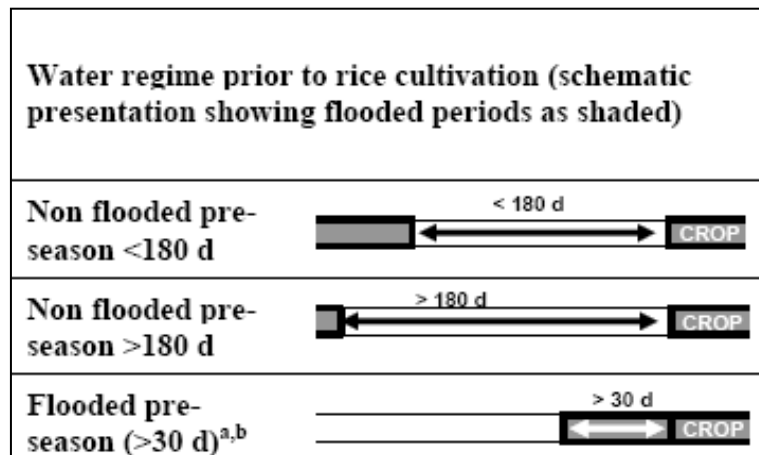
The scaling factors were derived from Table 5.12 and 5.13 respectively for $\text{EF}_{\text{before}}$ and $\text{EF}_{\text{during}}$. (see Table RM-1).

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 RM-1 below)

Figure RM-1: 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 50 cm during the cropping season), (ii) drought prone (drought periods occur during every cropping season), and (iii) deep water rice (Floodwater rises to more than 50 cm 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 CH₄.ha⁻¹.day⁻¹, i.e. a ratio maximum/minimum of 10. Thus, the user should carefully inform the water managements before and during the cultivation period of the rice systems, because a small change can result in 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.

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

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 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 user according to the type and management of the residues or organic amendment (Table RM-2). 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
Straw incorporated long (>30d) before cultivation)	0.29
Compost	0.05
Farm yard manure	0.14
Green manure	0.5

12.3. Non-CO₂ GHG emissions (CH₄ and N₂O) from Biomass burning

Non-CO₂ GHG emissions from biomass burning are based on the generic method presented for all Biomass in chapter 2.4 of Volume 4. Amount of GHG emitted is determined using the following equation:

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

Where:

GHG_{fire} = amount of GHG emissions from fire, kg of each GHG, (CH₄, N₂O) 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 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. G_{ef} is set to 0.07 kg.t^{-1} DM for N₂O and 2.7

kg.t⁻¹ DM for CH₄, using the default values proposed for the agricultural residues in Table 2.5.

Then the total amount is calculated in kg CO₂-eq using the GWP retained by the user (see Module Description). For the default value of 5.5 DM of rice straw the amount of non-CO₂ released is therefore equivalent to $5.5 \times 0.8 \times 0.07 = 0.308$ kg N₂O plus $5.5 \times 0.8 \times 2.7 = 11.88$ kg CH₄, i.e., considering the official GWP for CDM project, 0.345 t CO₂-eq.

12.4. Description of the Rice Module

Two different tables are composed for the Rice Module, the first one is for the user to describe the different rice systems present within the project boundaries, the second one is for the user to identify the surface change both with and without the project implementation and the dynamic of change (see Background part).

Building the different Rice systems

	Cultivation Water Regime				Organic Amendment type (Straw or other)	rate tonne	Specific C change Delta C* tCO ₂ eq/ha/yr
	Your description	Cultivation period (Days)	During the cultivation Period	Before the cultivation period need help			
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 informing:

- The length in day of the rice cultivation period; the user can find useful information at www.irri.org/science/ricestat and 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 RM-2).

Figure RM-2: 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.
- The user has the possibility to inform eventual specific C change (in t CO₂-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.

Informing the changes (surface and dynamics)

Areas (ha) of the different options						
Type	Start		Without Project		With Project	
	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		

The user must inform the changes in surface associated with each rice system described previously. The dynamics are set by default to linear, but can be changed (see background part). The last line provides alert error if the total for systems 1 to 10 changes over time.

Default		Start t0	Without project		With Project		Soil C variations (tCO ₂ e)		Total CO ₂ eq. from fire		Total CO ₂ e _q		Difference tCO ₂ e _q	
			End	Rate	End	Rate	Without	With	Without	With	Without	With		
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 1) newly implemented grasslands after deforestation (System G1) or from conversion of other land use systems (System G3), and for 2) 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 remaining 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.

User 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 occurred each 5 years. Those options correspond to the option detailed by NGGI-IPCC-2006. 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.

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 30 cm 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 C_{soil} are based on the relative factors k_{soil} given by NGGI-IPCC-2006 for Grassland (see Table 6.2 page 6.16 of NGGI-IPCC-2006). 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 (Deforestation, A/R and NFOLUC modules).

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

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

User must inform the changes in surface for each grassland 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 management characteristics and details indicated in other parts, 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).

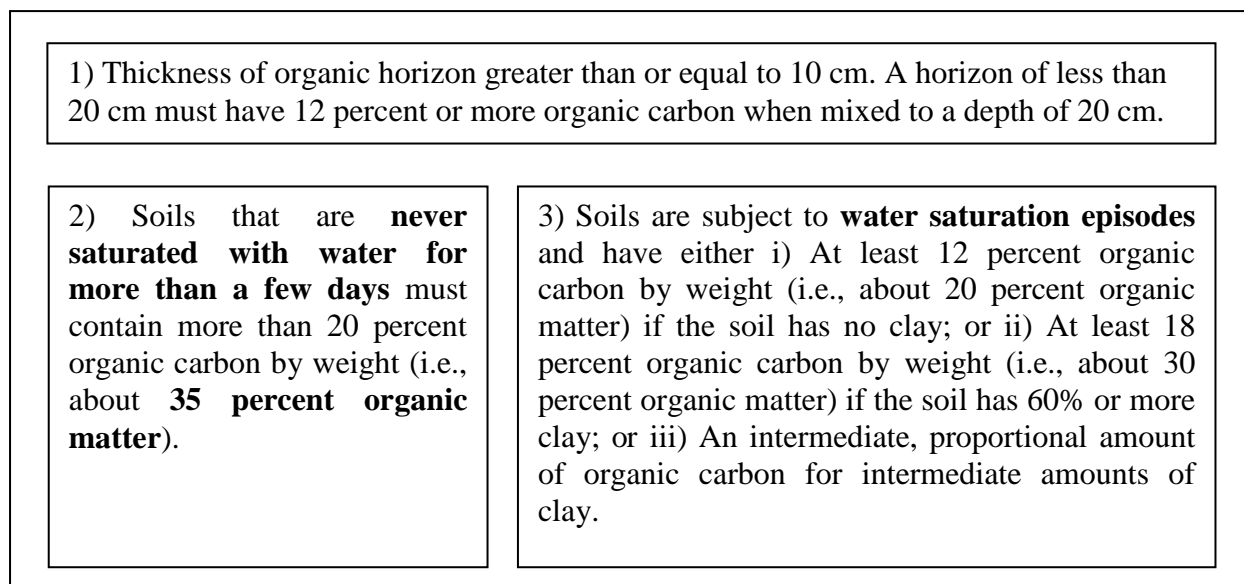
The areas informed are also used to build the matrix of change.

14. ORGANIC SOILS MODULE

14.1. Generalities ¹⁵

This Module calculates GHG balance associated with the management of organic soils. It permit to consider patch 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)¹⁶:

Figure OM-1: Definition of organic soils (FAO, 1998)



¹⁵ Material used to develop this module can be found in Chapter 7 “Wetlands” of the Volume 4 (AFOLU) of the NGGI-IPCC-2006.

¹⁶ FAO. 1998. World Reference Base for Soil Resources. World Soil Resources Reports 84. FAO, Rome. 88pp. (ISBN 92-5-104141-5).

The Organic soils Module is built according to 4 parts:

- 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 (t CO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start		Without Project		With Project		Start	End		All Period		
				0	0	Linear	0	Linear	0		0	Without	With	Without	
Managed Forest	1.36		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual	20.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Perennial	1.36		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Grassland	5.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0

- 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 (t CO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start		Without Project		With Project		Start	End		All Period		
				0	0	Linear	0	Linear	0		0	Without	With	Without	
Nutrient-poor peat	2.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Nutrient Rich	2.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0

- On site CO₂ emissions from peat use

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

Type of Peat	C fraction (tonnes C (tonne air-dry peat)-)			Air-dry weight of extracted peat, tonnes yr-1 (If you have volume of Peat use conversion factor on the right -->)						Emission (t CO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start		Without Project		With Project		Start	End		All Period		
				0	0	Linear	0	Linear	0		0	Without	With	Without	
Nutrient-poor peat	0.3		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Nutrient Rich	0.34		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0

- On-site N₂O emissions from peatlands undergoing active peat extraction

On-site N₂O emissions from peatlands undergoing active peat extraction

Type of Peat	Emission factors ((kg N ₂ O-N ha-1 yr-1)			Surface of organic soils concerned (ha)						Emission (t CO2eq) per year			Total Emission (tCO2eq)		Difference
	IPCC	Specific	Default	Start		Without Project		With Project		Start	End		All Period		
				0	0	Linear	0	Linear	0		0	Without	With	Without	
Nutrient-poor peat	0.00		YES	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Nutrient Rich	3.60		YES	0	0	Linear	0	Linear	0	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. The tool allows for calculating the impact of the drainage of organic soils on four types of land uses : managed forest, annual, perennial, grassland¹⁷.

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.

¹⁷ 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

Wetland drainage, especially peatland, results in an increase in CO₂ emissions due to increased oxidation of soil organic material, an increase in N₂O emissions and a possible reduction of CH₄ emissions that occur in un-drained organic soils. However there is currently no methodology to assess CH₄ 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 CO₂eq.

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

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 wastewater treatment, and other purposes (International Peat Society, 2004).

Peat extraction starts with vegetation clearing, which prevents further carbon sequestration, so only CO₂ emissions are considered. They are obtained by multiplying an emission factor by the area concerned (cf. Table OM-2 and table 7.4 of the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU)).

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 stilled 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.

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

14.4. On site CO₂ emissions from peat use

Once the peat 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 CO₂eq. 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 (cf. Table 7.5 of the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU)).

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

14.5. On-site N₂O emissions from peatlands undergoing active peat extraction

More than CO₂ emissions, the active extraction of peat leads to emit N₂O. The method for estimating N₂O 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 accounts automatically the surface indicated in the previous part (On-site CO₂ emissions from peatlands undergoing active peat extraction) multiplied by an emission factor (cf. Table 7.6 of the NGGI-IPCC-2006, Chapter 7 “Wetlands” of the Volume 4 (AFOLU)). The IPCC only provides default emission factors for nutrient-rich organic soils in boreal and temperate climate zone equals to 1.8 kg N₂O-N ha⁻¹ year⁻¹ and another one for tropical climate equals to 3.6 kg N₂O-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 (Smith et al., 2007) for specific technical mitigation options not covered in NGGI-IPCC-2006.

GHG covered by the “Livestock Module” are (i) methane (CH₄) 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.

15.2. Methane emissions from enteric fermentation

Methane emissions from enteric fermentation				Head Number			Emission (t CO ₂ e) per year			Total Emission (tCO ₂ e)		Difference		
Choose Livestocks:	IPCC factor	Specific factor	Default Factor	Start	Without Project		With Project		Start	End			Without	With
				#0	End	Rate	End	Rate	Without	With				
Dairy cattle	40	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Other cattle	31	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Buffalo	55	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Sheep	5	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Swine (Market)	1,5	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Swine (Breeding)	1,5	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Goats	5	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Carnels	46	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
Carnels	46	YES	YES	0	0	Linear	0	Linear	0	0	0	0	0	0
User Defined- Specified value		NO	NO	0	0	Linear	0	Linear	0	0	0	0	0	0
User Defined- Specified value		NO	NO	0	0	Linear	0	Linear	0	0	0	0	0	0
Sub-Total t									0	0	0	0	0	0

EX-ACT uses the Tier 1 method so that only animal population data (in addition to information already provided in the description module) is needed to estimate the emissions. The users always have the possibility to use their own emission factors if available. To fill the information the user 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). In addition the user 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 Production Yearbook. 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 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:

- 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.

Two additional information might be informed by the user:

PLEASE SPECIFY INFORMATION BELOW IF AVAILABLE

Country "Type"	<i>Not specified</i>
Mean Annual Temperature (MAT*) in °C	

Alternatively the user 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 CH₄ and N₂O emissions from manure management (see sections below).

- The user has also the possibility to 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 CH₄ and N₂O emissions from manure management (see sections below).

Table LM-1: Methane emissions factors by continent for Dairy and Other Cattle, in kg CH₄ 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 decided to separate Developed and Developing countries even if the coefficients may be the same for most livestock categories, for example. Table LM-2 reported corresponding emission factors.

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		
Deer	20	20
Alpacas	8	8
Swine	1	1.5

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

Table LM-3: Specific methane emissions factors from enteric fermentation reported in published articles for different livestock categories and regions, in kg CH₄ 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
Colourful broiler	Taiwan	8.5 10 ⁻⁵	-	Yang et al., 2003
Broiler	Taiwan	1.6 10 ⁻⁵	-	Yang et al., 2003

The user should then inform 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 CO₂-eq.

15.3. Methane emissions from manure management

Methane emissions from manure management														
Choose Livestocks:	IPCC factor	Specific factor	Default Factor	Head Number			Emission (t CO ₂ eq) per year			Variation of Emission (tCO ₂ eq)				
				Start to	Without Project	With Project	Start	Without	With	All Period	Without	With	Difference	
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

The user does not need to give any information if he wants to use the default IPCC coefficients. The livestock categories, including those chosen or provided by the user, are copied from the table for methane emissions from enteric fermentation. Details about calculation can be encountered in section 10.4 of Chapter 8 of NGGI-IPCC-2006. 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.

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 CH₄ head⁻¹ yr⁻¹

Category	Developed Country			Developing country		
	MAT<1 5	15<MAT< 25	MAT>2 5	MAT<1 5	15<MAT< 25	MAT>2 5
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 it is possible it is recommended that the user seeks more specific emission factors. Some additional coefficients are provided below to illustrate other available EF for CH₄ emission 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 done 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 CO₂-eq.

15.4. Nitrous oxide 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)								
Choose Livestocks:	IPCC factor	Specific factor	Default Factor	Start	Without Project		With Project		Start	End		All Period		Difference				
				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

The user 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 the user, are copied from the table for methane emissions from enteric fermentation and also used in CH₄ emissions from manure management. Details about calculation can be encountered in section 10.5 of Chapter 8 of NGGI-IPCC-2006. 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.

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

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. 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.

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. This factor ranges from 0 to 0.1 according to the manure management (see Table 10.21). 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 the user uses 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 equation 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.

It is recognised here that in the next version, the improvement of N₂O emissions from manure management should be a priority!

15.5. Additional Technical Mitigation

Livestocks	Dominant Practice*	Factor	Percent of head with practices (0%=none;100%=all)						Emission (t CO ₂ e) per year			Variation of Emission (tCO ₂ e)			
			Without Project			With Project			Start	End		All Period	Without	With	Difference
			Start to	End	Rate	End	Rate	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. (2007) 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. (2007) showed that the use of more concentrates commonly increases CH₄ emission on an animal basis, but since it also increases performance (milk and meat), the end result is an overall reduction of CH₄ 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 age at slaughter 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 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. (2007) and reported in Table LM-15 and LM-16 below.

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

Region	Animal category and technical options					
	Dairy cattle			Other cattle		
	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. (2007) do not report coefficients according to the same regions that are used in EX-ACT. Some assumptions were made: percentage of the Middle East regions were set equal to that reported for Africa. For Asia (Insular), Asia (India Subcontinent) it retained values provided respectively for South Eastern and Southern Agro-Ecological Zones; values for Asia (Continental) corresponded 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.

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

The user 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 change 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 “N₂O emissions from managed soils, and CO₂ 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 CO₂ equivalent) from production, transportation storage and transfer of agricultural chemicals.

16.2. Carbon dioxide emissions from Lime application

Type of lime	IPCC factor	Specific factor	Default Factor	Amount of Lime in tonnes per year						Emission (t CO ₂ eq) per year			Variation of Emission (tCO ₂ eq)		
				Start t0	Without Project		Rate	End	Rate	Start	End		Change of the period		Difference
					End	Linear					Without	With	Without	With	
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 CO₂ emissions when carbonates lime dissolve.

CO₂ emissions are calculated using default emissions factors provided by IPCC guidelines, i.e. 0.12 for limestone and 0.13 for dolomite. CO₂ emissions are obtained by multiplying the emission factor with the quantities of each type of carbonates applied. When the user does not know the type of lime used, it can select the third line of the table that uses an average emission factor. User may also specify its 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 CO₂-eq.

16.3. Carbon dioxide emissions from Urea Application

Urea	IPCC factor	Specific factor	Default Factor	Amount of Urea in tonnes per year						Emission (t CO ₂ eq) per year			Variation of Emission (tCO ₂ eq)		
				Start t0	Without Project		Rate	End	Rate	Start	End		Change of the period		Difference
					End	Linear					Without	With	Without	With	
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(NH₂)₂) to the soils leads to a loss of CO₂. The amount of CO₂ 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. User

may also specify its own emissions factor that must by definition be less than the default emission factor.

Calculations are then done for the information of quantities of urea informed concerning the beginning, and forecast with and without the project and the dynamics chosen. Results provide the corresponding emissions in t CO₂-eq.

16.4. N₂O emissions from N application on managed soils

This section excludes the N₂O emissions form N application as manure because it is already covered in the specific Livestock Module.

Type of input	IPCC factor	Specific factor	Default Factor	Without Project			With Project		Start		End		Without		With		Difference
				Start t0	End	Rate	0	Rate	0	Without	With	Without	With				
Urea	0.01		YES	0	0	Linear	0	Linear	0,0	0,0	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	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	0	0	0
Sewage	0.01		YES	0	0	Linear	0	Linear	0,0	0,0	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	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 N₂O emissions, i.e. N₂O 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 compost. Emissions are calculated based on amount of N applied and an emission factor associated with the type of input (Table I-1).

Table I.1. Default emission factors used to compute N₂O 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
Compost	0.01

Indirect emissions may arise from 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. N₂O emissions associated with N deposition from chemical industries. Thus these emissions were not included. Users have the possibility to 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 NH₃ or NO_x per kg of N from synthetic fertilizer applied. This re-deposition of N having the same emission factor (0.01 kg N-N₂O 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 the user to consider more specific emission factors when available.

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

Type of input**	Default factor*	Specific factor	Default Factor	Without Project			With Project		Start			End		Total Emission		Difference	
				Start	End	Rate	End	Rate	Without	With	Without	With	Without	With			
Urea	4.8		YES	0	0	Linear	0	Linear	0.0	0.0	0.0	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	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	0.0	0.0	0.0	0.0	0
* from Lal (2004) Table 5 - central value -tCO2/t product									Sub-Total 1-4			0.0		0.0		0.0	
** 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 used the central value of the range of estimates reviewed by Lal (2004)

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 done 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 the 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 CO₂-eq.

17. OTHER INVESTMENT MODULE

Material used to develop this module came from diverse 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 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 the user to compute GHG emissions linked with 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.

Origin of Electricity Default values (T CO ₂ / MWh)	Please select the country of origin			Losses of electricity during transportation	
YES	0,000			10%	
OPTION 1 (Based on Total Electricity consumption over the whole duration of the project)					
Total Electricity Consumption (MWh)			Associated tCO ₂ eq		
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 CO ₂ eq)		
Start	Without Project		With Project		All Period
t0	End	Rate	End	Rate	Without
0	0	Linear	0	Linear	0
OPTION1 + OPTION2		Sub-Total Without	0,0	Sub-Total With	0,0
					Difference
					0,0

The default GHG emissions (in CO₂-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. The user 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 (Form EIA-1605, 2007, Appendix F. Electricity Emission Factors). These factors correspond to the average for the years 1999-2002. The user may use its own coefficient providing a specific value.

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	Democratic Rep. of Congo	0.004

Region	CO ₂ (tons/MWh)	Region	CO ₂ (tons/MWh)	Region	CO ₂ (tons/MWh)
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		

Region	CO ₂ (tons/MWh)	Region	CO ₂ (tons/MWh)	Region	CO ₂ (tons/MWh)
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 the user 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 tCO₂ per m³ and 2.85 for gasoline. These coefficients were derived from data reported in table 3.3.1 of NGGI-IPCC-2006 for off-road transportation.

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

Total Liquid Fuel Consumption (m3)	Gasoil/Diesel	Gasoline	Associated tCO ₂ eq
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 CO ₂ /m ³	Specific Value	Default Factor	Annual Fuel Consumption (m ³ /yr)					Emission (t CO ₂ eq)	
				Start t0	End	Without Project Rate	With Project End	With Project Rate	All Period Without	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 CO ₂ /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. EX-ACT used default emissions reviewed by Lal (2004) and reported in Table Inv-2.

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

User should provide the type and surface concerned with and without the project.

Installation of irrigation system	surface (ha)	Type of irrigation system	Associated tCO ₂ eq
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 permits the user to account for GHG emissions associated with construction.¹⁸ Table Inv-3 reports the default coefficient retained by EX-ACT.

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.

Type of construction or infrastructure	Default value t CO ₂ /m ²	Specific Value	Default Factor	surface (m ²)		Emission (t CO ₂ eq)	
				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 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_Carbonate

18. RESULTS MODULES

18.1. Generalities

All calculations done 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-CO₂, for both scenarios, without and with project, plus de gross fluxes per year of accounting for both scenarios. Actually 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 of 4 sections:

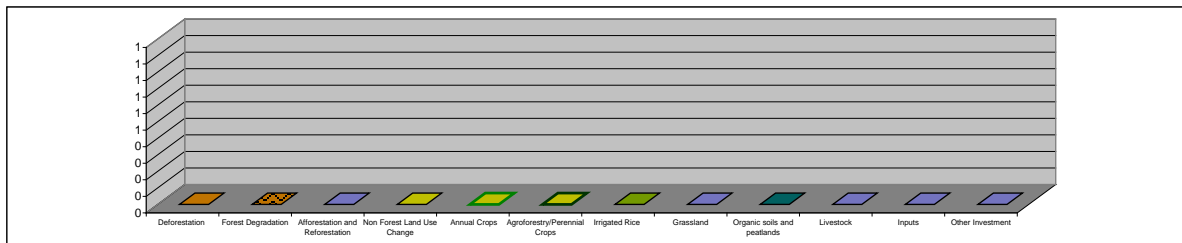
- General context summary

Project Summary		Area (Initial state in ha)		Duration of the Project (years)	
Name		Forest/Plantation	0	Implementation	0
Continent		Cropland	0	Capitalisation	0
Climate		Annual	0	Total	0
Dominante Soil T		Perennial	0	Total Area	
		Rice	0	Mineral soils	0
		Grassland	0	Organic soils	0
		Other Land	0	Total Area	0
		Degraded	0		
		Other	0		
		Organic soils/peatlands	0		

- Affectation of the different carbon balances

Components of the Project	Balance (Project - Baseline) All GHG in tCO ₂ eq	CO ₂			N ₂ O	CH ₄	Per phase of the project		Mean per year		
		Biomass	Soil				Implement.	Capital.	Total	Implement.	Capital.
Deforestation	0	0	0	0	0	0	0	0	0	0	0
Forest Degradation	0	0	0	0	0	0	0	0	0	0	0
Afforestation and Reforestation	0	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	0
Agriculture											
Annual Crops	0	0	0	0	0	0	0	0	0	0	0
Acroforestry/Perennial Crops	0	0	0	0	0	0	0	0	0	0	0
Irrigated Rice	0	0	0	0	0	0	0	0	0	0	0
Grassland	0	0	0	0	0	0	0	0	0	0	0
Organic soils and peatlands	0	--	0	0	0	0	0	0	0	0	0
Other GHG Emissions		CO ₂ (other)									
Livestock	0	---	0	0	0	0	0	0	0	0	0
Inputs	0	0	0	---	---	0	0	0	0	0	0
Other Investment	0	0	---	---	---	0	0	0	0	0	0
Final Balance	0	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	0,0

- Graphical representation of the project’s components impacts



- Estimations of uncertainty level

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 16: Schematic representation of results provided in the “Gross results” Module

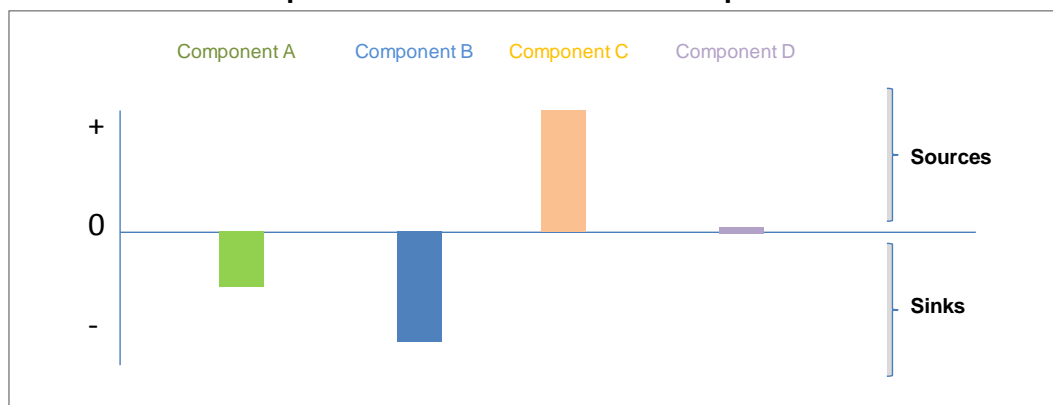
Components	Carbon results for the without project scenario per component	Carbon results for the with project scenario per component	Carbon results per year per component	
			without	with

18.4. Graphical representation of the project impacts

In order to get a better visibility of the results per component, each Results Module provides a graphical representation of the components impacts. It allows to achieve comparisons between the component’s potential that act positively or negatively on Climate Change mitigation. The graphic below represents the diverse 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 the 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. It 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 is less emitting than the baseline, while deforesting creates a source of GHG emissions. This is why the “Gross Results” is also proposed to the user to be able to understand what is exactly happening in each scenario.

Figure 17: Schematic representation of results chart provided



18.5. Estimations of uncertainty level

Finally, within the “Balance” Module, a table is provided about the level of uncertainty, after the graphical representation of the results. As previously said, EX-ACT calculations are based on either default coefficients (Tier 1 approach) or values provided by the user (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 is providing indications of the minimum level of uncertainty that the user may expect, based on expert opinion. Different categories have been created, in order to reflect the level of uncertainties (low uncertainties, 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-CO₂, as well as in percent.

19. CONCLUSION

These technical guidelines describe the structure of the EX-ACT tool, detail its scientific background to make the user 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 the user 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 sequestering 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](#) 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

MODULE METADATA



1. EASYPol module	XXX
2. Title in original language	
English	EX-ANTE: Carbon-Balance Tool (EX-ACT)
French	
Spanish	
Other language	
3. Subtitle in original language	
English	Technical Guidelines for EX-ACT Version 3
French	
Spanish	
Other language	
4. Summary	<p>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 CH₄ and N₂O emissions expressed in t CO₂e 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 to identify the mitigation impacts of various investment project options, and thus provide an additional criterion for consideration in project selection.</p> <p>These technical guidelines for using EX-ACT Version 3 aim at providing the user with the details of procedures and numbers used to perform calculation of C balance.</p>
5. Date	January 2011
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7. Module type	<input type="checkbox"/> Thematic overview <input type="checkbox"/> Conceptual and technical materials <input checked="" type="checkbox"/> Analytical tools <input type="checkbox"/> Applied materials <input type="checkbox"/> Complementary resources
8. Topics covered by the module	<input type="checkbox"/> Agriculture in the macroeconomic context <input checked="" type="checkbox"/> Agricultural and sub-sectoral policies



- Agro-industry and food chain policies
- Environment and sustainability
- Institutional and organizational development
- Investment planning and policies
- Poverty and food security
- Regional integration and international trade
- Rural Development
- Resilience and capacity building

9. Subtopics covered by the module

10. Training path

11. Keywords

carbon balance, carbon sequestration, carbon sinks, carbon sources, climate mitigation, EX-ACT, GHG, IPCC, reduction of emissions, resilience