Use of the IPCC Inventory Software for Establishing National GHG inventories in the Agriculture, Forestry and Other Land Use (AFOLU) sector

UNFCCC On-line Training

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AFOLU anthropogenic GHG Emissions and Removals

- **Emission and Removal Processes -** GHG fluxes in the AFOLU Sector can be estimated in two ways

1. as net changes in C stocks in C pools over time, *used for most CO_2 fluxes*. *The use of C stock changes to estimate CO_2 emissions and removals from C pools, is based on the fact that changes in ecosystem C stocks are predominately (but not exclusively) through CO_2 exchange between the land surface and the atmosphere (i.e. other C transfer process such as leaching are assumed to be negligible)*

2. directly as gas flux rates to and from the atmosphere *(used for estimating non-CO_2 emissions, CO_2 emissions not sourced from C pools and some CO_2 emissions and removals from C pools when C stock are not quantifiable in an operational way)*.

AFOLU anthropogenic GHG Emissions and Removals

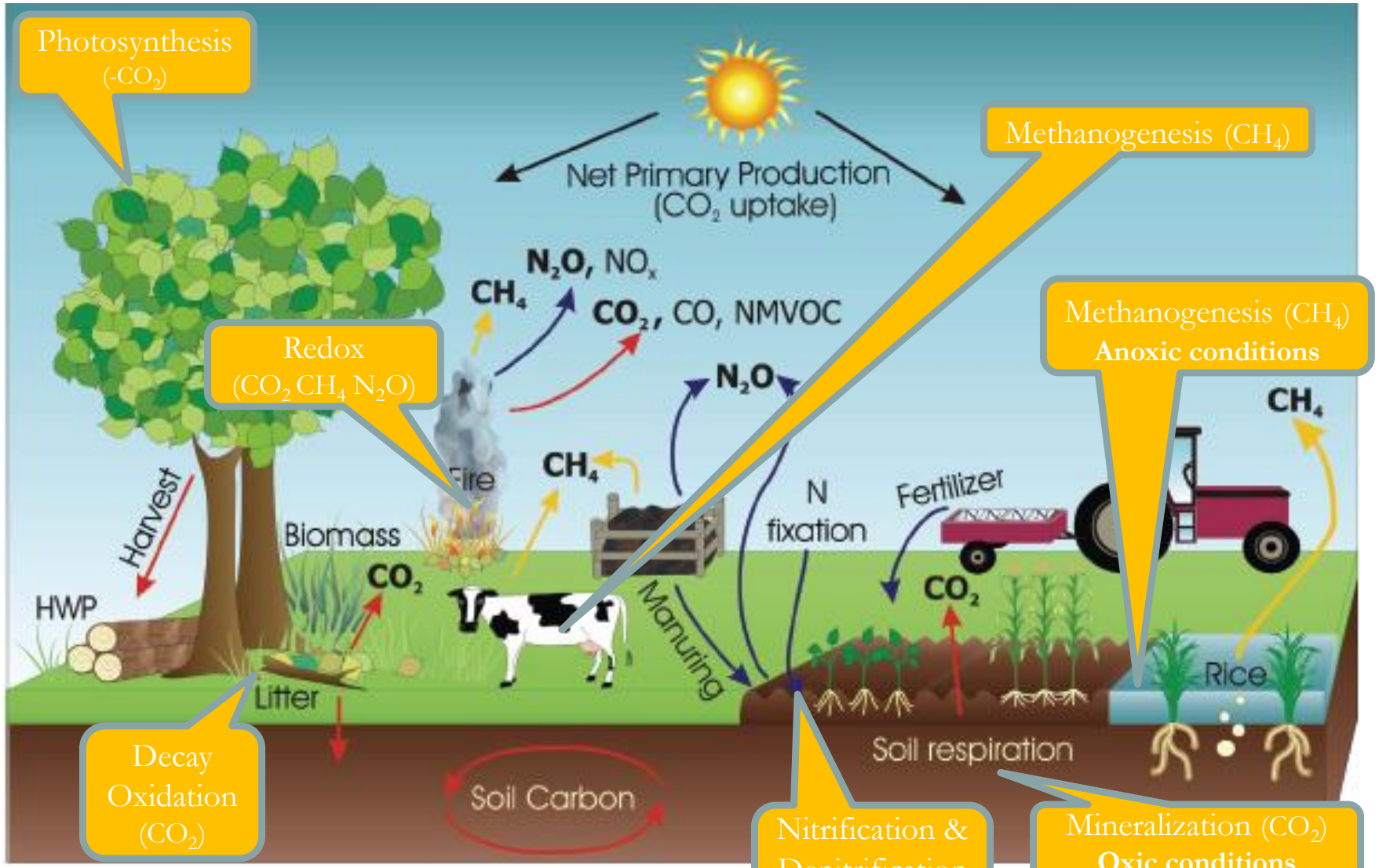
❑AFOLU sources/sinks

- Plant **biomass** is the sink of CO_2 removal from the atmosphere, of the CO_2 annual net absorption (*photosynthesis minus respiration - NPP*):
  - ✓A fraction is stored, and in managed land incrementally accumulating as perennial biomass
  - ✓A fraction is transferred to other C pools (DOM, SOM, HWP) as C stocks

- DOM and SOM C stocks decays across time to CO_2, although the annual net C stock change can be positive depending on systems' phases, management practices and disturbances

- Non-CO_2 emissions are largely a product of microbiological processes (i.e., within soils, animal digestive tracts and manure) and combustion of organic matter

Processes covered by IPCC Guidance on AFOLU



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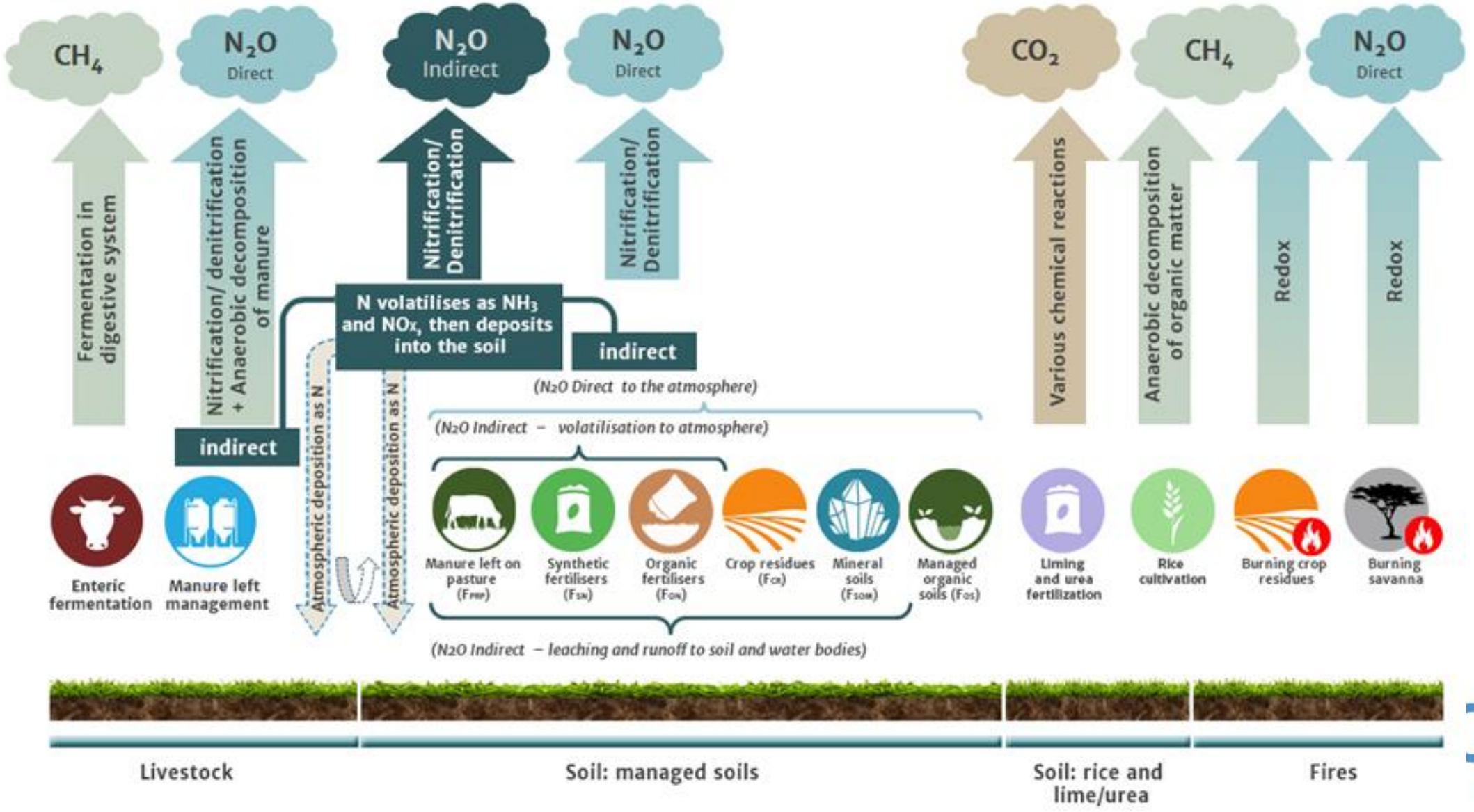
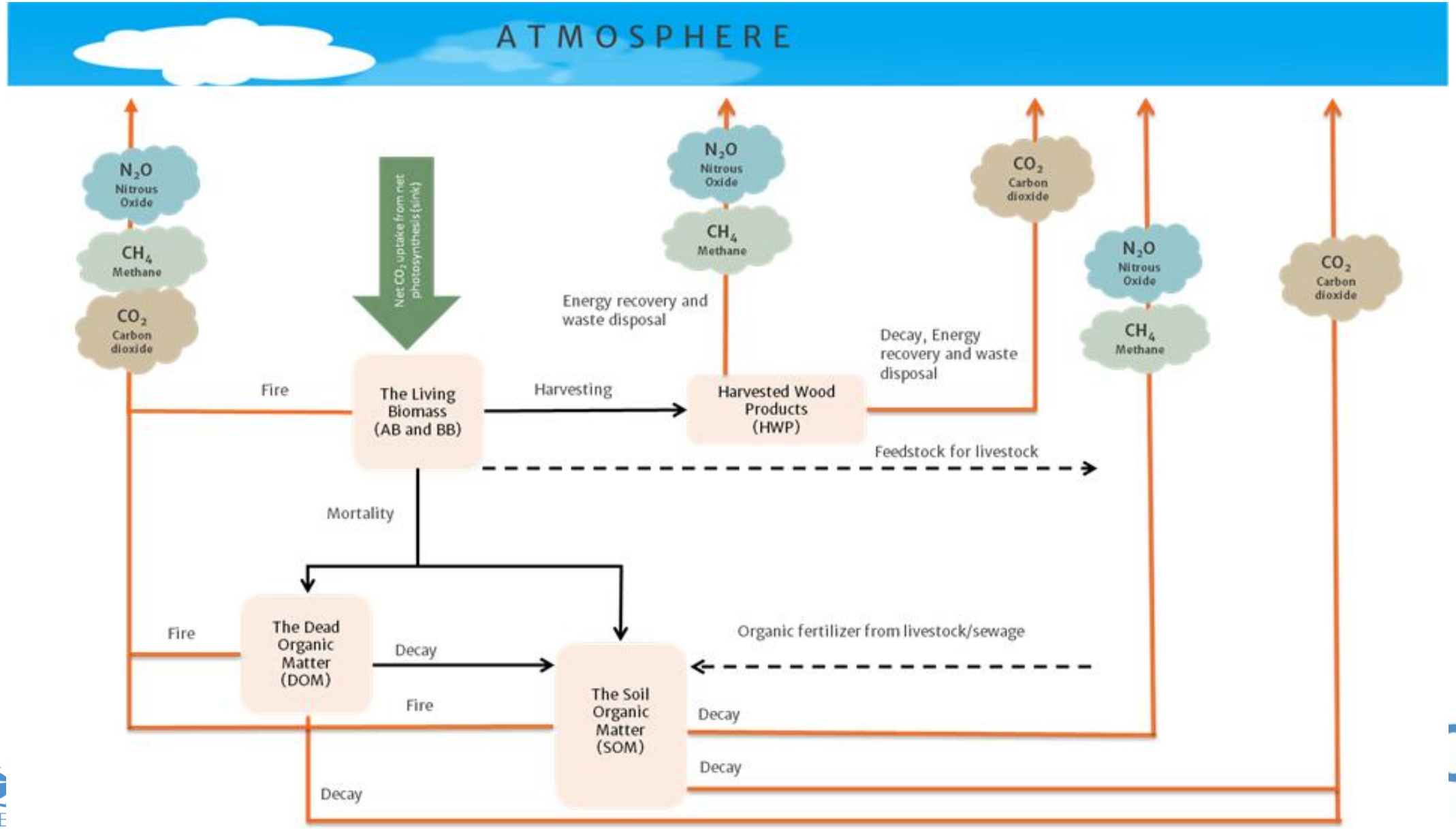
GHG emissions in Agriculture



GHG emissions and CO_2 removals from land use (C pools)



Outline

- **Use of dedicated data managers**
  - ✓ Livestock Manager
  - ✓ Land Type Manager
  - ✓ Land Representation Manager

- **AFOLU specific worksheets**
  - ✓ 3.A Livestock
  - ✓ 3.B Land *(SOC mineral)*
  - ✓ 3.C Aggregate Sources and non-CO_2 Emissions Sources on Land *(SOC mineral related)*

- **Input activity data, emission factors and other parameters** *(practical exercises)*

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.A.1 – Enteric fermentation	44			
3.A.1.a – Cattle	*10*			
3.B.1.a.i – Dairy Cow	5		2	
			3	
3.A.1.a.ii – Other Cattle	5		2	
			3	
3.A.1.b – Buffalo	5		2	
			3	
3.A.1.c – Sheep	5		2	
			3	
3.A.1.d – Goats	4		2	
			2	
3.A.1.e – Camels	4		2	
			2	
3.A.1.f – Horses	4		2	
			2	
3.A.1.g – Mules and Assess	4		2	
			2	
3.A.1.h – Swine	4		2	
			2	
3.A.1.j – Other	4		2	
			2	

Tier 2 requires an energy balance -i.e. feed intake vs energy uses + manure- to estimate the fraction of energy used by enteric flora and requires stratification of livestock populations by age, diet, productivity and husbandry system. The energy balance can be calculated through a detailed calculation or simply derived from the dry matter intake and its quality (energy content and digestibility)

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.A.2 – Manure management	104			
3.A.2.a – Cattle	22			
3.B.2.a.i – Dairy Cow	11	5		
		1	5	
3.A.2.a.ii – Other Cattle	11	5		
		1	5	
3.A.2.b – Buffalo	11	5		
		1	5	
3.A.2.c – Sheep	11	5		
		1	5	
3.A.2.d – Goats	10	5		
		1	4	
3.A.2.e – Camels	10	5		
		1	4	
3.A.2.f – Horses	10	5		
		1	4	
3.A.2.g – Mules and Assess	10	5		
		1	4	
3.A.2.h – Swine	10	5		
		1	4	
3.A.2.j – Other	10	5		
		1	4	

Tier 2 requires an energy balance -i.e. feed intake vs energy uses + manure- to estimate the fraction of energy used by enteric flora and requires stratification of livestock populations by age, diet, productivity and husbandry system. The energy balance can be calculated through a detailed calculation or simply derived from the dry matter intake and its quality (energy content and digestibility).
Further Tier 2 requires daily estimates of:

- Volatile solid excretion rate, base don additional info on the urinary energy and ash content of manure
- N excretion rate, based on daily N intake and N retention rate

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.B.1 – Forest land	73			
3.B.1.a – Forest land remaining Forest land	13	4 B + (1**)		
		1* SOM 2.25A +1 +1		
			1** SOM 2.25B	3 SD
			1 DOM G&L	
3.B.1.b – Land converted to Forest land	*60*			
3.B.1.b.i – Cropland converted to Forest land	12	4 B + (1)		
		1 SOM 2.25B +1 +1		3 SD
			1 DOM G&L	
3.B.1.b.ii – Grassland converted to Forest land	12	4 B + (1)		
		1 SOM 2.25B +1 +1		3 SD
			1 DOM G&L	
3.B.1.b.iii – Wetlands converted to Forest land	12	4 B + (1)		
		1 SOM 2.25B +1 +1		3 SD
			1 DOM G&L	
3.B.1.b.iv – Settlements converted to Forest land	12	4 B + (1)		
		1 SOM 2.25B +1 +1		3 SD
			1 DOM G&L	
3.B.1.b.v – Other land converted to Forest land	12	4 B + (1)		
		1 SOM 2.25B +1 +1		3 SD
			1 DOM G&L	

The IPCC Default –i.e. the Gain & Loss– method applies to all Tiers (where default values are provided by IPCC), while the Stock-Difference method applies to Tier 3 only

A worksheet for “abrupt biomass loss” is provided (eq 2.16), although it does not apply to harvesting losses

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.B.2 – Cropland	55			
3.B.2.a – Cropland remaining Cropland	10	1 B + (1)		
		1 SOM 2.25B & 1* SOM 2.25A +1 +1		3 SD
			1 DOM G&L	
3.B.2.b – Land converted to Cropland	45			
3.B.2.b.i – Forest land converted to Cropland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.2.b.ii – Grassland converted to Cropland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.2.b.iii – Wetlands converted to Cropland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.2.b.iv – Settlements converted to Cropland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.2.b.v – Other land converted to Cropland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD

The IPCC Default –i.e. the Gain & Loss– method applies to all Tiers (where default values are provided by IPCC), while the Stock-Difference method applies to Tier 3 only

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.B.3 – Grassland	55			
3.B.3.a – Grassland remaining Grassland	10	1 B + (1)		
		1 SOM 2.25B & 1* SOM 2.25A +1 +1		3 SD
			1 DOM G&L	
3.B.3.b – Land converted to Grassland	45			
3.B.3.b.i – Forest land converted to Grassland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.3.b.ii – Cropland converted to Grassland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.3.b.iii – Wetlands converted to Grassland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.3.b.iv – Settlements converted to Grassland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD
3.B.3.b.v – Other land converted to Grassland	9	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD

The IPCC Default –i.e. the Gain & Loss– method applies to all Tiers (where default values are provided by IPCC), while the Stock-Difference method applies to Tier 3 only

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.B.4 – Wetlands	28			
3.B.4.a – Wetlands remaining Wetlands	*12*			
3.B.4.a.i – Peat Extraction remaining Peat Extraction	3	+1 +2		
3.B.4.a.ii – Flooded land remaining Flooded land				
3.B.4.a.iii – Other Wetlands remaining Other Wetlands	9	+2		3 SD
		1* SOM2.25A		
			2 B&DOM G&L	
			1 SOM2.25B	
3.B.4.b – Land converted to Wetlands	*16*			
3.B.4.b.i – Land converted for Peat Extraction	6	2 B&DOM +1 +2		1 SD
3.B.4.b.ii – Land converted to Flooded land	1	1		
3.B.4.b.iii – Land converted to Other Wetlands	9	1 SOM2.25B +2		3 SD
		2 B		
			1 DOM G&L	

The IPCC Default –i.e. the Gain & Loss– method applies to all Tiers (where default values are provided by IPCC), while the Stock-Difference method applies to Tier 3 only

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.B.5 – Settlements	61			
3.B.5.a – Settlements remaining Settlements	11	+1 +2		
		1* SOM 2.25A		
			2 B&DOM G&L + (1**)	
			1** SOM 2.25B	3 SD
3.B.5.b – Land converted to Settlements	*50*			
3.B.5.b.i – Forest land converted to Settlements	10	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +2		3 SD
3.B.5.b.ii – Cropland converted to Settlements	10	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +2		3 SD
3.B.5.b.iii – Grassland converted to Settlements	10	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +2		3 SD
3.B.5.b.iv – Wetlands converted to Settlements	10	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +2		3 SD
3.B.5.b.v – Other land converted to Settlements	10	1 B + (1)		
			1 DOM G&L	
		1 SOM 2.25B +1 +1		3 SD

The IPCC Default –i.e. the Gain & Loss– method applies to all Tiers (where default values are provided by IPCC), while the Stock-Difference method applies to Tier 3 only

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.B.6 – Other land	20			
3.B.6.a – Other land remaining Other land				
3.B.6.b – Land converted to Other land	*20*			
3.B.6.b.i – Forest land converted to Other land	4	(1)		
			1 DOM SD	
		1 SOM 2.25B +1		
3.B.6.b.ii – Cropland converted to Other land	4	(1)		
			1 DOM SD	
		1 SOM 2.25B +1		
3.B.6.b.iii – Grassland converted to Other land	4	(1)		
			1 DOM SD	
		1 SOM 2.25B +1		
3.B.6.b.iv – Wetlands converted to Other land	4	(1)		
			1 DOM SD	
		1 SOM 2.25B +1		
3.B.6.b.v – Settlements converted to Other land	4	(1)		
			1 DOM SD	
		1 SOM 2.25B +1		

The IPCC Default –i.e. the Gain & Loss– method applies to all Tiers (where f\default values are provided by IPCC)

Worksheets map

IPCC Category	Number of Worksheets			
	Total	IPCC Tier (Equations)		
		Tier 1	Tier 2	Tier 3
3.C.1 – Biomass burning	12			
3.C.1.a – Biomass burning in Forest land	3	3		
3.C.1.b – Biomass burning in Cropland	3	3		
3.C.1.c – Biomass burning in Grassland	3	3		
3.C.1.d – Biomass burning in all other lands	3	3		
3.C.2 – Liming	1	1		
3.C.3 – Urea application	1	1		
3.C.4 – Direct N_2O emissions	10	9 +1		
3.C.5 – Indirect N_2O emissions from managed soils	2	2		
3.C.6 – Indirect N_2O emissions from manure management	4	4		
3.C.7 – Rice cultivation	1	1		
3.C.8 – CH_4 emissions from drained inland organic soils	1	1		
3.C.9 – CH_4 from drainage ditches on organic soils	1	1		
3.C.10 – CH_4 from rewetting of inland organic soils	1	1		
3.C.11 – CH_4 from rewetting of mangroves and tidal marshes	1	1		
3.C.12 – N_2O emissions from aquaculture	1	1		
3.C.13 – CH_4 from rewetted and created Wetlands in inland wetland mineral soils	1	1		
3.C.14 – Other	1		1***	
3.D.1 – Harvested Wood Products	13	13		
3.D.2 – Other	1		1***	

The methodological tier of CO_2 emissions estimated as C stock losses in 3.B categories could be higher than that of non-CO_2 emissions

IPCC Category	Worksheets Number Total
3.A. – Livestock	148
3.A.1 – Enteric fermentation	44
3.A.2 – Manure management	104
3.B. – Land	292
3.B.1 – Forest land	73
3.B.2 – Cropland	55
3.B.3 – Grassland	55
3.B.4 – Wetlands	28
3.B.5 – Settlements	61
3.B.6 – Other land	20
3.C. – Aggregated Sources and non-CO_2 emissions sources on land	38
3.C.1 – Biomass burning	12
3.C.2 – Liming	1
3.C.3 – Urea application	1
3.C.4 – Direct N_2O emissions	10
3.C.5 – Indirect N_2O emissions from managed soils	2
3.C.6 – Indirect N_2O emissions from manure management	4
3.C.7 – Rice cultivation	1
3.C.8 – CH_4 emissions from drained inland organic soils	1
3.C.9 – CH_4 from drainage ditches on organic soils	1
3.C.10 – CH_4 from rewetting of inland organic soils	1
3.C.11 – CH_4 from rewetting of mangroves and tidal marshes	1
3.C.12 – N_2O emissions from aquaculture	1
3.C.13 – CH_4 from rewetted and created Wetlands in inland wetland mineral soils	1
3.C.14 – Other	1
3.D. - Other	14
3.D.1 – Harvested Wood Products	13
3.D.2. – Other	1
TOTAL AFOLU SECTOR	492

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Worksheets map *[notes]*

()	for biomass and in the year of change only
+1	for drained organic soils only
+2	on-site and off-site emissions associated with extracted peat decay
+1	for rewetted organic soils only
+2	for rewetted organic soil or for SOM excavation in Wetlands
*	for regions where Approach 1 of land representation is applied only
**	for management changes only
***	IPCC generic methodology [ADxEF] applies, but no IPCC default values are provided for EF

Summary

- **All methods in the 2006 IPCC Guidelines are implemented in the IPCC Inventory Software**

  Thus, needed flexibility to deal with any national circumstances, as per IPCC tiered approach, is ensured

- **Subnational disaggregation**

  Thus, tracking of specific activities/projects, and associated emission level & trend, within a national GHG inventory is allowed

- **AFOLU sector Guidebook – version 1 under development**

Case Study for Livestock

- **2 Regions with**
  - 2 different Livestock Characterizations
    A. Basic *(Tier 1)* – Dairy cows, Other cattle,
    B. Enhanced *(Tier 2)* – Mature dairy (High *vs* Low productivity), Other Cattle (Mature *vs* Growing [dairy high, dairy low, other])
  - 2 different climate zones
    A. Annual Average Temperature 22°C
    B. Annual Average Temperature 12°C
  - 2 different sets of Manure Management Systems
    A. Solid storage *(3 months)* + Spread; Pasture/Range/Paddock
    B. Liquid Slurry *(6 months)* + Spread; Anaerobic Digester
- **For both Regions estimate**
  - CH_4 emissions from Enteric Fermentation
  - CH_4 and N_2O emissions from Manure Management

GHG emissions from Livestock

I. **Livestock Manager**
   - ✓ Stratification of livestock population
   - ✓ Stratification of manure

II. **Livestock population**
   - ✓ Annual Average Population
   - ✓ Typical Animal Mass

III. **Average Feed Intake** *(Tier 2)*
   - ✓ Gross Energy Intake *vs* Dry Matter Intake

IV. **Volatile Solid Excretion Rate** *(Tier 2)*

V. **N Excretion Rate**

CH_4 emissions from Enteric Fermentation

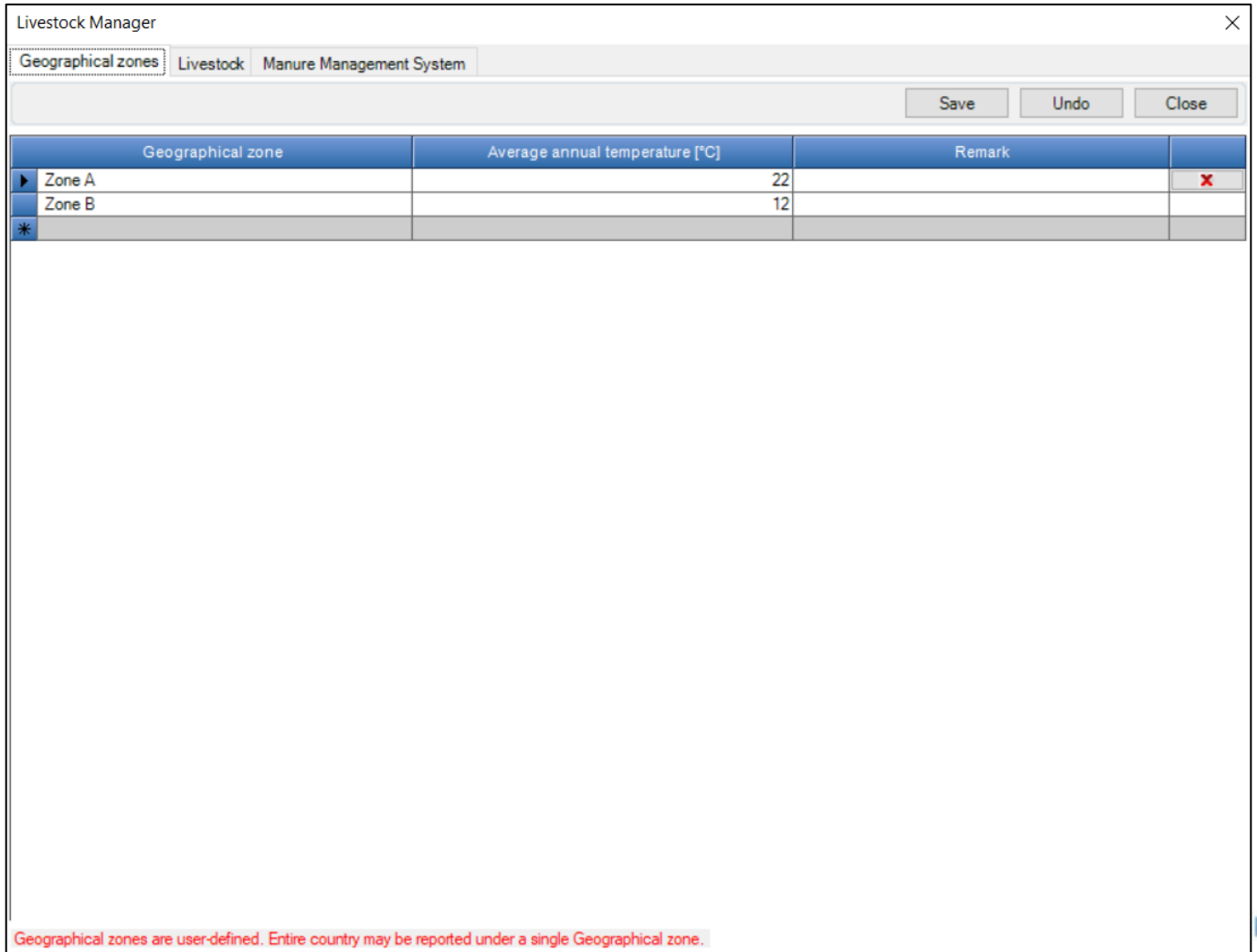
CH_4 emissions from Manure Management

N_2O emissions from Manure Management

Livestock Manager

❑ Geographical zones

- ✓ Characterized by the “Average Annual Temperature”
- ✓ A single Geographical zone or several Geographical zones



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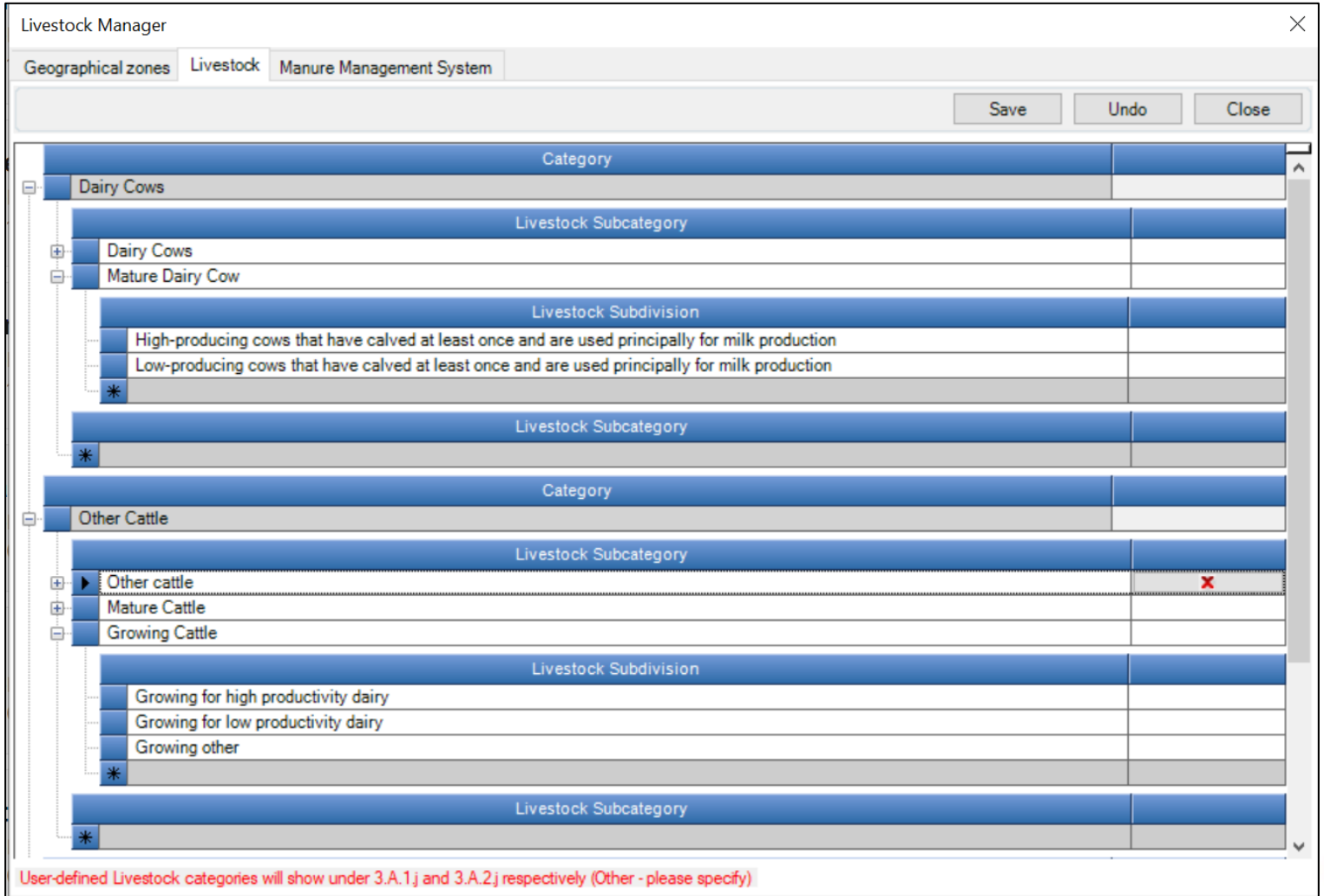
Livestock Manager

❑ Livestock Characterization

➢ A single characterization for the entire inventory

Basic or *Enhanced* or *Country-specific* or *Any combination*



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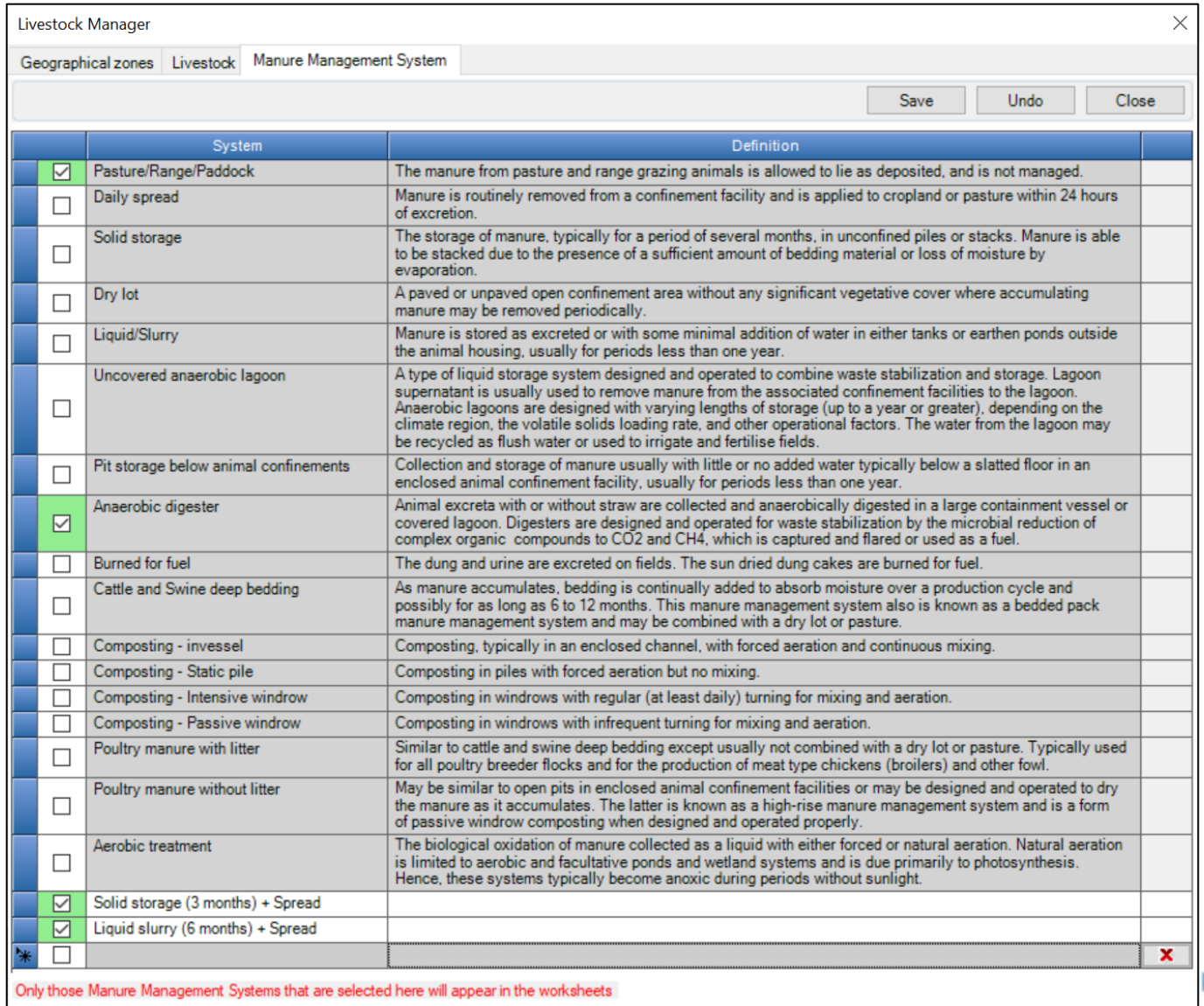
Livestock Manager

❑ Manure Management Systems

✓ A single set for the entire Inventory



	System	Definition
☑	Pasture/Range/Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.
☐	Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
☐	Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
☐	Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
☐	Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year.
☐	Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilise fields.
☐	Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.
☑	Anaerobic digester	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.
☐	Burned for fuel	The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.
☐	Cattle and Swine deep bedding	As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.
☐	Composting - invessel	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
☐	Composting - Static pile	Composting in piles with forced aeration but no mixing.
☐	Composting - Intensive windrow	Composting in windrows with regular (at least daily) turning for mixing and aeration.
☐	Composting - Passive windrow	Composting in windrows with infrequent turning for mixing and aeration.
☐	Poultry manure with litter	Similar to cattle and swine deep bedding except usually not combined with a dry lot or pasture. Typically used for all poultry breeder flocks and for the production of meat type chickens (broilers) and other fowl.
☐	Poultry manure without litter	May be similar to open pits in enclosed animal confinement facilities or may be designed and operated to dry the manure as it accumulates. The latter is known as a high-rise manure management system and is a form of passive windrow composting when designed and operated properly.
☐	Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.
☑	Solid storage (3 months) + Spread	
☑	Liquid slurry (6 months) + Spread	
☐		

Only those Manure Management Systems that are selected here will appear in the worksheets

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Case Study for Livestock

Livestock Population

Region	Characterisation	species/category/subcategory	Population heads 1990	Population heads 2000	Method
A	Basic	Dairy cows	2,000	3,333	Tier 1
		Other cattle	8,000	13,333	Tier 1
B	Enhanced	Mature dairy, High productivity	3,700	6,167	Detailed Tier 2
		Other Cattle, Mature	2,500	4,167	Detailed Tier 2
		Mature dairy, Low productivity	1,500	2,500	Simplified Tier 2
		growing Dairy, High productivity	1,000	1,667	Simplified Tier 2
		growing Dairy, Low productivity	300	500	Simplified Tier 2
		growing Other	1,000	1,667	Simplified Tier 2

Light Blue indicates Tier 2

Light Green indicates Tier 1

Case Study for Livestock

Manure Management Systems

species/category/subcategory	Method	Manure Management System (manure apportion and MCF)															
		Solid storage (3 months) + Spread				Pasture/Range/Paddock				Liquid Slurry (6 months) + Spread				Anaerobic Digester			
		1990	2000	N2O EF	MCF%	1990	2000	N2O EF	MCF%	1990	2000	N2O EF	MCF%	1990	2000	N2O EF	MCF%
Dairy cows	Tier 1	1.000	1.000	0.010													
Other cattle	Tier 1					1.000	1.000	NA									
Mature dairy, High productivity	Detailed Tier 2													1.000	1.000	0.001	0.000
Other Cattle, Mature	Detailed Tier 2									1.000	1.000	0.005	21.000				
Mature dairy, Low productivity	Simplified Tier 2									1.000	1.000	0.005	21.000				
growing Dairy, High productivity	Simplified Tier 2													1.000	1.000	0.001	0.000
growing Dairy, Low productivity	Simplified Tier 2									1.000	1.000	0.005	21.000				
growing Other	Simplified Tier 2									1.000	1.000	0.005	21.000				

Light Blue indicates Tier 2

Light Green indicates Tier 1

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Case Study for Livestock

Parameters I

species/category/subcategory	Method	Population heads	TAM kg	WG kg/day	C	MW kg	Work hours	Ca	Tw	Cfi	Cfi (in_cold	Milk kg/day	Milk's Fat %	Females giving birth %	C_Pregnancy
Dairy cows	Tier 1	2,000	550												
Other cattle	Tier 1	8,000	389												
Mature dairy, High productivity	Detailed Tier 2	3,700	570					0.00	---	0.386	-----	10.3	4	75	0.1
Other Cattle, Mature	Detailed Tier 2	2,500	410	-----	-----	410	1	0.36	3	0.333	calc	3	4.2	60	0.1
Mature dairy, Low productivity	Simplified Tier 2	1,500	530					0.00				4.4	4		
growing Dairy, High productivity	Simplified Tier 2	1,000	300	0.9				0.00				0	0		
growing Dairy, Low productivity	Simplified Tier 2	300	240	0.9				0.00				0	0		
growing Other	Simplified Tier 2	1,000	180	0.35				0.36				0	0		

Light Blue indicates Tier 2

Light Green indicates Tier 1

Case Study for Livestock

Parameters II

species/category/subcategory	Method	DE %	FED MJ/kgDM	NEma MJ/kgDM	Ym %	UE	ASH	Bo	Nex kgN/t	CP %	Enteric Fermentation Tier 1 CH4 EF	Manure Management Tier 1 CH4 EF
Dairy cows	Tier 1								0.54		IPCC default	IPCC default
Other cattle	Tier 1								0.39		IPCC default	IPCC default
Mature dairy, High productivity	Detailed Tier 2	70			6.5	0.02	0.11	0.24		17		
Other Cattle, Mature	Detailed Tier 2	60			7	0.04	0.179	0.18		9		
Mature dairy, Low productivity	Simplified Tier 2	65	18.45		6	0.04	0.145	0.13		10		
growing Dairy, High productivity	Simplified Tier 2	70	18.45	7	4	0.02	0.11	0.24		10		
growing Dairy, Low productivity	Simplified Tier 2	65	18.45	6	4	0.04	0.145	0.13		9.5		
growing Other	Simplified Tier 2	60	18.45	5	7	0.04	0.179	0.18		9		

Light Blue indicates Tier 2
Light Green indicates Tier 1

Case Study for SOM in mineral soils

1. Case study on Eq. 2.25 (SOM in mineral soils)

category	Cropland		Cropland		Forest land	
subcategory	annual		perennial		managed	
subdivision	intensive		agroforestry - pepper		restoration AB (AC10)	
	tot area	*change area*	*tot area*	*change area*	*tot area*	*change area*
Year	*ha*		*ha*		*ha*	
1999	600	---	400	---	---	---
2000	500	-100 →	500	`+100	---	---
2010	400	-100 →	600	`+100	---	---
2020	400	---	500	-100 →	100	`+100

2. Two additional areas to:

   - Apply the Stock-Difference method to SOC changes in 500 ha of Cropland in rotation system (2-year annual + 8-year fallow)
   - Estimate CH_4 emissions from created wetlands in inland wetland mineral soils *(lotus cultivation)*

Case Study for Eq 2.25 (SOM in mineral soils)

- **Case study area: 1,000 ha**
- **3 land use subdivisions:**
  A. Cropland, annual, intensive
  B. Cropland, perennial, agroforestry – pepper
  C. Forest land, managed, restoration AB (AC10)
- **Time series 1999-2020, 3 land use changes identified:**
  - ✓ In 1999, A. covers 600 ha and B. 400 ha
  - ✓ In 2000, 100 ha of A. are converted to B.
  - ✓ In 2010, 100 ha of A. are converted to B.
  - ✓ In 2020, 100 ha of B. are converted to C.
  - ✓ 2010 and 2020 changes occur on a land subject to a dedicated activity
- **Three different land representations approaches(1, 2, 3)**
  - ✓ Approach 1 *-no land use change identification-*
  - ✓ Approach 2 *-land use change identification-*
  - ✓ Approach 3 *-land use change identification and tracking across time-*

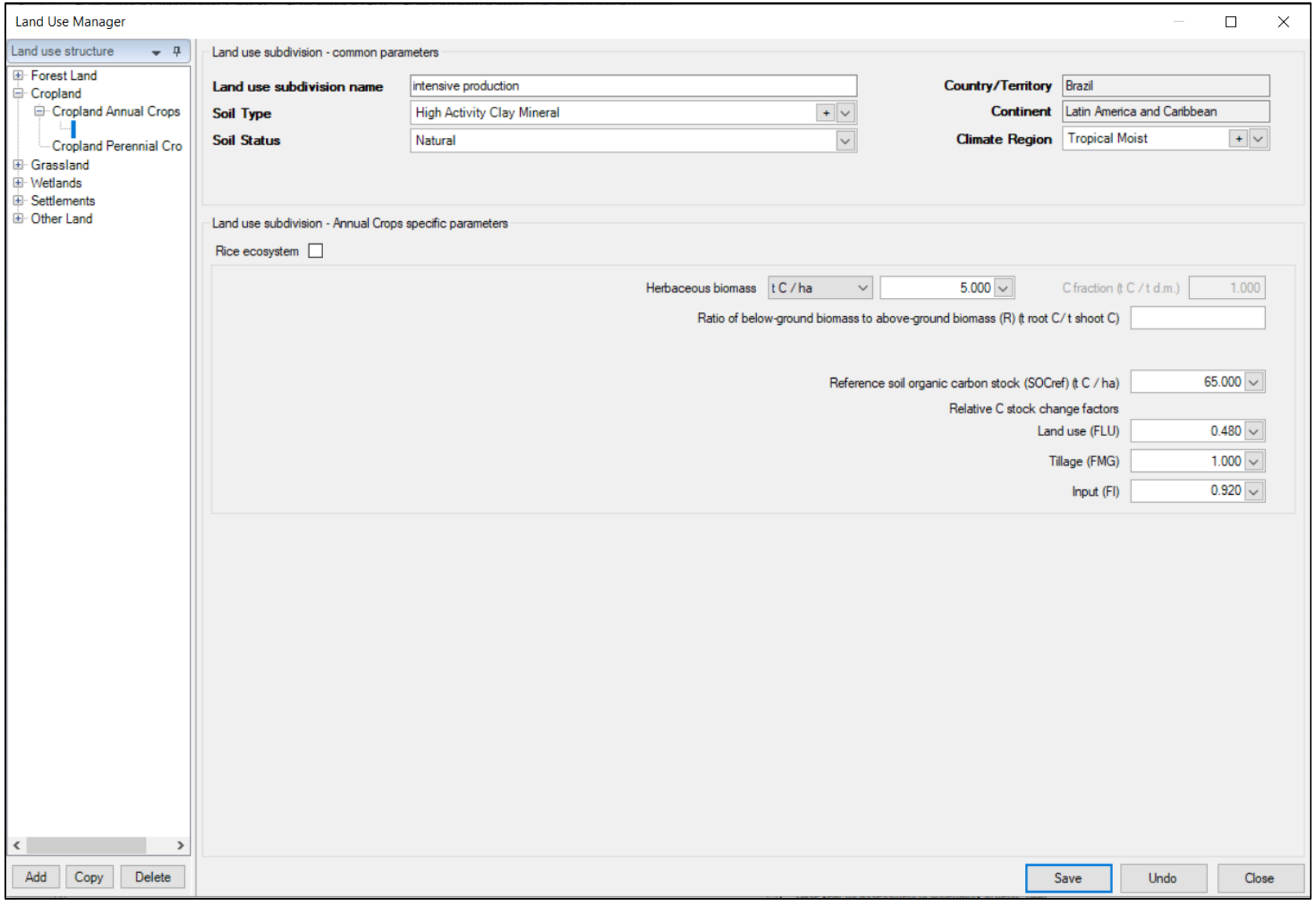
SOC Change estimates

- **Land Use Manager (subdivisions' setting)**
- **Land Representation Manager (input of activity data)**
- **Mineral soil SOC change**
  - Equation 2.25
    - ✓ *(Formulation A)*
    - ✓ *(Formulation B)*
  - *[Stock Difference Method]*
- **Direct N_2O emissions from managed soils**
- **Indirect N_2O emissions from managed soils**
- ***[CH_4 emissions from rewetted/created wetlands inland mineral soils]***

Land Use Manager (LUM)

- **First step when preparing a GHG inventory for land-related sources/sinks**
- **Input subdivisions to the 12 main land subcategories are to be input here**
  [managed Forest land, unmanaged Forest land, annual Cropland, perennial Cropland , managed Grassland, unmanaged Grassland, managed Wetlands, unmanaged Wetlands, Settlements (Treed), Settlements (Other), managed Other land, unmanaged Other land]
- **Describe as subdivisions, each and every different use/management of land in the area inventoried, further stratified by climate zone and soil type**
- **Parameters to be input are subcategory-specific and are used by the software to estimate C stock changes and associated GHG emissions/removals**
- **There are not limits to the number of subdivisions that can be input**

Land Use Manager (LUM) – *annual cropland*



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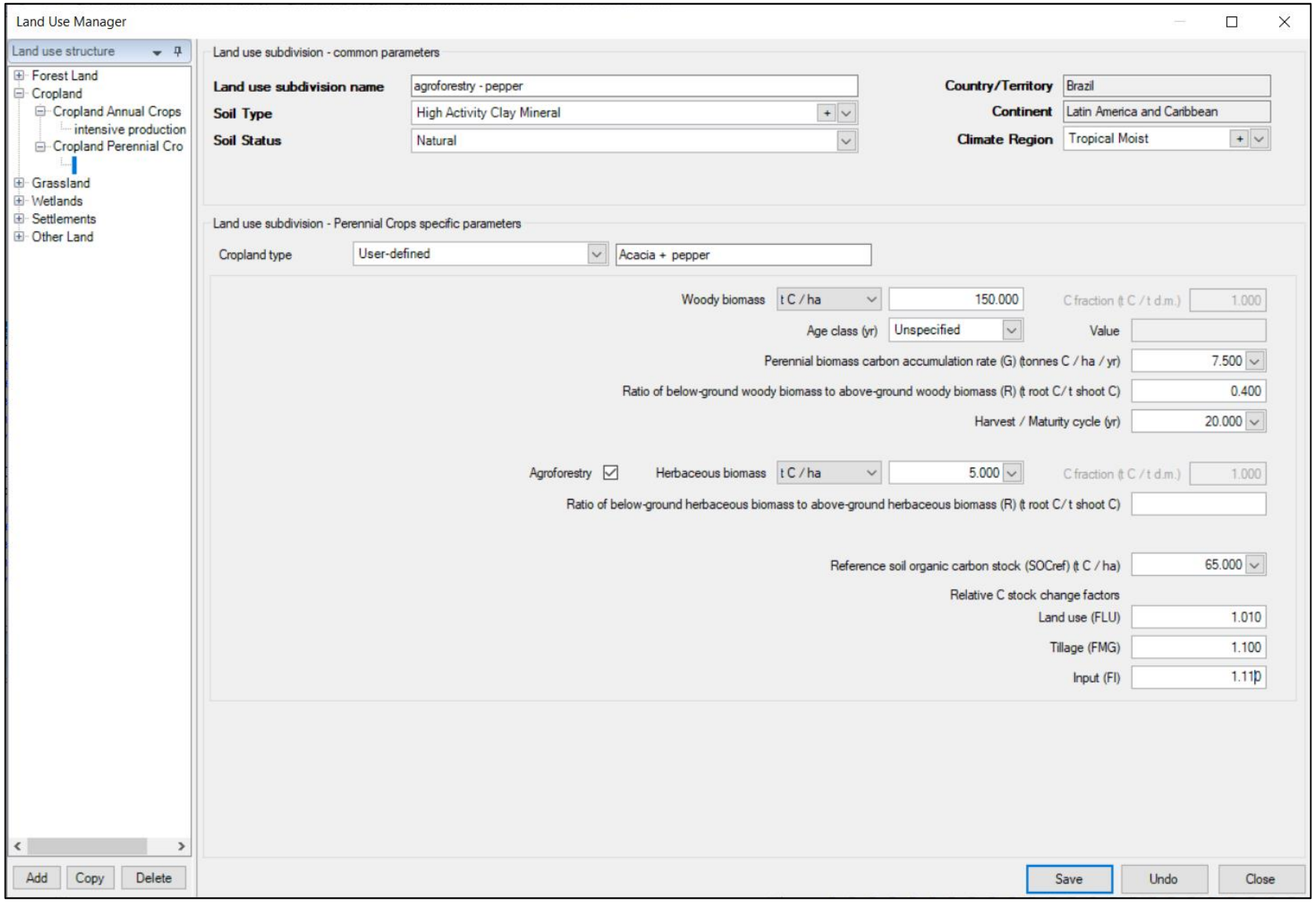
Land Use Manager (LUM) – *perennial cropland*



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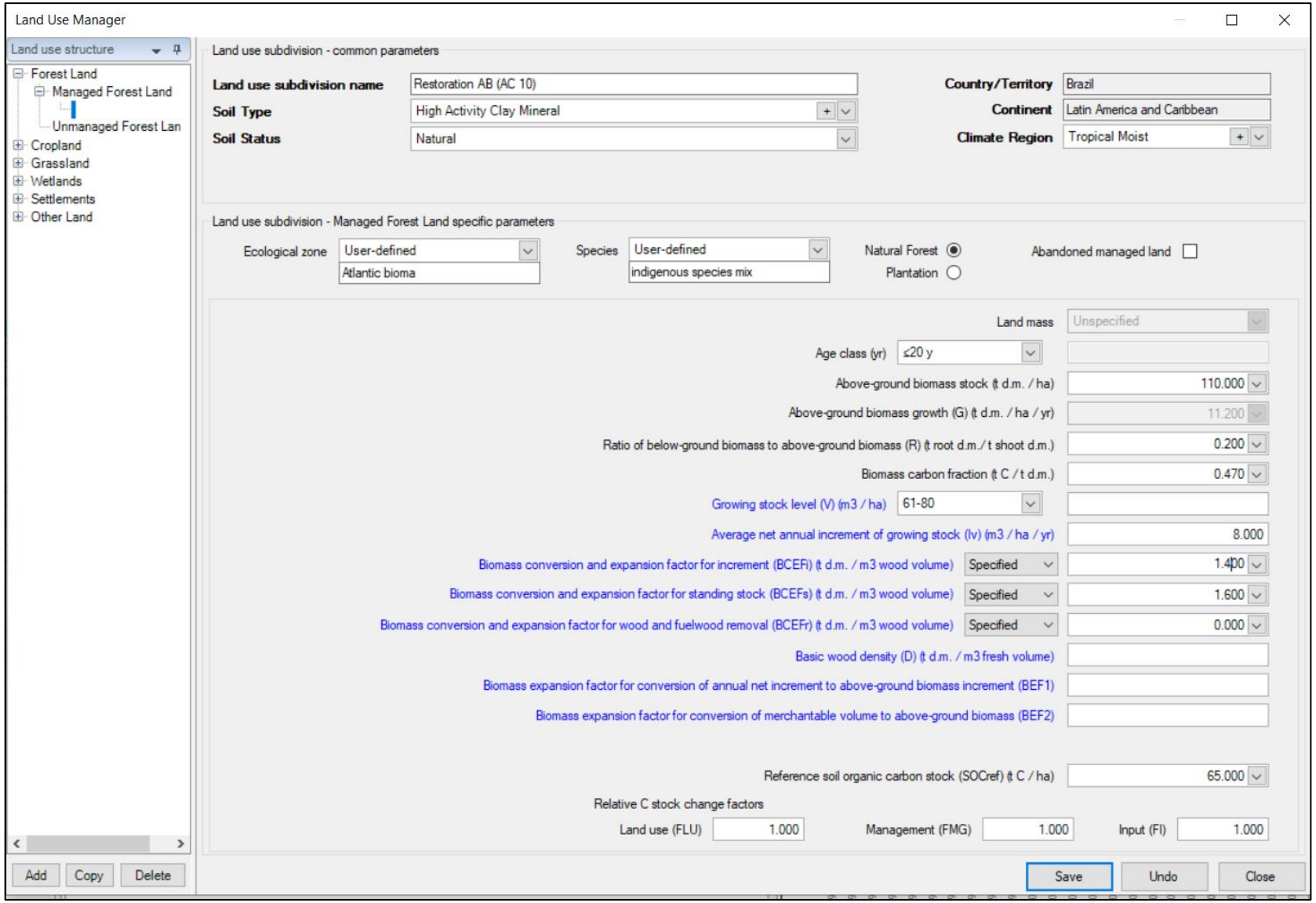
Land Use Manager (LUM) – *forest land*



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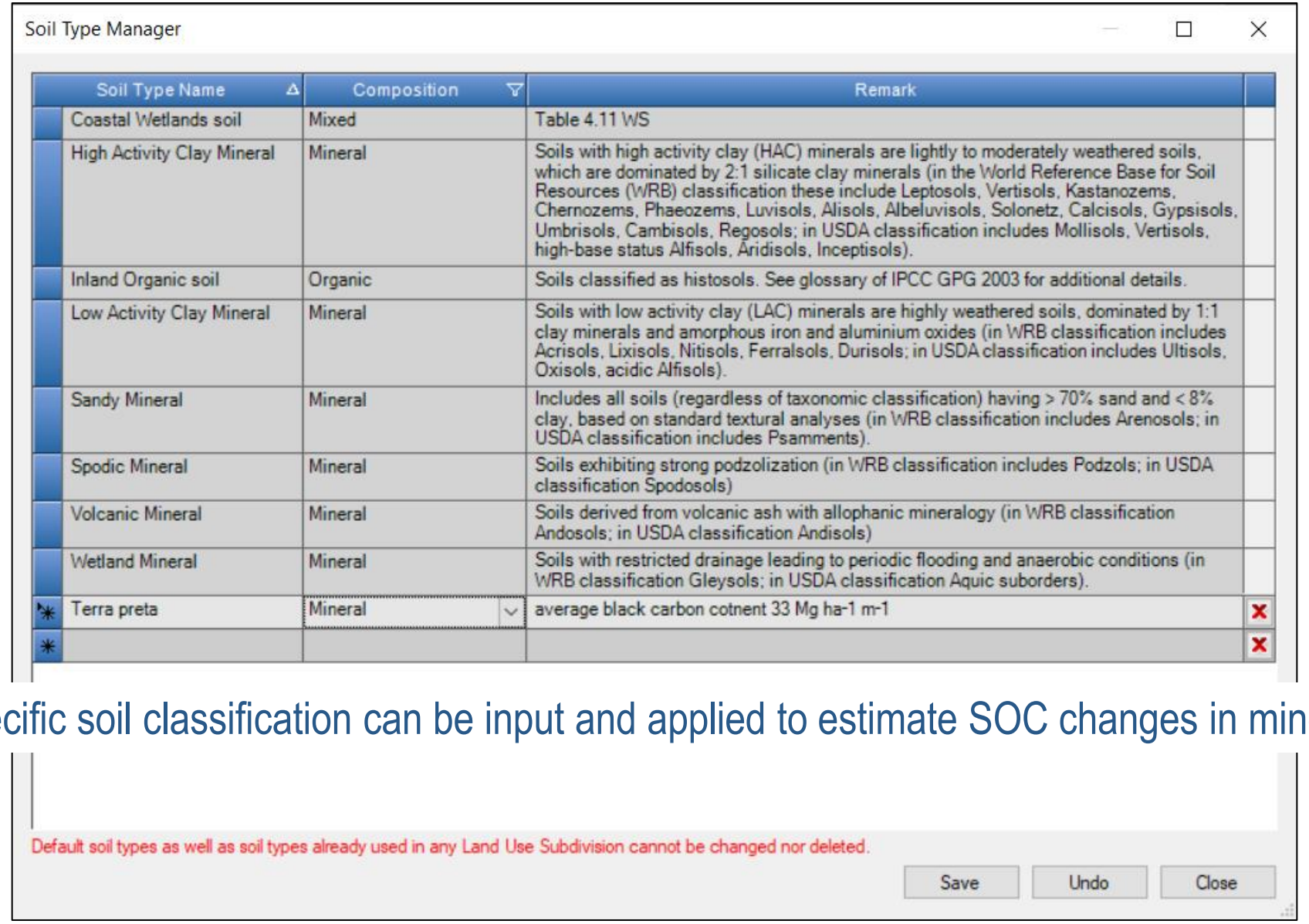
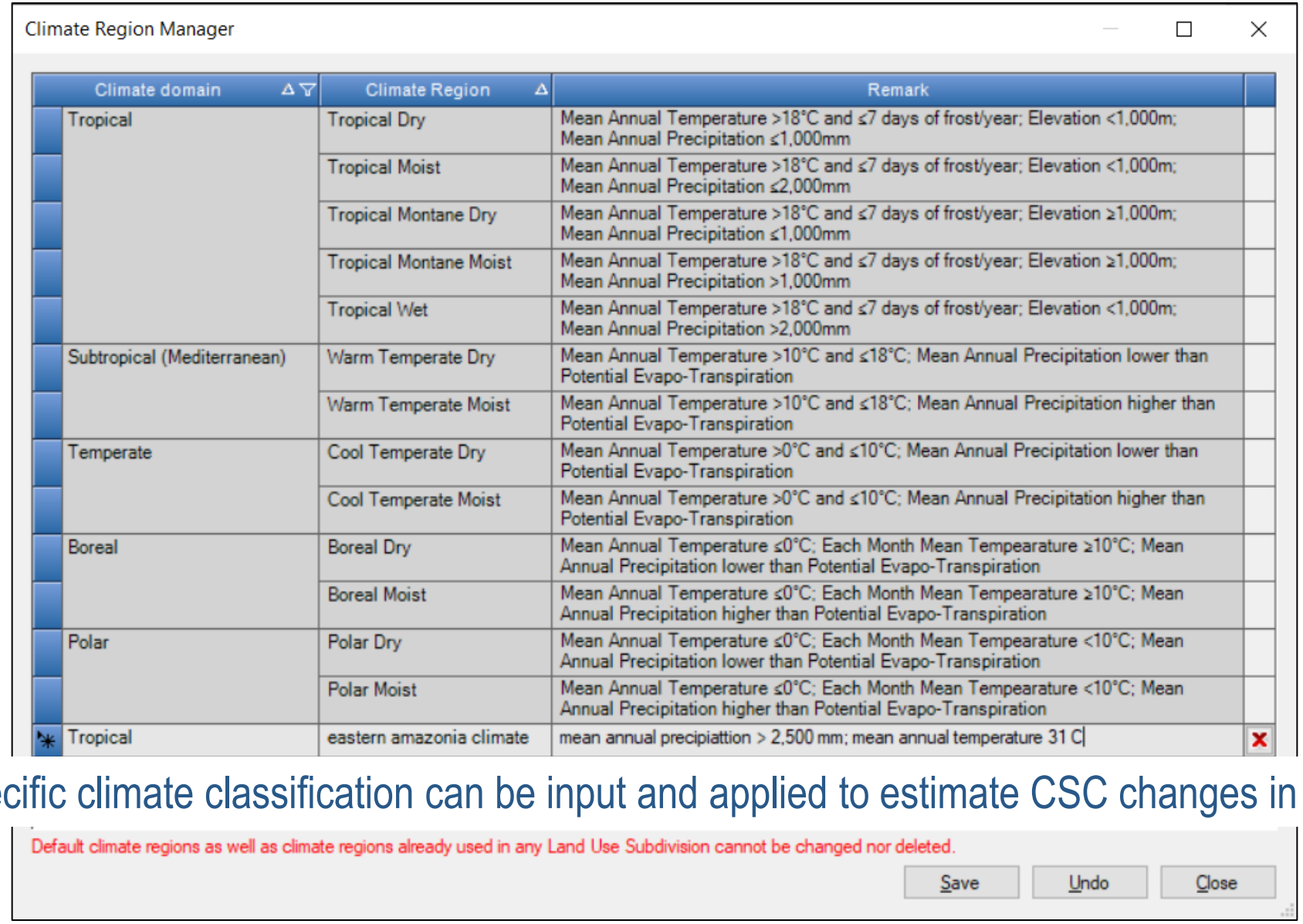
LUM – Soil Type Manager



User-specific soil classification can be input and applied to estimate SOC changes in mineral soils

LUM – Climate Region Manager



Climate domain	Climate Region	Remark
Tropical	Tropical Dry	Mean Annual Temperature >18°C and ≤7 days of frost/year; Elevation <1,000m; Mean Annual Precipitation ≤1,000mm
	Tropical Moist	Mean Annual Temperature >18°C and ≤7 days of frost/year; Elevation <1,000m; Mean Annual Precipitation ≤2,000mm
	Tropical Montane Dry	Mean Annual Temperature >18°C and ≤7 days of frost/year; Elevation ≥1,000m; Mean Annual Precipitation ≤1,000mm
	Tropical Montane Moist	Mean Annual Temperature >18°C and ≤7 days of frost/year; Elevation ≥1,000m; Mean Annual Precipitation >1,000mm
	Tropical Wet	Mean Annual Temperature >18°C and ≤7 days of frost/year; Elevation <1,000m; Mean Annual Precipitation >2,000mm
Subtropical (Mediterranean)	Warm Temperate Dry	Mean Annual Temperature >10°C and ≤18°C; Mean Annual Precipitation lower than Potential Evapo-Transpiration
	Warm Temperate Moist	Mean Annual Temperature >10°C and ≤18°C; Mean Annual Precipitation higher than Potential Evapo-Transpiration
Temperate	Cool Temperate Dry	Mean Annual Temperature >0°C and ≤10°C; Mean Annual Precipitation lower than Potential Evapo-Transpiration
	Cool Temperate Moist	Mean Annual Temperature >0°C and ≤10°C; Mean Annual Precipitation higher than Potential Evapo-Transpiration
Boreal	Boreal Dry	Mean Annual Temperature ≤0°C; Each Month Mean Tempearature ≥10°C; Mean Annual Precipitation lower than Potential Evapo-Transpiration
	Boreal Moist	Mean Annual Temperature ≤0°C; Each Month Mean Tempearature ≥10°C; Mean Annual Precipitation higher than Potential Evapo-Transpiration
Polar	Polar Dry	Mean Annual Temperature ≤0°C; Each Month Mean Tempearature <10°C; Mean Annual Precipitation lower than Potential Evapo-Transpiration
	Polar Moist	Mean Annual Temperature ≤0°C; Each Month Mean Tempearature <10°C; Mean Annual Precipitation higher than Potential Evapo-Transpiration
Tropical	eastern amazonia climate	mean annual precipiattion > 2,500 mm; mean annual temperature 31 C

User-specific climate classification can be input and applied to estimate CSC changes in C pools

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Land Representation Approaches

Approach I - 1,000 ha

Unit	Year	Land use			Area
		category	subcategory	subdivision	ha
1	1999	Cropland	Annual	Soybean intensive	600 ha
	2000 - 2009				500 ha
	2010-2020				400 ha
2	1999	Cropland	Perennial	Agroforestry - pepper	400 ha
	2000 - 2009				500 ha
	2010 - 2019				600 ha
	2020				500 ha
---	1999 - 2019	Forest land	Managed	Restoration AB (AC10)	---
3	2020				100 ha

Approach II - 1,000 ha

Unit	Year	Land use			Area
		category	subcategory	subdivision	ha
1	1999	Cropland	Annual	Soybean intensive	600 ha
	2000-2009				500 ha
	2010-2020				400 ha
2.1	1999-2019	Cropland	Perennial	Agroforestry - pepper	400 ha
[2.2]	2020				
---	1999	*Cropland to* Cropland	*Annual to* Perennial	*Soybean intensive to* Agroforestry - pepper	---
2.2	2000-2019				100 ha
[2.1]	2020				---
---	1999-2009	*Cropland to* Cropland	*Annual to* Perennial	*Soybean intensive to* Agroforestry - pepper	---
2.3	2010-2020				100 ha
---	1999	*Cropland to* Forest land	*Perennial to* Managed	*Agroforestry - pepper* Restoration AB (AC10)	---
3	2020				100 ha

Approach III - 1,000 ha

Unit	Year	Land use			Area
		category	subcategory	subdivision	ha
---	1999	Cropland	Perennial	Agroforestry - pepper	---
0	2000-2019				100 ha
[3]	2020				---
1	1999	Cropland	Annual	Soybean intensive	600 ha
	2020-2009				500 ha
	2010-2020				400 ha
2	1999-2009	Cropland	Annual	Soybean intensive	
	2010-2019	Cropland	Perennial	Agroforestry - pepper	100 ha
	2020	Forest land	Managed	Restoration AB (AC10)	
3	1999 - 2019	Cropland	Perennial	Agroforestry - pepper	400 ha
[0]	2020				500 ha

- Units of ***Land remaining*** in blue
- Units of ***Land under conversion*** in orange
- "---", the unit does not exist in that/those years (no area)
- "*[2.1]*" "*[3]*", means that the unit has been merged, in the year, into the unit of land indicated within the brackets
- "*[2.2]*" "*[0]*", means that the unit indicated within the brackets has been merged, in the year, into the unit

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Land Representation Approaches

Approach I - 1,000 ha					
Unit	Year	Land use			Area
		category	subcategory	subdivision	ha
1	1999	Cropland	Annual	Soybean intensive	600 ha
	2000 - 2009				500 ha
	2010-2020				400 ha
2	1999	Cropland	Perennial	Agroforestry - pepper	400 ha
	2000 - 2009				500 ha
	2010 - 2019				600 ha
	2020				500 ha
---	1999 - 2019	Forest land	Managed	Restoration AB (AC10)	---
3	2020				100 ha

- Units of ***Land remaining*** in blue
- Units of ***Land under conversion*** in orange

Land Representation Approaches

Approach II - 1,000 ha					
Unit	Year	Land use			Area
		category	subcategory	subdivision	ha
1	1999	Cropland	Annual	Soybean intensive	600 ha
	2000-2009				500 ha
	2010-2020				400 ha
2.1	1999-2019	Cropland	Perennial	Agroforestry - pepper	400 ha
[2.2]	2020				
---	1999	*Cropland to* Cropland	*Annual to* Perennial	*Soybean intensive to* Agroforestry - pepper	---
2.2	2000-2019				100 ha
[2.1]	2020				---
---	1999-2009	*Cropland to* Cropland	*Annual to* Perennial	*Soybean intensive to* Agroforestry - pepper	---
2.3	2010-2020				100 ha
---	1999	*Cropland to* Forest land	*Perennial to* Managed	*Agroforestry - pepper* Restoration AB (AC10)	---
3	2020				100 ha

- Units of ***Land remaining*** in blue
- Units of ***Land under conversion*** in orange
- "---", the unit does not exist in that/those years (no area)
- "*[2.1]*" "*[3]*", means that the unit has been merged, in the year, into the unit of land indicated within the brackets
- "*[2.2]*" "*[0]*", means that the unit indicated within the brackets has been merged, in the year, into the unit

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Land Representation Approaches

Approach III - 1,000 ha					
Unit	Year	Land use			Area
		category	subcategory	subdivision	ha
---	1999	Cropland	Perennial	Agroforestry - pepper	---
0	2000-2019				100 ha
[3]	2020				---
1	1999	Cropland	Annual	Soybean intensive	600 ha
	2020-2009				500 ha
	2010-2020				400 ha
2	1999-2009	Cropland	Annual	Soybean intensive	100 ha
	2010-2019	Cropland	Perennial	Agroforestry - pepper	
	2020	Forest land	Managed	Restoration AB (AC10)	
3	1999 - 2019	Cropland	Perennial	Agroforestry - pepper	400 ha
[0]	2020				500 ha

- Units of ***Land remaining*** in blue
- Units of ***Land under conversion*** in orange
- "---", the unit does not exist in that/those years (no area)
- "*[2.1]*" "*[3]*", means that the unit has been merged, in the year, into the unit of land indicated within the brackets
- "*[2.2]*" "*[0]*", means that the unit indicated within the brackets has been merged, in the year, into the unit

Land Representation

Approach 1

- land use categories are identified, and areas quantified
- land use/management changes are neither identified nor quantified since data are not spatially-explicit

Approach 2

- land use categories are identified, and areas quantified
- land use/management changes are identified (data spatially explicit)
- the areas of changes (between 2 points in time) are:
  - * quantified
  - * not tracked over time

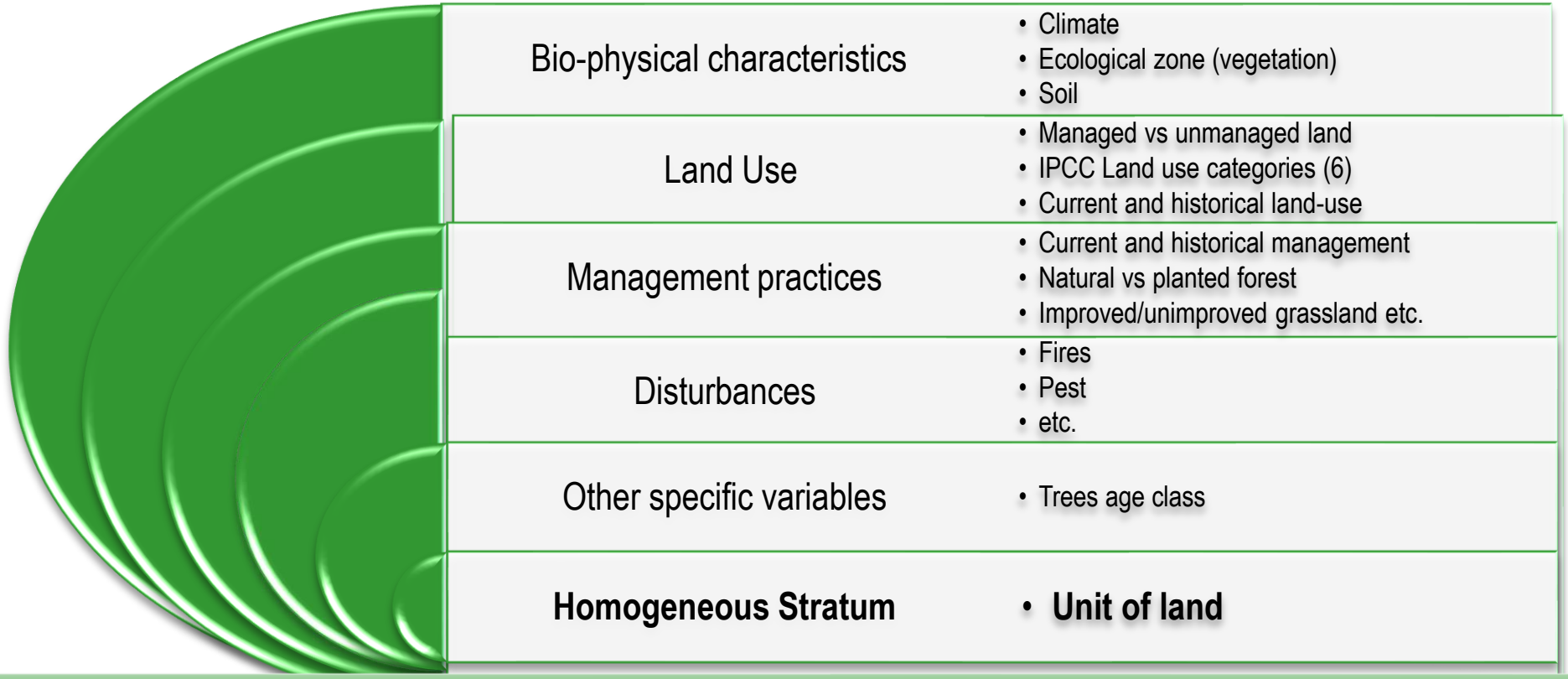
Approach 3

- land use categories are identified, and areas quantified
- land use/management changes are identified (data spatially explicit)
- the areas of changes (between 2 points in time) are:
  - * quantified
  - * tracked over time

Land Representation

- **To be used for the GHG inventory, land use data needs to be:**
  - ✓ adequate, i.e., capable of representing the all land-use/management categories, and conversions between land-use categories *(excluding for Approach 1)*;
  - ✓ consistent, i.e., capable of representing land-use categories consistently over time, without being unduly affected by artificial discontinuities in time-series data;
  - ✓ complete, which means that all land within a country should be included, with increases in some areas balanced by decreases in others, recognizing the bio-physical stratification of land;
  - ✓ transparent, i.e., data sources, definitions, methodologies and assumptions should be clearly described.

Land Representation



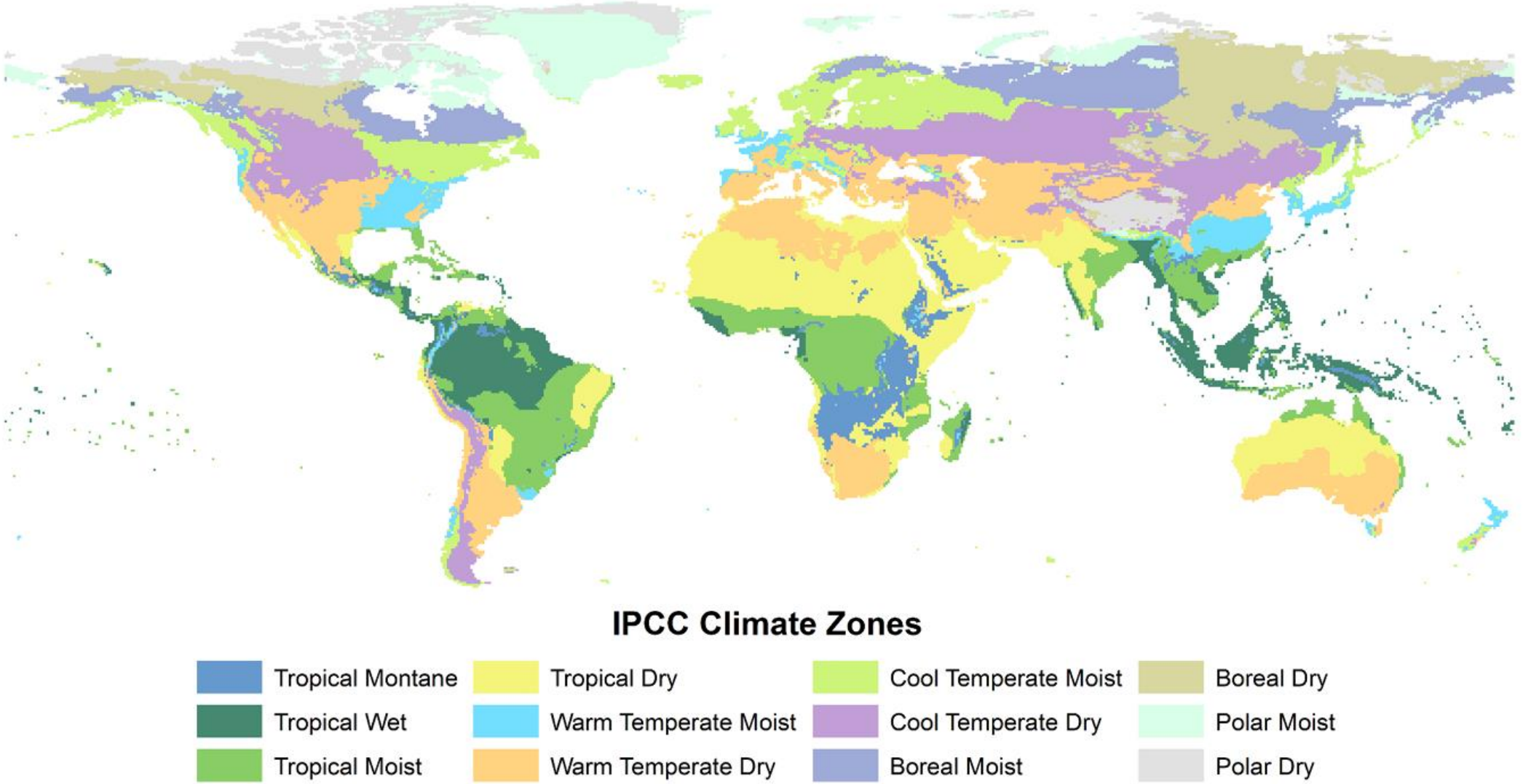
Bio-physical characteristics	• Climate • Ecological zone (vegetation) • Soil
Land Use	• Managed vs unmanaged land • IPCC Land use categories (6) • Current and historical land-use
Management practices	• Current and historical management • Natural vs planted forest • Improved/unimproved grassland etc.
Disturbances	• Fires • Pest • etc.
Other specific variables	• Trees age class
Homogeneous Stratum	• **Unit of land**

Stratification of land is aimed at identifying areas with homogeneous characteristics,

Thus, C stocks and C-stock changes have the lowest variability within the stratum

Land Representation

Bio-physical Characteristics (Climate)



Land Representation

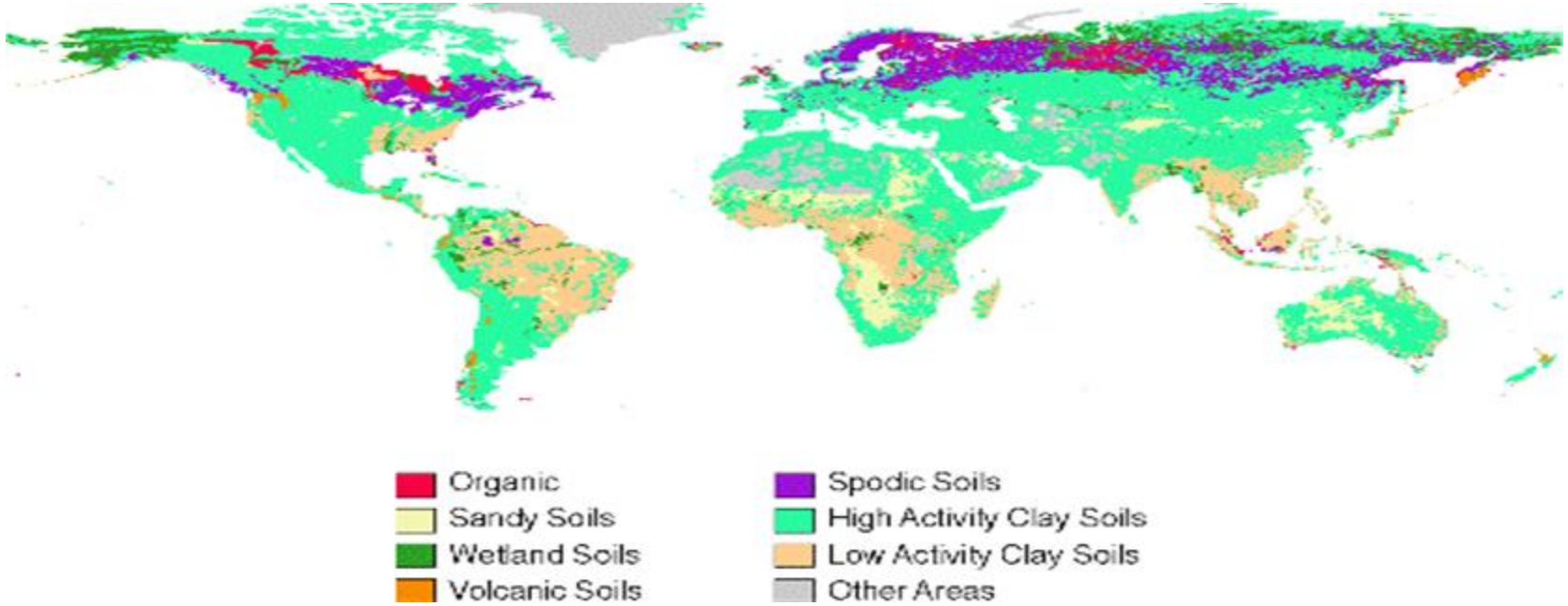
Bio-physical Characteristics (Vegetation)

Global Ecological Zones (GEZ)*

Tropical rainforest	Tropical moist deciduous forest	Tropical dry forest	Tropical shrubland	Tropical desert
Tropical mountain systems	Subtropical humid forest	Subtropical dry forest	Subtropical steppe	Subtropical desert
Subtropical mountain systems	Temperate oceanic forest	Temperate continental forest	Temperate steppe	Temperate desert
Temperate mountain systems	Boreal coniferous forest	Boreal tundra woodland	Boreal mountain systems	Polar

* provided by FAO

Land Representation
Bio-physical Characteristics (Soil)



from the World Harmonized Soil Database

Consistent Land Representation

- A consistent land representation is a time series of annual area estimates of units of land, as disaggregated according to stratification, that reports:
  - ✓ The total area of the territory is constant across the entire time series
  - ✓ The land classification methodology is consistent across the entire timeseries *(no artifact land conversions caused by changes in the classification method/background-data)*
  - ✓ In each year Y, all units of land under conversion are reported within the *Land under conversion* relevant categories until the end of the transition period (D)
  - ✓ In each year Y, all units of land that did not undergo a conversion in the last Y-D years are reported within the *Land remaining* relevant categories

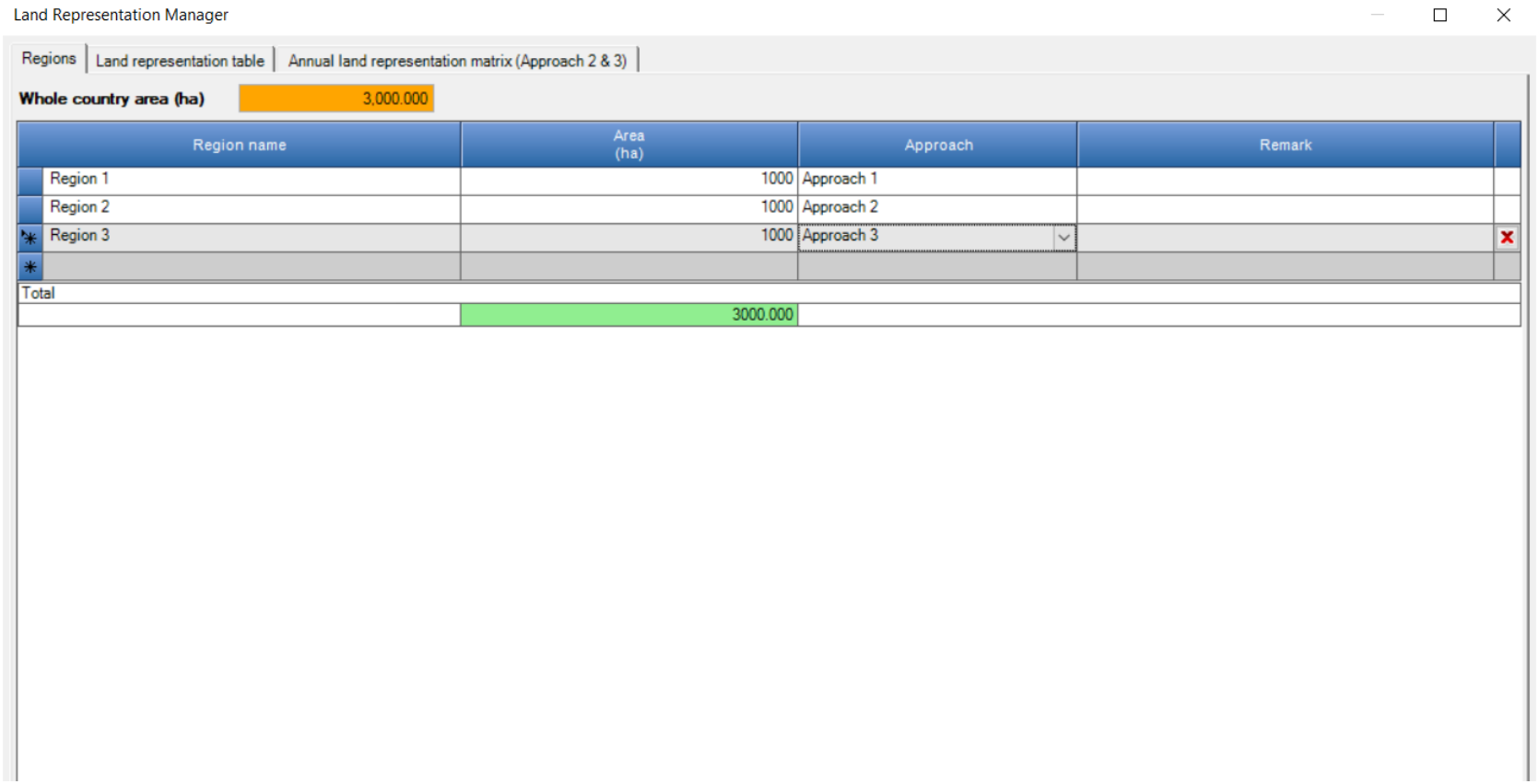
Land Representation Manager (LRM)

- **Allows to use any of the three IPCC approaches**:
  - ✓ Approach 1 *-no land use change identification-*
  - ✓ Approach 2 *-land use change identification-*
  - ✓ Approach 3 *-land use change identification and tracking across time-*
- **Ensures consistency of land representation**
  - ✓ Discrepancy-check in area data input
  - ✓ Tracking of unit of lands across the time series - *spatially explicit tracking under Approach 3-*
- Area data are automatically transferred to relevant worksheets where GHG emissions/removals from land-related activities are estimated
- Each unit of land gets assigned an identification code on the basis of the current and previous land use/management
- To ease the work of compilers, an additional user-defined code can be assigned to each unit of land

Land Representation Manager (LRM)

- **Data input shall be done from the first inventory year forward**
- Once input in an inventory year, the unit of land is copied by the software in all years of the time series updating its "conversion-status" according to the time passed since its conversion and the transition period set
- Approach 1 does not identify land-use conversions, thus:
  - ✓ SOC changes are estimated comparing total SOC stock across the land representation (Region/Country) in the inventory year and 20 years before the inventory year
  - ✓ The Land Representation Manager requires for each unit of land to input the area in the inventory year as well as the area of 20 years before
- Any Unit of land is an area homogenous per
  - ✓ physical conditions *-climate/vegetation zone and soil type-* and
  - ✓ current and historical socio-economic functions *-land use & management type-*

LRM – Regions Tab



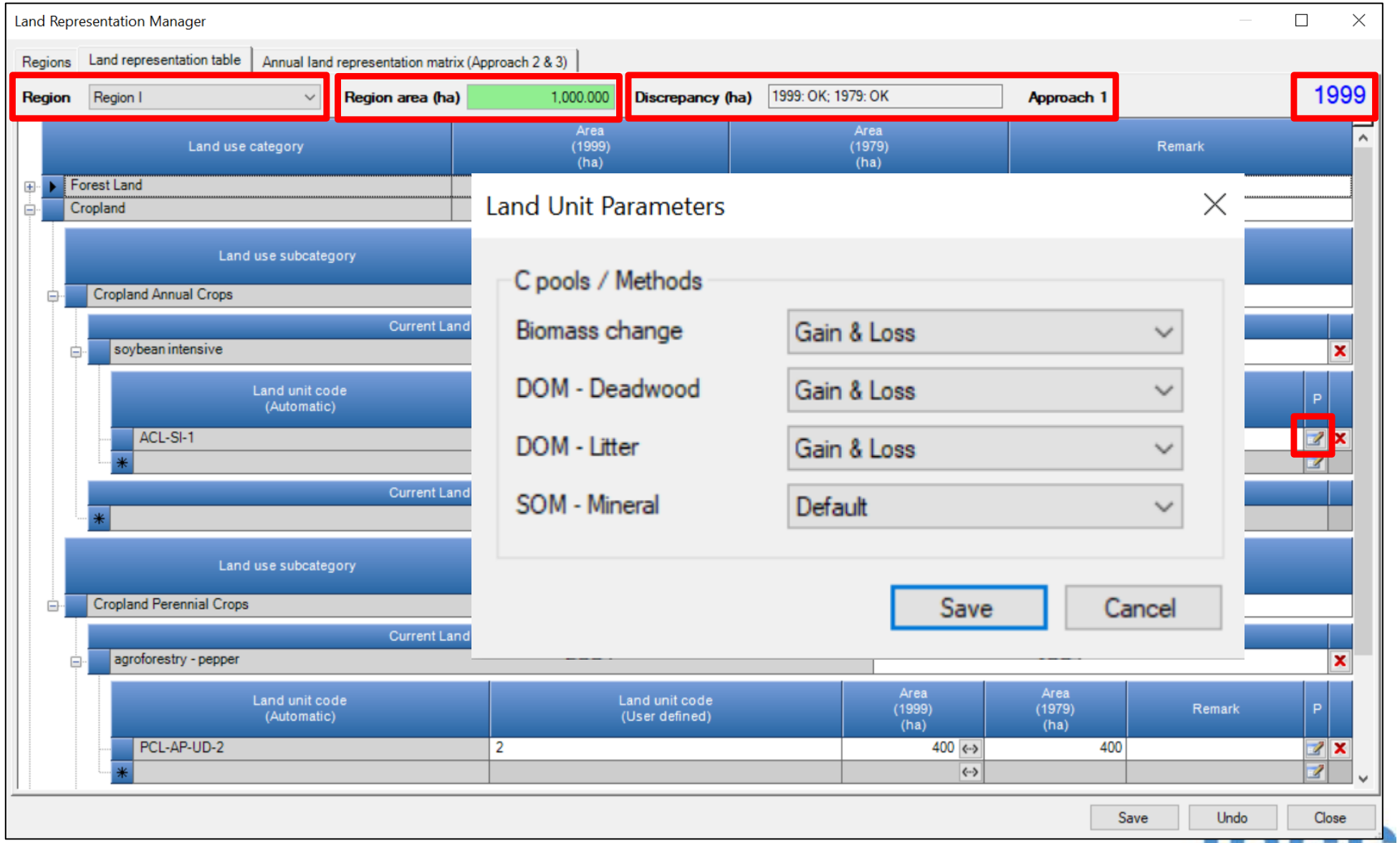
- ✓ A country can be represented in a single set of National data or in a number of Regions
- ✓ For each Region the land representation approach is to be selected

LRM – Land Representation Tab [1999] [Appr. 1]

Input the area of each unit of land, by default, the area is assigned to the current and subsequent years

Input area (ha) the unit of land had 20-year before *(Formulation A, Eq 2.25)*

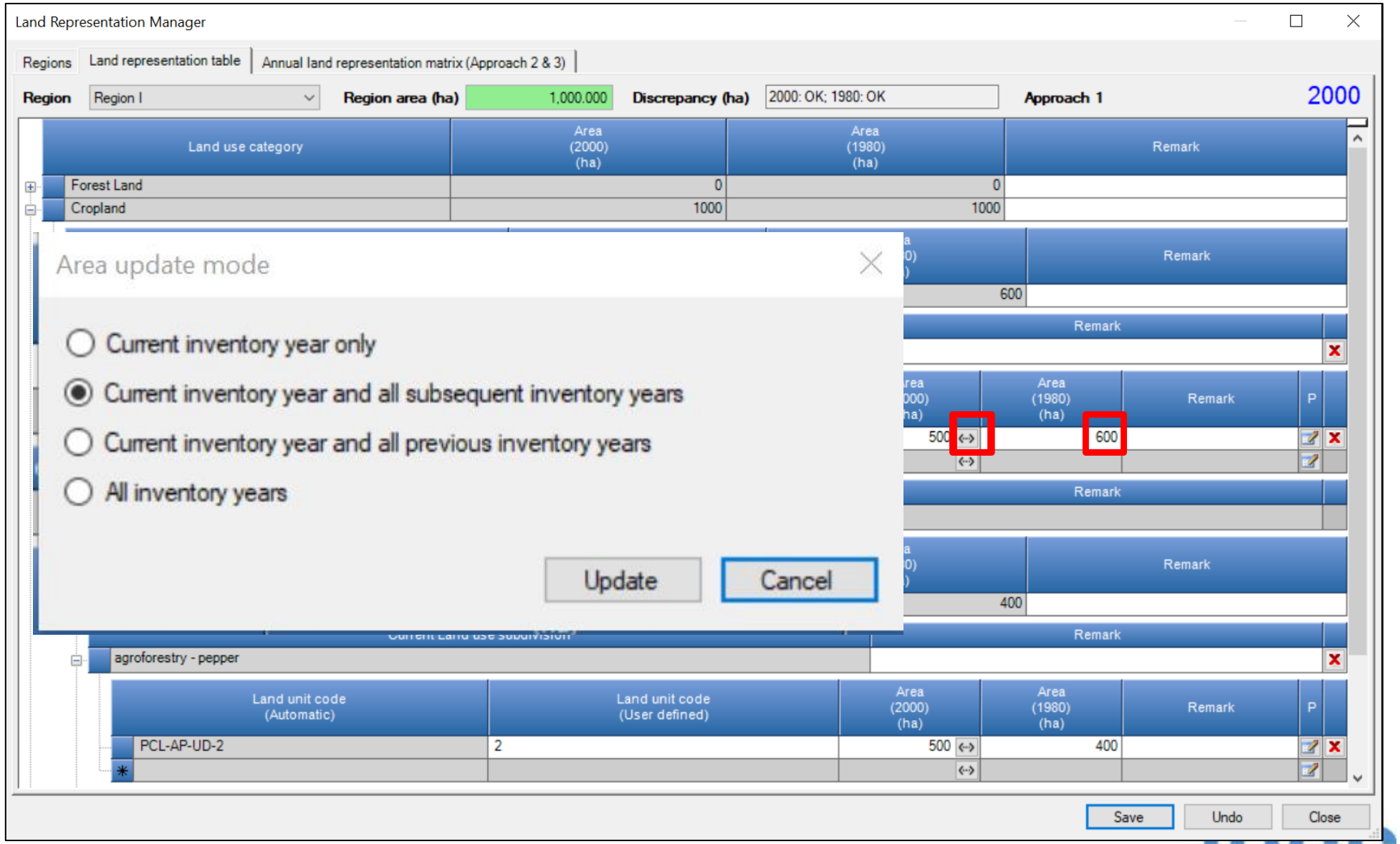
Select, *for each C pool*, the methodological approach to be applied to estimate Carbon-Stock-Changes (CSCs)



LRM – Land Representation Tab [2000] [Appr. 1]

Select the time period to which the revised area value applies

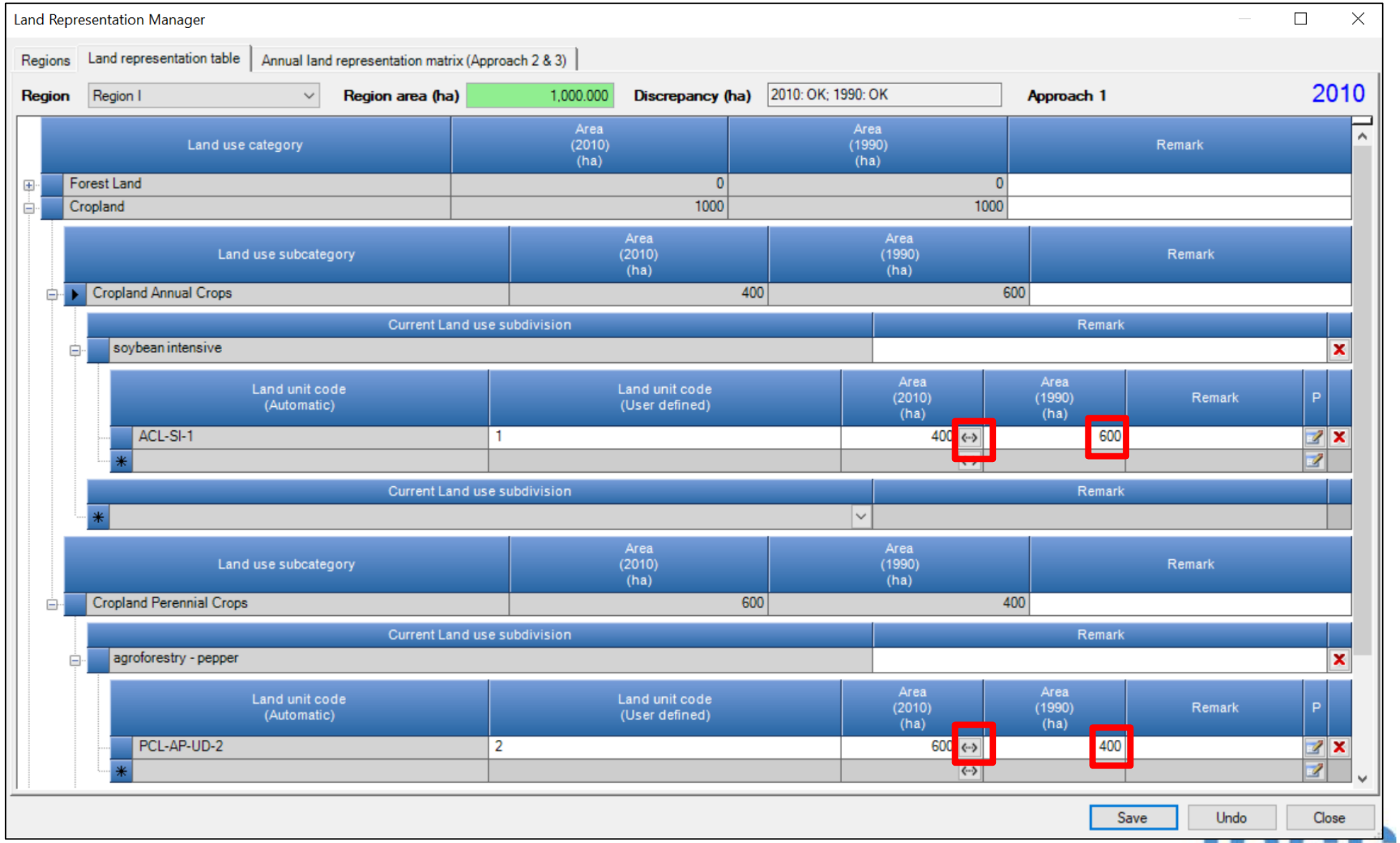
Input area (ha) the unit of land had 20-year before *(Formulation A, Eq 2.25)*



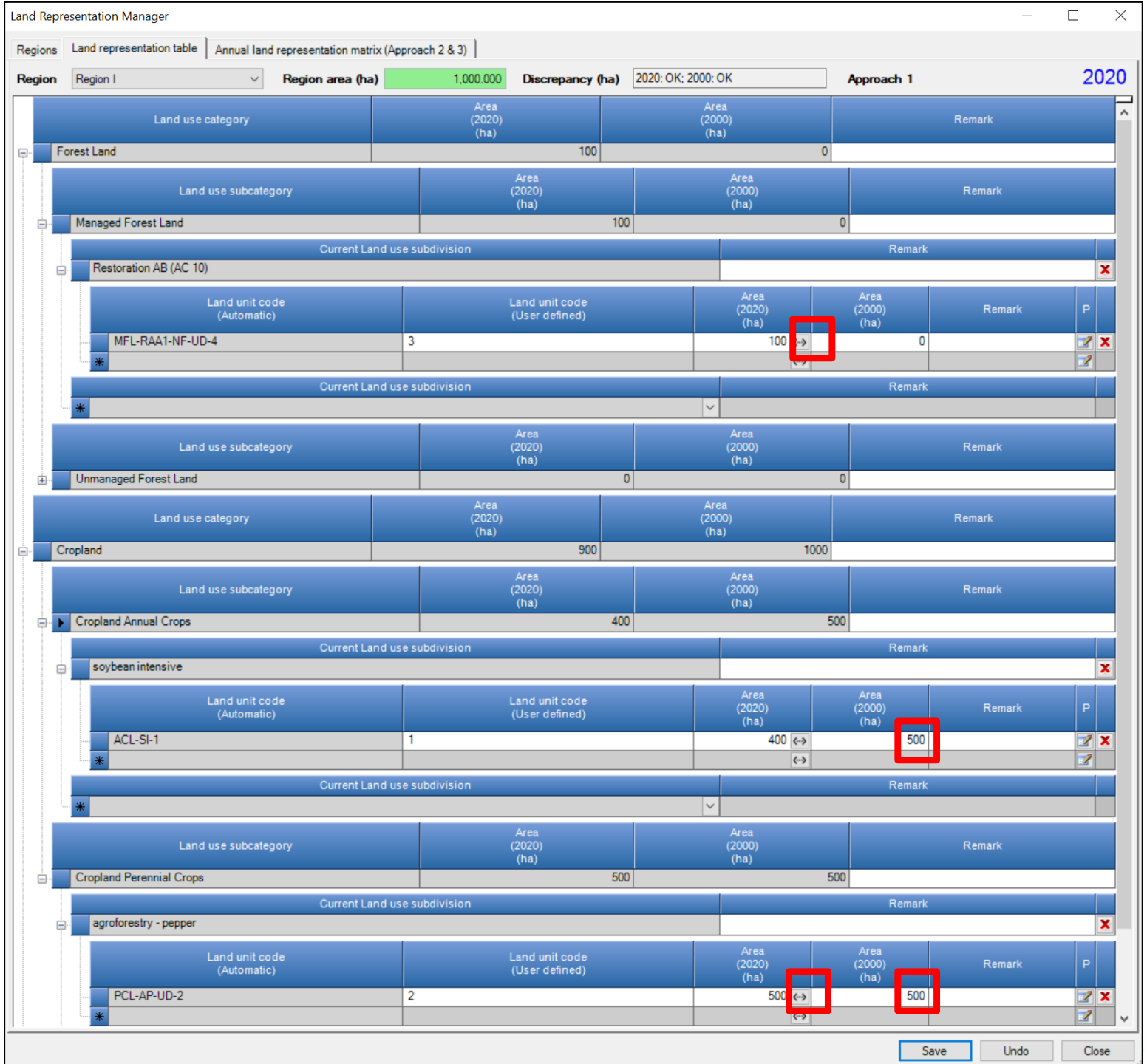
LRM – Land Representation Tab [2010] [Appr. 1]

Select the time period to which the revised area value applies

Input area (ha) the unit of land had 20-year before *(Formulation A, Eq 2.25)*



LRM
Land Representation Tab [2020] [Appr. 1]



Select the time period to which the revised area value applies

The software automatically update the area (ha) the unit of land had 20-year before *(Formulation A, Eq 2.25)*

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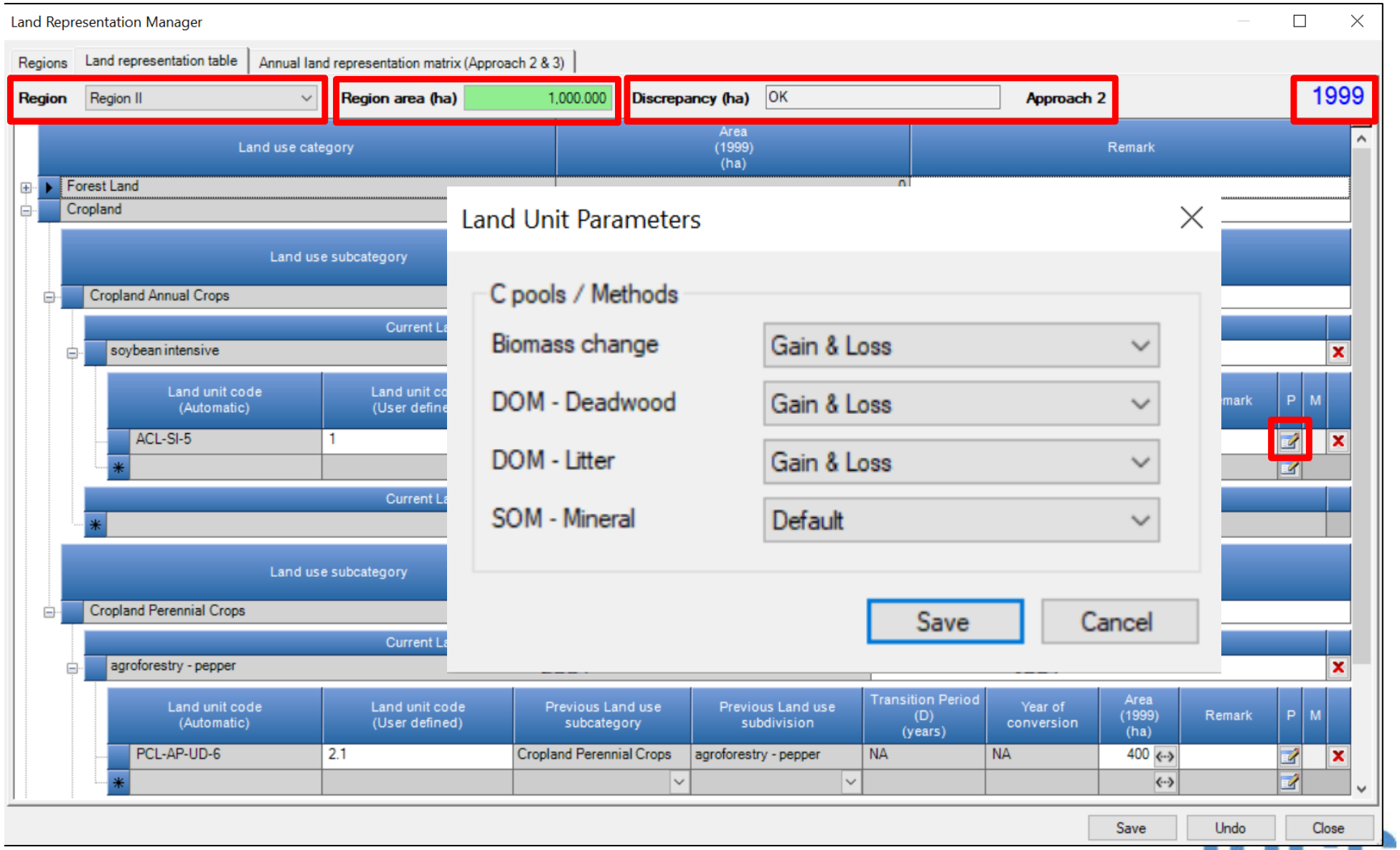
LRM – Land Representation Tab [1999] [Appr. 2]

Input the area of each unit of land, by default, the area is assigned to the current and subsequent years

For each unit of land, Approach 2 requires information on the transition period applied to conversions. For those units of land not undergoing a conversion the software automatically fills the field with "NA"

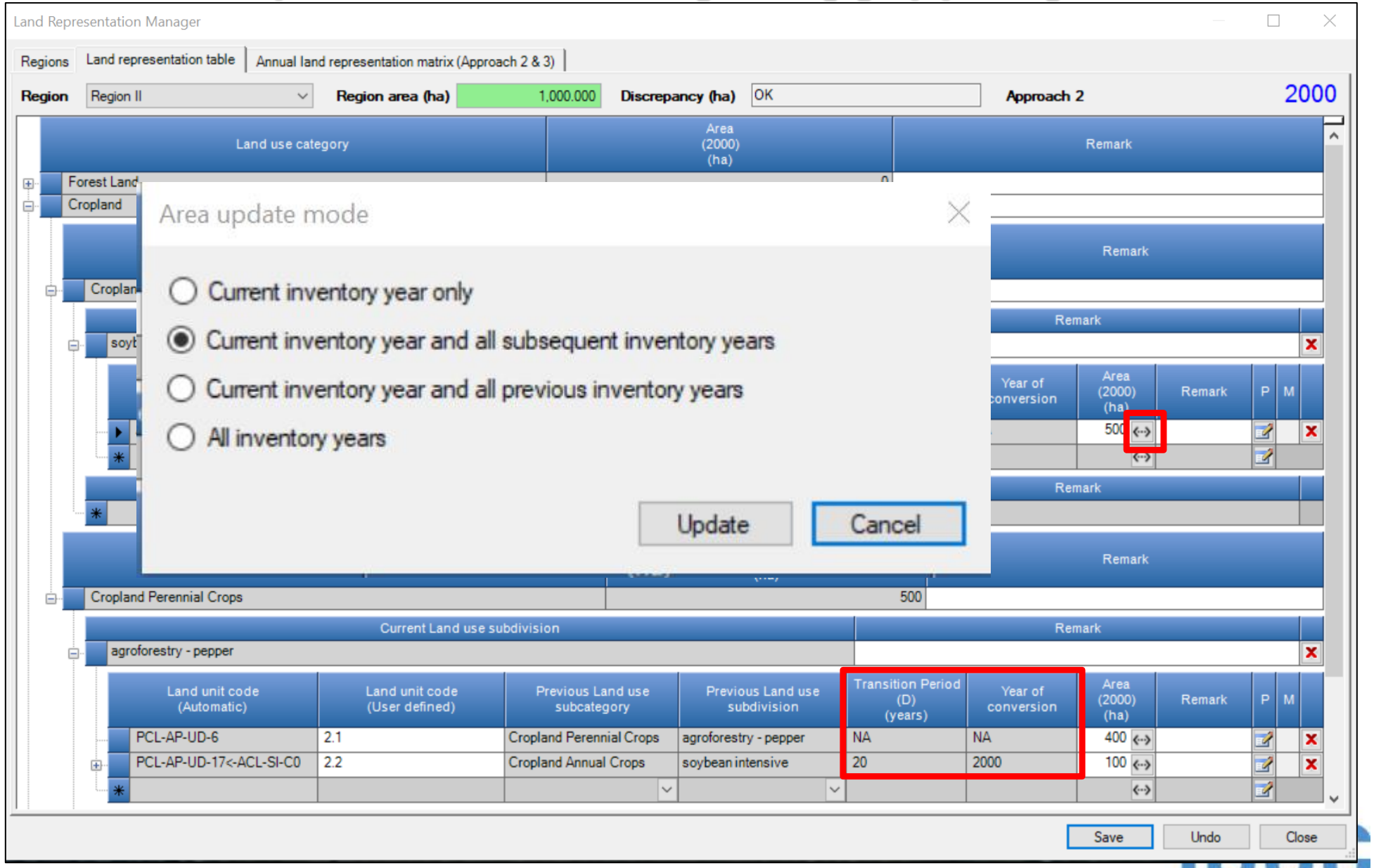
Select, *for each C pool*, the methodological approach to be applied to estimate Carbon-Stock-Changes (CSCs)



LRM – Land Representation Tab [2000] [Appr. 2]

For each unit of land converted in the year, input the transition period

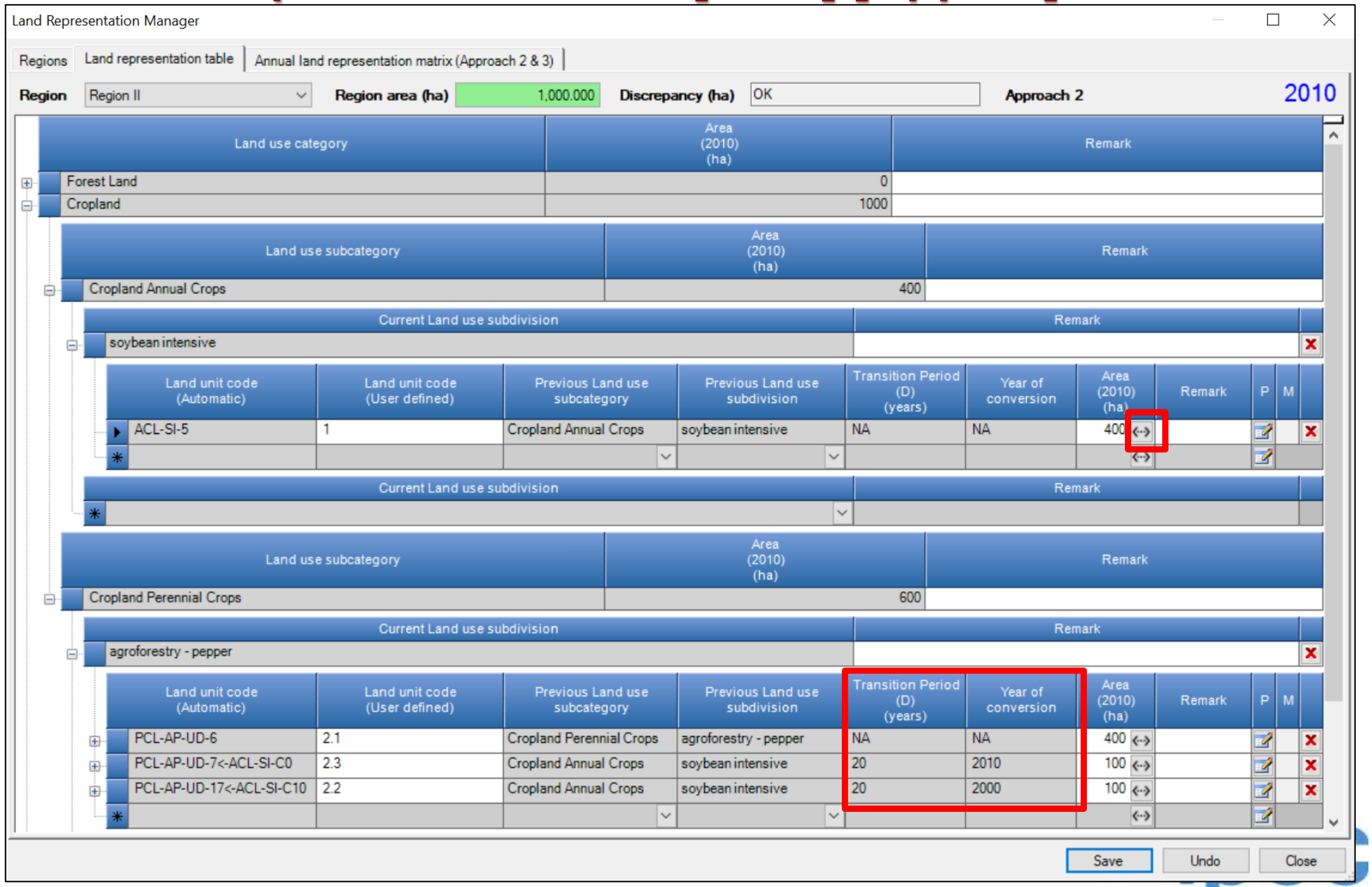
Select the time period to which the revised area value applies



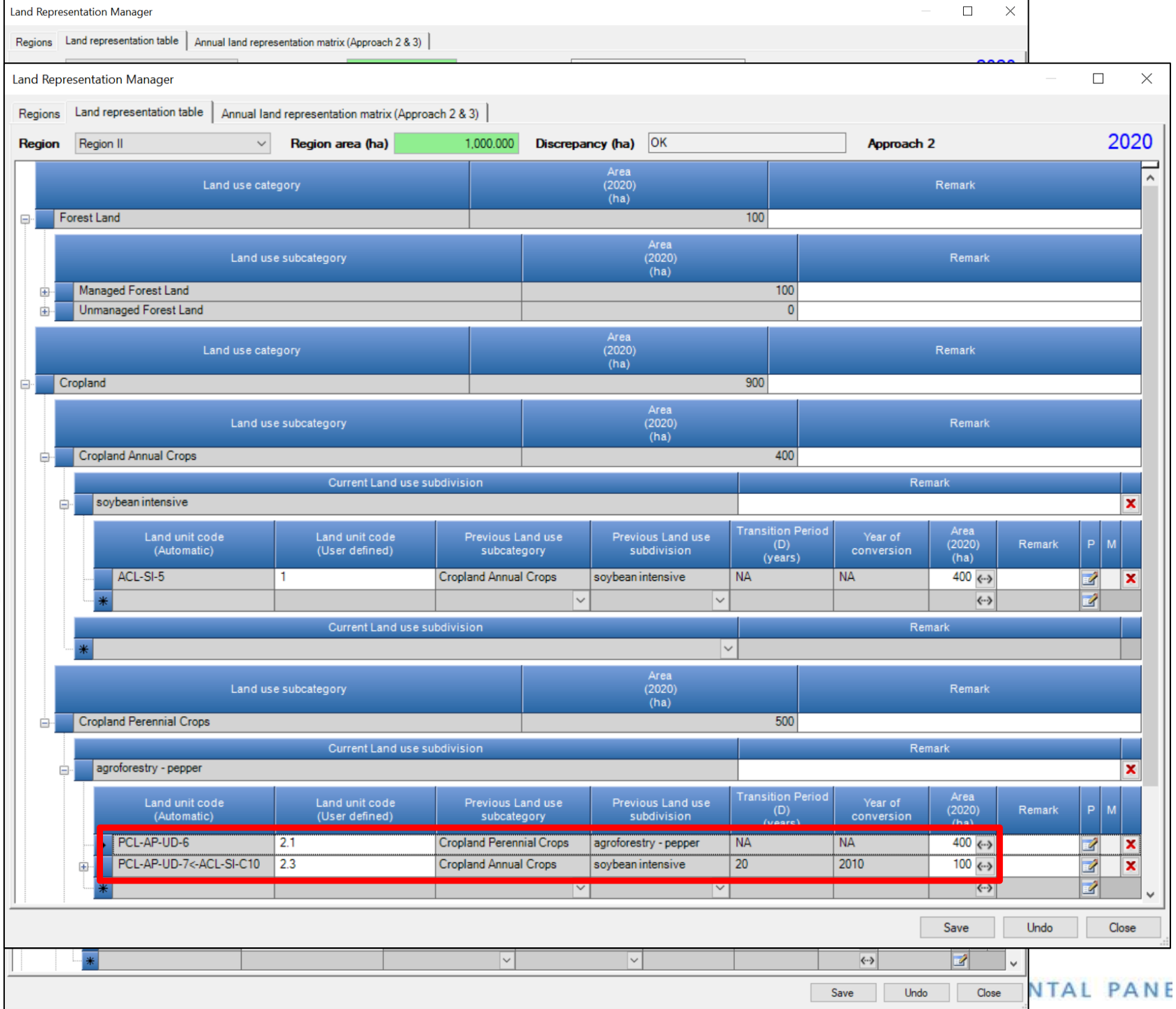
LRM – Land Representation Tab [2010] [Appr. 2]

For each unit of land converted in the year, input the transition period

Select the time period to which the revised area value applies



LRM
Land Representation Tab [2020] [Appr. 2]



Any unit of land ends that eds its conversion period is reclassified automatically by the software as a *land remaining under its land use/management.* Thus, the user may decide to merge it with any other unit of land with identical soil/climate and current/historical use/management. This can be done by using the functionality “m”

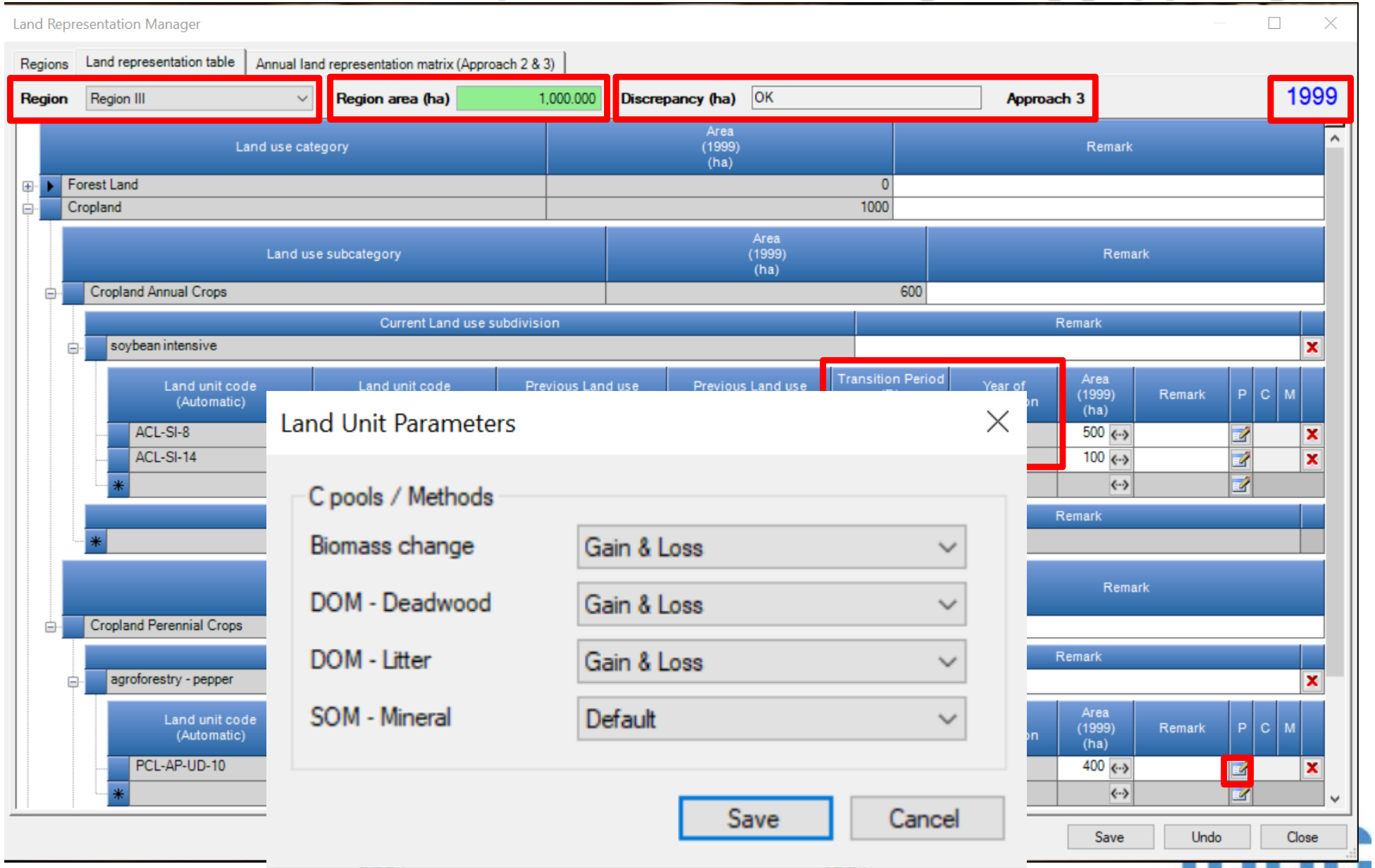
E.g. unit of land 2.2. that ended its transition period is merged into unit of land 2.1

LRM – Land Representation Tab [1999] [Appr. 3]

Input the area of each unit of land, by default, the area is assigned to the current and subsequent years

For each unit of land, Approach 3 requires information on the transition period applied to conversions. For those units of land not undergoing a conversion the software automatically fills the field with “NA”

Select, *for each C pool*, the methodological approach to be applied to estimate Carbon-Stock-Changes (CSCs)



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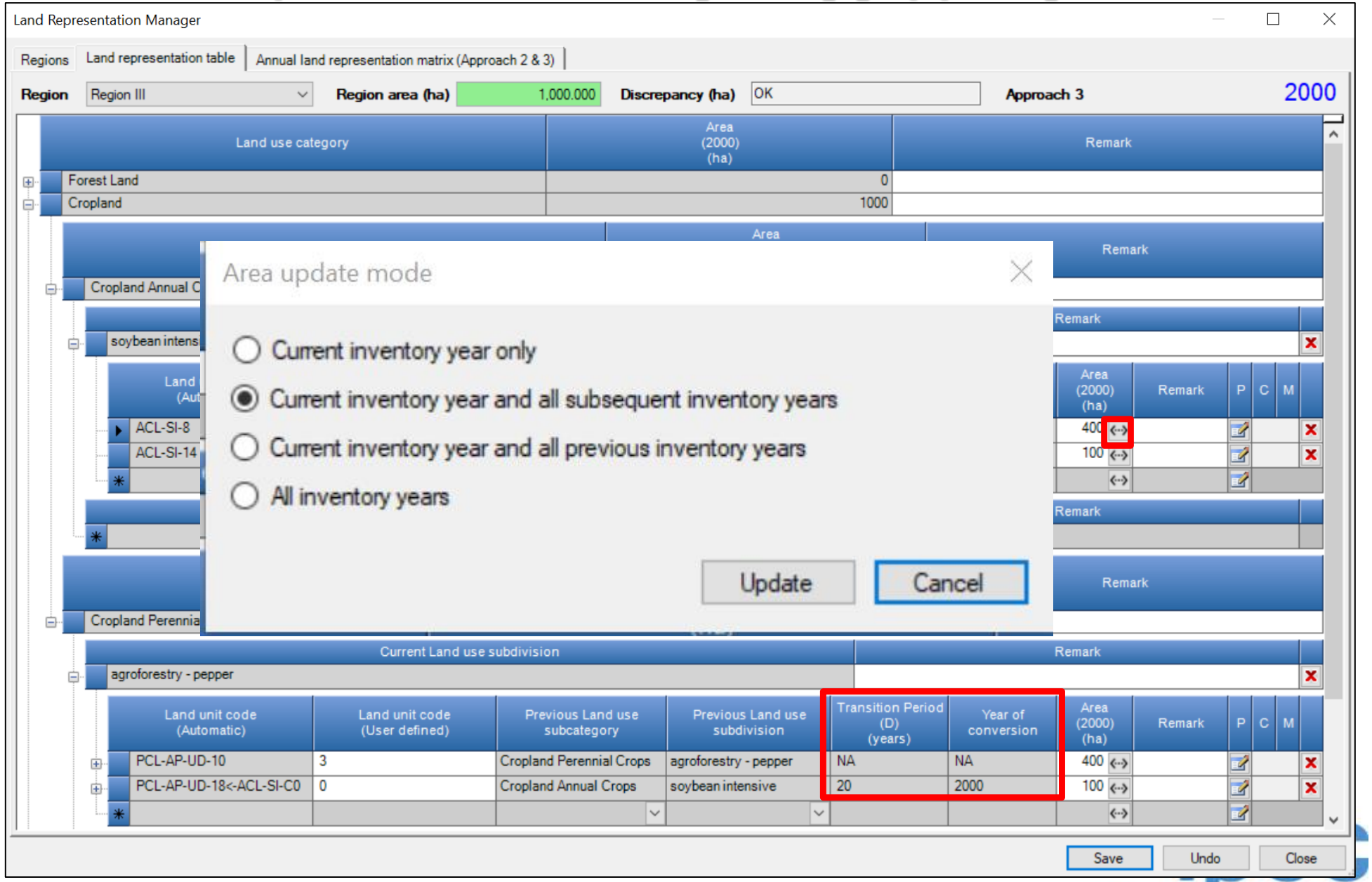
LRM – Land Representation Tab [2000] [Appr. 3]

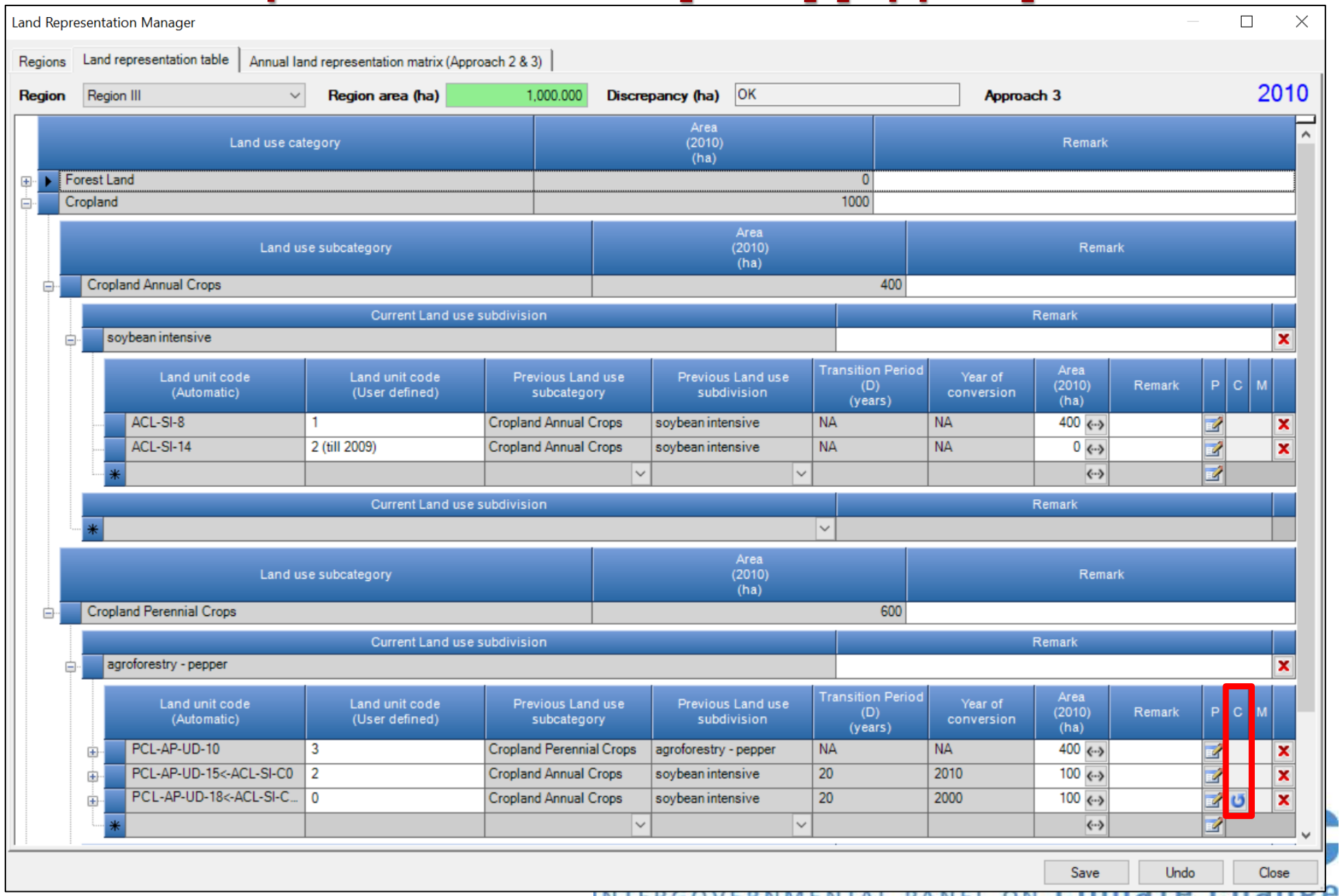
For each unit of land converted in the year, input the transition period

Select the time period to which the revised area value applies



LRM – Land Representation Tab [2010] [Appr. 3]

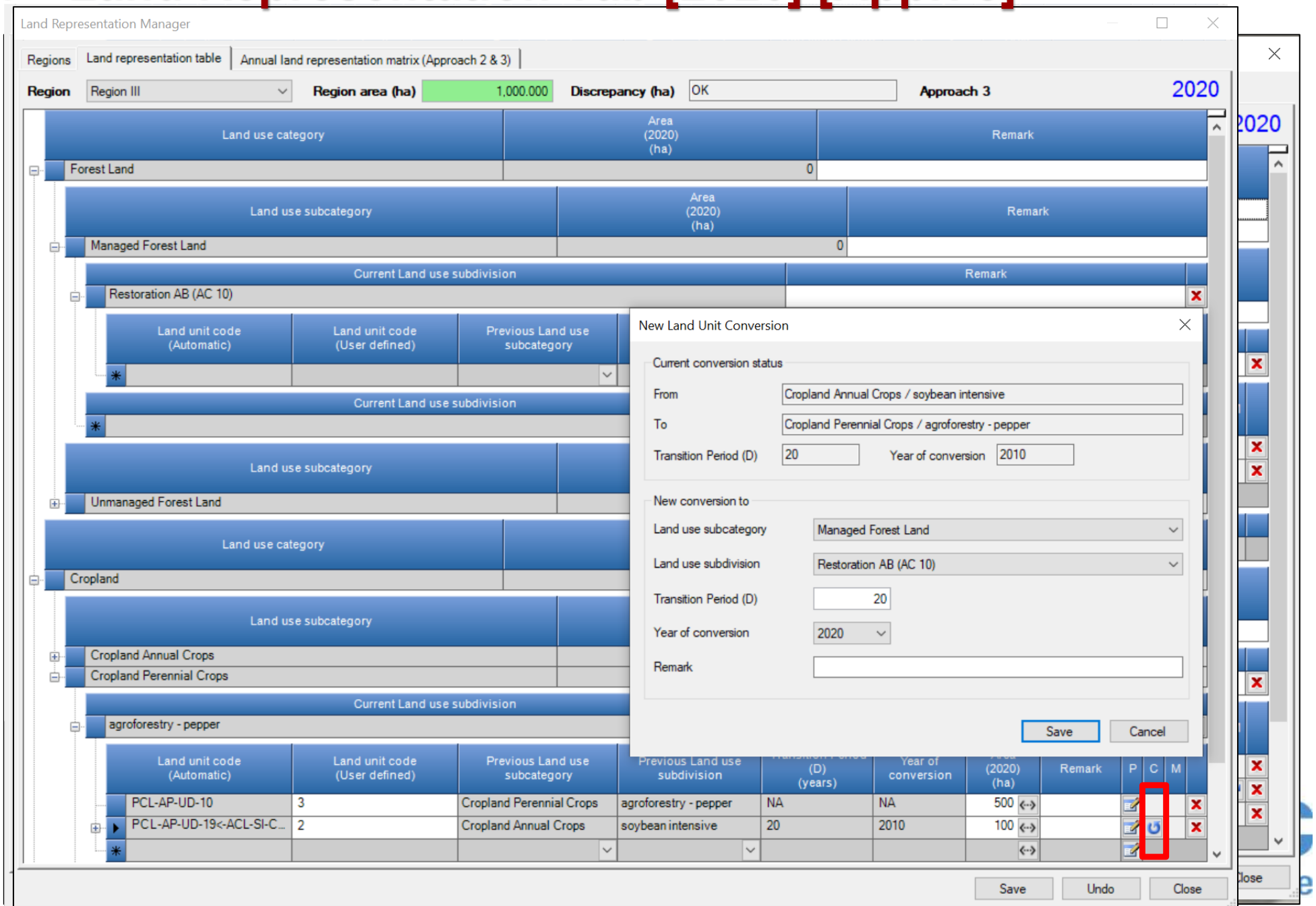
In tracking units of land across time in a spatially explicit way Approach 3 requires tracking of multiple conversions of each unit of land, where relevant. This can be done by using the functionality "c"



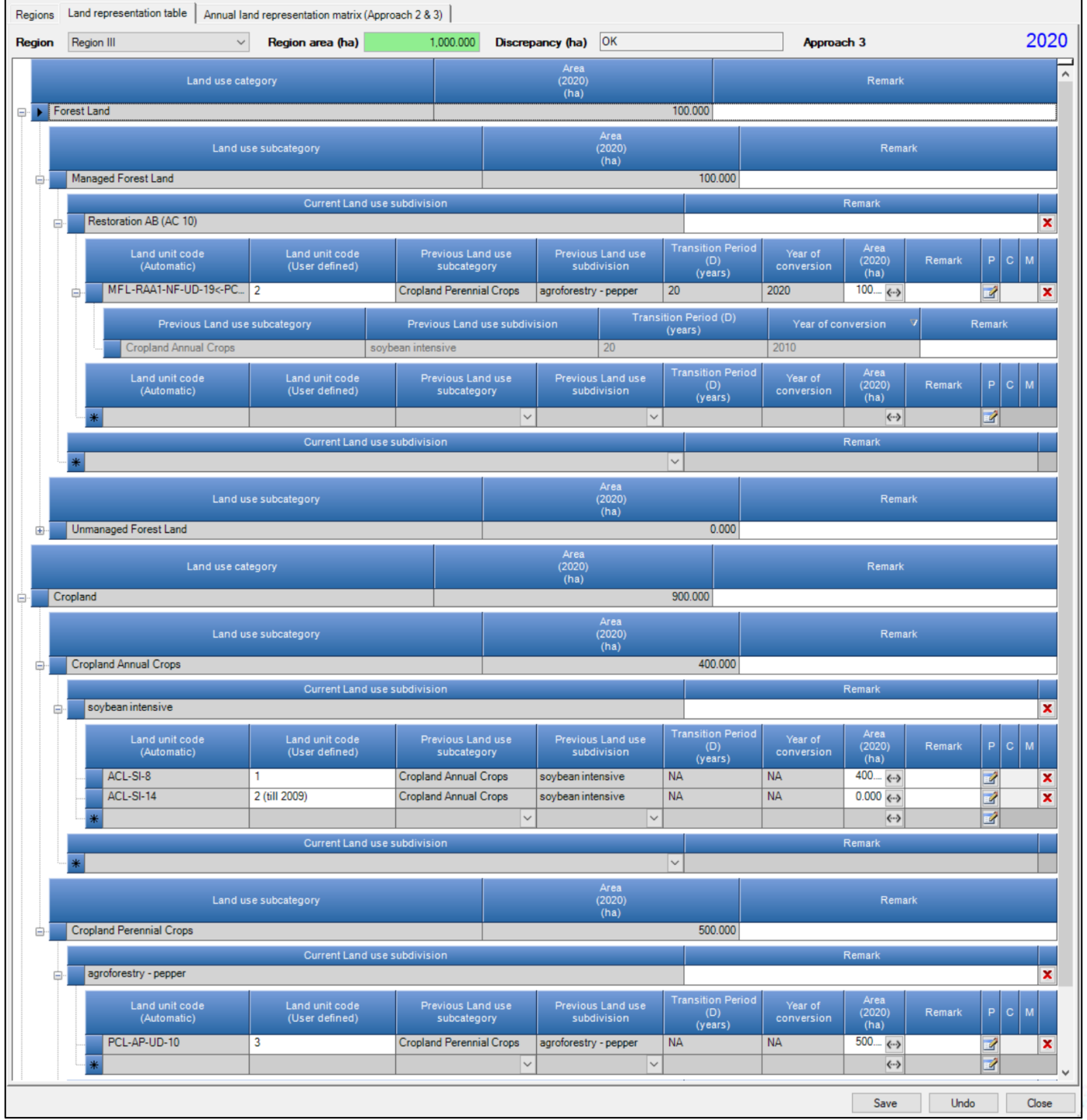
LRM – Land Representation Tab [2020] [Appr. 3]

Unit of land 0 that ended its transition period is merged into unit of land 3.

Unit of land 2 is further converted to Managed Forest land. Once information on the new conversion is input through functionality “c”, unit of land 2 is transferred from section of the LRM for Cropland to the section for Forest land



LRM
Land Representation Tab [2020] [Appr. 3]



Select the time period to which the revised area value applies

Upon use of functionality “c”, unit of land 2 is transferred within the LRM from Cropland section to Forest land section

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Annual land representation matrix – 2010 [Appr. 2&3]

Land Representation Manager

Regions | Land representation table | Annual land representation matrix (Approach 2 & 3)

Region Region II **Region area (ha)** 1,000.000 **Approach 2** 2000

Final		Initial: Managed Forest Land	Unmanaged Forest Land	Cropland Annual Crops	Cropland Perennial Crops	Managed Grassland	Unmanaged Grassland	Managed Wetlands	Unmanaged Wetlands	Settlements (Treed)	Settlements (Other)	Managed Other Land	Unmanaged Other Land	Final Area (ha)	Net change (ha)
Forest Land	Managed Forest Land													0	0
	Unmanaged Forest Land													0	0
Cropland	Cropland Annual Crops			500										500	-100
	Cropland Perennial Crops			100	400									500	100
Grassland	Managed Grassland													0	0
	Unmanaged Grassland													0	0
Wetlands	Managed Wetlands													0	0
	Unmanaged Wetlands													0	0
Settlements	Settlements (Treed)													0	0
	Settlements (Other)													0	0
Other Land	Managed Other Land													0	0
	Unmanaged Other Land													0	0
	Initial Area (ha)	0	0	600	400	0	0	0	0	0	0	0	0	1000	0

No data Input - for verification only (not exportable yet)

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Annual land representation matrix – 2010 [Appr. 2&3]

Land Representation Manager

Regions | Land representation table | Annual land representation matrix (Approach 2 & 3)

Region Region II **Region area (ha)** 1,000.000 **Approach 2** 2010

Final		Initial: Managed Forest Land	Unmanaged Forest Land	Cropland Annual Crops	Cropland Perennial Crops	Managed Grassland	Unmanaged Grassland	Managed Wetlands	Unmanaged Wetlands	Settlements (Treed)	Settlements (Other)	Managed Other Land	Unmanaged Other Land	Final Area (ha)	Net change (ha)
Forest Land	Managed Forest Land													0	0
	Unmanaged Forest Land													0	0
Cropland	Cropland Annual Crops			400										400	-100
	Cropland Perennial Crops			100	500									600	100
Grassland	Managed Grassland													0	0
	Unmanaged Grassland													0	0
Wetlands	Managed Wetlands													0	0
	Unmanaged Wetlands													0	0
Settlements	Settlements (Treed)													0	0
	Settlements (Other)													0	0
Other Land	Managed Other Land													0	0
	Unmanaged Other Land													0	0
	Initial Area (ha)	0	0	500	500	0	0	0	0	0	0	0	0	1000	0

No data Input - for verification only (not exportable yet)

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Annual land representation matrix – 2020 [Appr. 2/3]

Land Representation Manager

Regions | Land representation table | Annual land representation matrix (Approach 2 & 3)

Region Region III **Region area (ha)** 1,000.000 **Approach 3** 2020

Final		Initial: Managed Forest Land	Forest Land: Unmanaged Forest Land	Cropland: Cropland Annual Crops	Cropland: Cropland Perennial Crops	Grassland: Managed Grassland	Grassland: Unmanaged Grassland	Wetlands: Managed Wetlands	Wetlands: Unmanaged Wetlands	Settlements: Settlements (Treed)	Settlements: Settlements (Other)	Other Land: Managed Other Land	Other Land: Unmanaged Other Land	Final Area (ha)	Net change (ha)
Forest Land	Managed Forest Land				100									100	100
	Unmanaged Forest Land													0	0
Cropland	Cropland Annual Crops			400										400	0
	Cropland Perennial Crops				500									500	-100
Grassland	Managed Grassland													0	0
	Unmanaged Grassland													0	0
Wetlands	Managed Wetlands													0	0
	Unmanaged Wetlands													0	0
Settlements	Settlements (Treed)													0	0
	Settlements (Other)													0	0
Other Land	Managed Other Land													0	0
	Unmanaged Other Land													0	0
	Initial Area (ha)	0	0	400	600	0	0	0	0	0	0	0	0	1000	0

No data Input - for verification only (not exportable yet)

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Mineral soil SOC change – Equation 2.25

BOX 2.1 (UPDATED)
ALTERNATIVE FORMULATIONS OF EQUATION 2.25 FOR APPROACH 1 ACTIVITY DATA VERSUS APPROACH 2 OR 3 ACTIVITY DATA WITH TRANSITION MATRICES

Two alternative formulations are possible for Equation 2.25 depending on the Approach used to collect activity data, including

Formulation A (Approach 1 for Activity Data Collection)

$$\Delta C_{Mineral} = \frac{\left[\sum_{c,s,i}\left(SOC_{REF_{c,s,i}} \bullet F_{LU_{c,s,i}} \bullet F_{MG_{c,s,i}} \bullet F_{I_{c,s,i}} \bullet A_{c,s,i}\right)\right]_0 - \left[\sum_{c,s,i}\left(SOC_{REF_{c,s,i}} \bullet F_{LU_{c,s,i}} \bullet F_{MG_{c,s,i}} \bullet F_{I_{c,s,i}} \bullet A_{c,s,i}\right)\right]_{(0-T)}}{D}$$

Formulation B (Approaches 2 and 3 for Activity Data Collection)

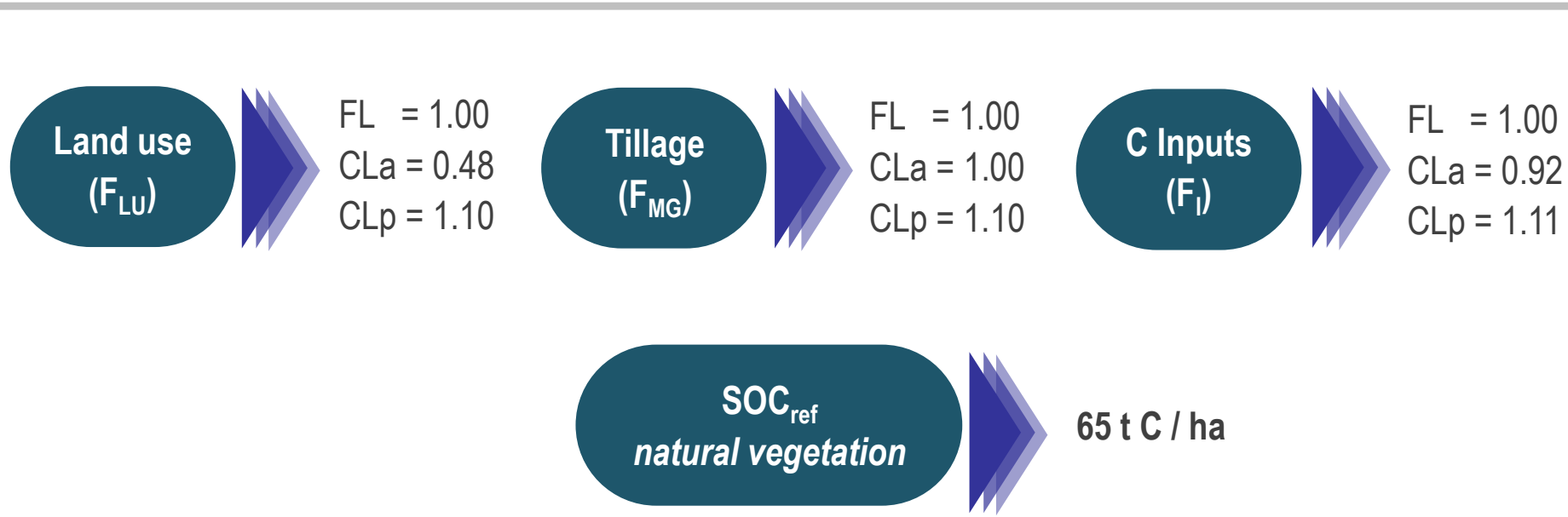
$$\Delta C_{Mineral} = \frac{\sum_{c,s,p}\left[\left\{\begin{array}{l}\left(SOC_{REF_{c,s,p}} \bullet F_{LU_{c,s,p}} \bullet F_{MG_{c,s,p}} \bullet F_{I_{c,s,p}}\right)_0 - \\ \left(SOC_{REF_{c,s,p}} \bullet F_{LU_{c,s,p}} \bullet F_{MG_{c,s,p}} \bullet F_{I_{c,s,p}}\right)_{(0-T)}\end{array}\right\} \bullet A_{c,s,p}\right]}{D}$$

Where:

p = a parcel of land representing an individual unit of area over which the inventory calculations are performed.

The software applies to each unit of land the formulation associated with the approach for land representation selected for the Region to which the unit of land belongs

Equation 2.25
Stock-Change Factors for the case study



Equation 2.25 – Test

- **A comparison between results got from the software and excel-based calculations**:
  - ✓ Formulation A with Approach 1 Land Representation
  - ✓ Formulation B with Approach 2 Land Representation
  - ✓ Formulation B with Approach 3 Land Representation
- **The software properly calculates annual SOC changes in each unit of land**
- **The use of software *vs* excel-based**
  - ✓ minimizes errors in data input
  - ✓ Avoids errors in algorithms
  - ✓ Allows storage of all data of the entire time series
  - ✓ Allow consistency of SOC estimates within the time series as well as consistency with CSC estimates in other C pools

Equation 2.25 – Formulation A

$$\Delta C_{Mineral} = \frac{\left(SOC_{0\_GHGI} - SOC_{(0-T)\_GHGI}\right)}{D}$$

$$= \frac{\left[\sum_{c,s,i,}\left(SOC_{REF_{c,s}} \cdot F_{LU_{c,i}} \cdot F_{MG_{c,i}} \cdot F_{I_{c,i}} \cdot A_{c,s,i}\right)\right]_0 - \left[\sum_{c,s,i,}\left(SOC_{REF_{c,s}} \cdot F_{LU_{c,i}} \cdot F_{MG_{c,i}} \cdot F_{I_{c,i}} \cdot A_{c,s,i}\right)\right]_{(0-D)}}{D}$$

Where, "D" is the **transition period** *(IPCC default is 20 years)*, and **"c"** *(climate)*, **"s"** *(soil)*, **"i"** *(management system)* **correspond to the variables, in each land use category/subcategory, according to which the estimate is stratified/disaggregated**

According to such variables, **SOC at equilibrium,** in any inventory year, for each stratum (unit of land) ***c,s,i***, is calculated as:

- $\left(\mathrm{SOC_{REF_{c,s}}} \cdot \mathrm{F_{LU_{c,i}}} \cdot \mathrm{F_{MG_{c,i}}} \cdot \mathrm{F_{I_{c,i}}} \cdot \mathrm{A_{c,s,i}}\right)_0$

i.e. the combination of current land uses and management systems of practices in the current inventory year "0" (t C)

- $\left(\mathrm{SOC_{REF_{c,s}}} \cdot \mathrm{F_{LU_{c,i}}} \cdot \mathrm{F_{MG_{c,i}}} \cdot \mathrm{F_{I_{c,i}}} \cdot \mathrm{A_{c,s,i}}\right)_{(0-D)}$

i.e. the combination of land uses and management systems of practices of D years before the current inventory year (t C)

Equation 2.25 – Formulation A (2000)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
1	0	600	0	0	500	0	0	400	0	0	400	0
2	0	0	400	0	0	500	0	0	600	0	0	500
3	0	0	0	0	0	0	0	0	0	100	0	0
SOC_0 tC	0	17,222	32,063	0	14,352	40,079	0	11,482	48,095	6,500	11,482	40,079
SOC_{0-T} tC	0	17,222	32,063	0	17,222	32,063	0	17,222	32,063	0	14,352	40,079
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	-143.520	400.793	0.000	-287.040	801.587	325.000	-143.520	0.000

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use
Category: Cropland
Subcategory: 3.B.2.a - Cropland Remaining Cropland
Sheet: SOC Changes in mineral soils - Approach 1 (Information item)

2000

Data

Region Region I - **Approach 1**

Land use category			Equation 2.25 - A		
Land unit code	Land use during reporting year		Soil organic carbon stock in mineral soils in year 2000 (tonnes C / ha)	Soil organic carbon stock in mineral soils in year 1980 (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)
			SOC(2000)	SOC(1980)	ΔCmineral = ((SOC(2000) - SOC(1980)) / 20
1	Cropland Annual C...	soybean intensive	14352	17222.4	-143.52
2	Cropland Perennial...	agroforestry - pepper	40079.325	32063.46	400.79325
Total			54431.325	49285.86	257.27325

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Equation 2.25 – Formulation A (2010)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
1	0	600	0	0	500	0	0	400	0	0	400	0
2	0	0	400	0	0	500	0	0	600	0	0	500
3	0	0	0	0	0	0	0	0	0	100	0	0
SOC_0 tC	0	17,222	32,063	0	14,352	40,079	0	11,482	48,095	6,500	11,482	40,079
SOC_{0-T} tC	0	17,222	32,063	0	17,222	32,063	0	17,222	32,063	0	14,352	40,079
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	-143.520	400.793	0.000	-287.040	801.587	325.000	-143.520	0.000

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use
Category: Cropland
Subcategory: 3.B.2.a - Cropland Remaining Cropland
Sheet: SOC Changes in mineral soils - Approach 1 (Information item)

2010

Data

Region Region I **- Approach 1**

Land use category			Equation 2.25 - A		
Land unit code	Land use during reporting year		Soil organic carbon stock in mineral soils in year 2010 (tonnes C / ha)	Soil organic carbon stock in mineral soils in year 1990 (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)
			SOC(2010)	SOC(1990)	ΔCmineral = ((SOC(2010) - SOC(1990)) / 20
1	Cropland Annual C...	soybean intensive	11481.6	17222.4	-287.04
2	Cropland Perennial...	agroforestry - pepper	48095.19	32063.46	801.5865
Total			59576.79	49285.86	514.5465

Land Use Manager | Land Representation Manager | Uncertainties

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Equation 2.25 – Formulation A (2020)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
1	0	600	0	0	500	0	0	400	0	0	400	0
2	0	0	400	0	0	500	0	0	600	0	0	500
3	0	0	0	0	0	0	0	0	0	100	0	0
SOC_0 tC	0	17,222	32,063	0	14,352	40,079	0	11,482	48,095	6,500	11,482	40,079
SOC_{0-T} tC	0	17,222	32,063	0	17,222	32,063	0	17,222	32,063	0	14,352	40,079
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	-143.520	400.793	0.000	-287.040	801.587	325.000	-143.520	0.000

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Cropland

Subcategory: 3.B.2.a - Cropland Remaining Cropland

Sheet: SOC Changes in mineral soils - Approach 1 (Information item)

2020

Data

Region Region I - **Approach 1**

Land use category			Equation 2.25 - A		
Land unit code	Land use during reporting year		Soil organic carbon stock in mineral soils in year 2020 (tonnes C / ha)	Soil organic carbon stock in mineral soils in year 2000 (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)
			SOC(2020)	SOC(2000)	ΔCmineral = ((SOC(2020) - SOC(2000)) / 20
1	Cropland Annual C...	soybean intensive	11481.6	14352	-143.52
2	Cropland Perennial...	agroforestry - pepper	40079.325	40079.325	0
Total			51560.925	54431.325	-143.52

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Equation 2.25 – Formulation B – Approach 2

$$\Delta C_{Mineral} = \frac{\left(SOC_{0\_GHGI} - SOC_{(0-T)\_GHGI}\right)}{T}$$

$$= \frac{\sum_{c,s,i,p}\left\{\left[\left(SOC_{REF_{c,s,p}} \bullet F_{LU_{c,i,p}} \bullet F_{MG_{c,i,p}} \bullet F_{I_{c,i,p}}\right)_0 - \left(SOC_{REF_{c,s,p}} \bullet F_{LU_{c,i,p}} \bullet F_{MG_{c,i,p}} \bullet F_{I_{c,i,p}}\right)_T\right] \bullet A_{c,s,i,p}\right\}}{D}$$

Where, "D" is the **transition period** *(IPCC default is 20 years)*, and **"c"** *(climate)*, **"s"** *(soil)*, **"i"** *(management system)* **correspond to the variables, in each land use category/subcategory, according to which the estimate is stratified/disaggregated**

According to such variables, **SOC at equilibrium,** in any inventory year, for each stratum (unit of land) ***c,s,i***, is calculated as:

- $\left(\mathrm{SOC_{REF}}_{c,s} \bullet \mathrm{F_{LU}}_{c,i} \bullet \mathrm{F_{MG}}_{c,i} \bullet \mathrm{F_{I}}_{c,i} \bullet \mathrm{A}_{c,s,i}\right)_0$

i.e. the combination of current land uses and management systems of practices in the current inventory year "0" (t C)

- $\left(\mathrm{SOC_{REF}}_{c,s} \bullet \mathrm{F_{LU}}_{c,i} \bullet \mathrm{F_{MG}}_{c,i} \bullet \mathrm{F_{I}}_{c,i} \bullet \mathrm{A}_{c,s,i}\right)_{(0-D)}$

i.e. the combination of land uses and management systems of practices of in the latest year "T" before the conversion (t C)

Equation 2.25 – Formulation B - A2 (2000)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
1	0	600	0	0	500	0	0	400	0	0	400	0
2.1	0	0	400	0	0	400	0	0	400	0	0	400
2.2	0	0	0	0	0	100	0	0	100	0	0	0
2.3	0	0	0	0	0	0	0	0	100	0	0	100
3	0	0	0	0	0	0	0	0	0	100	0	0
SOC_0 tC						8,016			16,032	6,500		8,016
SOC_{0-T} tC						2,870			5,741	8,016		2,870
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	0.000	257.273	0.000	0.000	514.547	-75.793	0.000	257.273

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Cropland

Subcategory: 3.B.2.a - Cropland Remaining Cropland

Sheet: Annual net C stock change in soil organic matter of mineral soils - Approach 2 and Approach 3 (Default method)

2000

Data

Region Region II - **Approach 2**

Land use category			Equation 2.25 - B											
			Area (ha)	Reference carbon stock for the climate and soil combination (tonnes C / ha)	Time dependence of stock change factors (D) or number of years over a single inventory time	Stock change factor for land-use system for the subdivision in the current inventory year (-)	Stock change factor for management regime for the subdivision in the current inventory year (-)	Stock change factor for C input for the subdivision in the current inventory year (-)	Soil organic carbon stock in mineral soils at equilibrium for the current subdivision (tonnes C / ha)	Stock change factor for land-use system at conversion (-)	Stock change factor for management regime at conversion (-)	Stock change factor for C input at conversion (-)	Soil organic carbon stock in mineral soils for the subdivision at conversion (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)
Land unit code	Initial land use	Land use during reporting year	National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	National statistics or international data sources	National statistics or international data sources	National statistics or international data sources	SOC(0) = SOCref * Flu(0) * Fmg(0) * Fi (0)	IPCC defaults or country-specific	IPCC defaults or country-specific	IPCC defaults or country-specific	SOC(c) = SOCref * Flu(c) * Fmg(c) * Fi (c)	ΔCmineral = ((SOC (0) - SOC(c)) * A) / D
			A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	Flu(c)	Fmg(c)	Fi(c)	SOC(c)	
2.2	Cropland... soybean...	Cropland... agrofores...	100	65	20	1.01	1.1	1.11	80.15865	0.48	1	0.92	28.704	257.27325
Total			100											257.27325

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Equation 2.25 – Formulation B - A2 (2010)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
1	0	600	0	0	500	0	0	400	0	0	400	0
2.1	0	0	400	0	0	400	0	0	400	0	0	400
2.2	0	0	0	0	0	100	0	0	100	0	0	0
2.3	0	0	0	0	0	0	0	0	100	0	0	100
3	0	0	0	0	0	0	0	0	0	100	0	0
SOC_0 tC						8,016			16,032	6,500		8,016
SOC_{0-T} tC						2,870			5,741	8,016		2,870
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	0.000	257.273	0.000	0.000	514.547	-75.793	0.000	257.273

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use
Category: Cropland
Subcategory: 3.B.2.a - Cropland Remaining Cropland
Sheet: Annual net C stock change in soil organic matter of mineral soils - Approach 2 and Approach 3 (Default method)

2010

Data

Region Region II - **Approach 2**

Land use category			Equation 2.25 - B												
			Area (ha)	Reference carbon stock for the climate and soil combination (tonnes C / ha)	Time dependence of stock change factors (D) or number of years over a single inventory time	Stock change factor for land-use system for the subdivision in the current inventory year (-)	Stock change factor for management regime for the subdivision in the current inventory year (-)	Stock change factor for C input for the subdivision in the current inventory year (-)	Soil organic carbon stock in mineral soils at equilibrium for the current subdivision (tonnes C / ha)	Stock change factor for land-use system at conversion (-)	Stock change factor for management regime at conversion (-)	Stock change factor for C input at conversion (-)	Soil organic carbon stock in mineral soils for the subdivision at conversion (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)	
Land unit code	Initial land use	Land use during reporting year	National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	National statistics or international data sources	National statistics or international data sources	National statistics or international data sources	SOC(0) = SOCref * Flu(0) * Fmg(0) * Fi (0)	IPCC defaults or country-specific	IPCC defaults or country-specific	IPCC defaults or country-specific	SOC(c) = SOCref * Flu(c) * Fmg(c) * Fi (c)	ΔCmineral = ((SOC (0) - SOC(c)) * A) / D	
			A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	Flu(c)	Fmg(c)	Fi(c)	SOC(c)	ΔCmineral	
2.3	Cropland... soybean...	Cropland... agrofores...	100	65	20	1.01	1.1	1.11	80.15865	0.48	1	0.92	28.704	257.27325	
2.2	soybean...	agrofores...	100	65	20	1.01	1.1	1.11	80.15865	0.48	1	0.92	28.704	257.27325	
Total			200											514.5465	

Equation 2.25 – Formulation B - A2 (2020)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
1	0	600	0	0	500	0	0	400	0	0	400	0
2.1	0	0	400	0	0	400	0	0	400	0	0	400
2.2	0	0	0	0	0	100	0	0	100	0	0	0
2.3	0	0	0	0	0	0	0	0	100	0	0	100
3	0	0	0	0	0	0	0	0	0	100	0	0
SOC_0 tC						8,016			16,032	6,500		8,016
SOC_{0-T} tC						2,870			5,741	8,016		2,870
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	0.000	257.273	0.000	0.000	514.547	-75.793	0.000	257.273

Biomass increase (G&L 1/4) | Biomass loss (G&L 2/4) | Biomass loss (G&L 3/4) | Biomass loss (G&L 4/4) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Forest Land

Subcategory: 3.B.1.b.i - Cropland converted to Forest Land

Sheet: Annual net C stock change in soil organic matter of mineral soils - Approach 2 and Approach 3 (Default method)

2020

Data

Region Region II - **Approach 2**

Land use category			Equation 2.25 - B												
			Area (ha)	Reference carbon stock for the climate and soil combination (tonnes C / ha)	Time dependence of stock change factors (D) or number of years over a single inventory time period (T) (yr)	Stock change factor for land-use system for the subdivision in the current inventory year (-)	Stock change factor for management regime for the subdivision in the current inventory year (-)	Stock change factor for C input for the subdivision in the current inventory year (-)	Soil organic carbon stock in mineral soils at equilibrium for the current subdivision (tonnes C / ha)	Stock change factor for land-use system at conversion (-)	Stock change factor for management regime at conversion (-)	Stock change factor for C input at conversion (-)	Soil organic carbon stock in mineral soils for the subdivision at conversion (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)	
Land unit code	Initial land use	Land use during reporting year	National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	IPCC defaults or country-specific	IPCC defaults or country-specific	IPCC defaults or country-specific	SOC(0) = SOCref * Flu(0) * Fmg(0) * Fi (0)	IPCC defaults or country-specific	IPCC defaults or country-specific	IPCC defaults or country-specific	SOC(c) = SOCref * Flu(c) * Fmg(c) * Fi (c)	ΔCmineral = ((SOC (0) - SOC(c)) * A) / D	
			A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	Flu(c)	Fmg(c)	Fi(c)	SOC(c)	ΔCmineral	
3	Cropland...	agrofores...	Manage...	Restorati...	100	65	20	1	1	1	65	1.01	1.1	1.11	80.15865	-75.79325	
Total					100										-75.79325		

Land unit code	Initial land use	Land use during reporting year	National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	National statistics or international data sources	National statistics or international data sources	National statistics or international data sources	SOC(0) = SOCref * Flu(0) * Fmg(0) * Fi (0)	IPCC defaults or country-specific	IPCC defaults or country-specific	IPCC defaults or country-specific	SOC(c) = SOCref * Flu(c) * Fmg(c) * Fi (c)	ΔCmineral = ((SOC (0) - SOC(c)) * A) / D	
			A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	Flu(c)	Fmg(c)	Fi(c)	SOC(c)	ΔCmineral	
2.3	Cropland...	soybean...	Cropland...	agrofores...	100	65	20	1.01	1.1	1.11	80.15865	0.48	1	0.92	28.704	257.27325	
Total					100										257.27325		

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Equation 2.25 – Formulation B – Approach 3

$$\Delta C_{Mineral} = \frac{\left(SOC_{0\_GHGI} - SOC_{(0-T)\_GHGI}\right)}{T}$$

$$= \frac{\sum_{c,s,i,p}\left\{\left[\left(SOC_{REF_{c,s,p}} \bullet F_{LU_{c,i,p}} \bullet F_{MG_{c,i,p}} \bullet F_{I_{c,i,p}}\right)_0 - SOC_{@conversion_{c,s,i,p}}\right] \bullet A_{c,s,i,p}\right\}}{D}$$

Where, "D" is the **transition period** *(IPCC default is 20 years)*, and **"c"** *(climate)*, **"s"** *(soil)*, **"i"** *(management system)* **correspond to the variables, in each land use category/subcategory, according to which the estimate is stratified/disaggregated**

According to such variables, **SOC at equilibrium,** in any inventory year, for each stratum (unit of land) ***c,s,i***, is calculated as:

- $\left(\mathrm{SOC_{REF}}_{c,s} \bullet \mathrm{F_{LU}}_{c,i} \bullet \mathrm{F_{MG}}_{c,i} \bullet \mathrm{F_{I}}_{c,i} \bullet \mathrm{A}_{c,s,i}\right)_0$

i.e. the combination of current land uses and management systems of practices in the current inventory year "0" (t C)

While the SOC just before the conversion ($SOC_{@conversion}$) of the unit land is not calculated as SOC at equilibrium of the combination of land uses and management systems of practices of in the latest year "T" before the conversion (t C).

$SOC_{@conversion}$ is the actual SOC of the unit of land in the latest year "T" before the conversion (t C)

Equation 2.25 – Formulation B – A3 (2000)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
0	0	0	0	0	0	100	0	0	100	0	0	0
1	0	600	0	0	500	0	0	400	0	0	400	0
2	0	100	0	0	100	0	0	0	100	100	0	0
3	0	0	400	0	0	400	0	0	400	0	0	500
SOC_0 tC						8,016			16,032	6,500		0
SOC_{0-T} tC						2,870			5,741	5,443		0
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	0.000	257.273	0.000	0.000	514.547	52.843	0.000	0.000

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Cropland

Subcategory: 3.B.2.a - Cropland Remaining Cropland

Sheet: Annual net C stock change in soil organic matter of mineral soils - Approach 2 and Approach 3 (Default method)

2000

Data

Region Region III - **Approach 3**

Land use category			Equation 2.25 - B								
			Area (ha)	Reference carbon stock for the climate and soil combination (tonnes C / ha)	Time dependence of stock change factors (D) or number of years over a single inventory time period (T) (yr)	Stock change factor for land-use system for the subdivision in the current inventory year (-)	Stock change factor for management regime for the subdivision in the current inventory year (-)	Stock change factor for C input for the subdivision in the current inventory year (-)	Soil organic carbon stock in mineral soils at equilibrium for the current subdivision (tonnes C / ha)	Soil organic carbon stock in mineral soils for the subdivision at conversion (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)
Land unit code	Initial land use	Land use during reporting year	National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	National statistics or international data sources	National statistics or international data sources	National statistics or international data sources	SOC(0) = SOCref * Flu (0) * Fmg(0) * Fi(0)		ΔCmineral = ((SOC(0) - SOC(c)) * A) / D
			A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	SOC(c)	ΔCmineral
0	Cropland An... soybean int...	Cropland Pe... agroforestry...	100	65	20	1.01	1.1	1.11	80.15865	28.704	257.27325
Total			100								257.27325

Equation 2.25 – Formulation B – A3 (2010)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
0	0	0	0	0	0	100	0	0	100	0	0	0
1	0	600	0	0	500	0	0	400	0	0	400	0
2	0	100	0	0	100	0	0	0	100	100	0	0
3	0	0	400	0	0	400	0	0	400	0	0	500
SOC_0 tC						8,016			16,032	6,500		0
SOC_{0-T} tC						2,870			5,741	5,443		0
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	0.000	257.273	0.000	0.000	514.547	52.843	0.000	0.000

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use
Category: Cropland
Subcategory: 3.B.2.a - Cropland Remaining Cropland
Sheet: Annual net C stock change in soil organic matter of mineral soils - Approach 2 and Approach 3 (Default method)

2010

Data

Region Region III - **Approach 3**

Land use category					Equation 2.25 - B									
					Area (ha)	Reference carbon stock for the climate and soil combination (tonnes C / ha)	Time dependence of stock change factors (D) or number of years over a single inventory time period (T) (yr)	Stock change factor for land-use system for the subdivision in the current inventory year (-)	Stock change factor for management regime for the subdivision in the current inventory year (-)	Stock change factor for C input for the subdivision in the current inventory year (-)	Soil organic carbon stock in mineral soils at equilibrium for the current subdivision (tonnes C / ha)	Soil organic carbon stock in mineral soils for the subdivision at conversion (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)		
Land unit code	Initial land use		Land use during reporting year		National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	National statistics or international data sources	National statistics or international data sources	National statistics or international data sources	SOC(0) = SOCref * Flu (0) * Fmg(0) * Fi(0)		ΔCmineral = ((SOC(0) - SOC(c)) * A) / D		
					A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	SOC(c)	ΔCmineral		
0	Cropland An...	soybean int...	Cropland Pe...	agroforestry...	100	65	20	1.01	1.1	1.11	80.15865	28.704	257.27325		
2		soybean int...		agroforestry...	100	65	20	1.01	1.1	1.11	80.15865	28.704	257.27325		
Total					200								514.5465		

Equation 2.25 – Formulation B – A3 (2020)

Year	1999			2000			2010			2020		
Category	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp	F	CLa	CLp
Land unit	Area (ha)											
0	0	0	0	0	0	100	0	0	100	0	0	0
1	0	600	0	0	500	0	0	400	0	0	400	0
2	0	100	0	0	100	0	0	0	100	100	0	0
3	0	0	400	0	0	400	0	0	400	0	0	500
SOC_0 tC						8,016			16,032	6,500		0
SOC_{0-T} tC						2,870			5,741	5,443		0
ΔC tC yr^{-1}	0.000	0.000	0.000	0.000	0.000	257.273	0.000	0.000	514.547	52.843	0.000	0.000

Biomass increase (G&L 1/4) | Biomass loss (G&L 2/4) | Biomass loss (G&L 3/4) | Biomass loss (G&L 4/4) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained | SOM Organic Rewetted

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Forest Land

Subcategory: 3.B.1.b.i - Cropland converted to Forest Land

Sheet: Annual net C stock change in soil organic matter of mineral soils - Approach 2 and Approach 3 (Default method)

2020

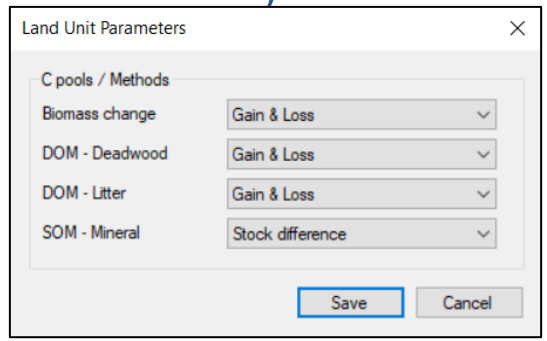
Data

Region Region III - **Approach 3**

Land use category			Equation 2.25 - B									
			Area (ha)	Reference carbon stock for the climate and soil combination (tonnes C / ha)	Time dependence of stock change factors (D) or number of years over a single inventory time period (T) (yr)	Stock change factor for land-use system for the subdivision in the current inventory year (-)	Stock change factor for management regime for the subdivision in the current inventory year (-)	Stock change factor for C input for the subdivision in the current inventory year (-)	Soil organic carbon stock in mineral soils at equilibrium for the current subdivision (tonnes C / ha)	Soil organic carbon stock in mineral soils for the subdivision in the year of conversion (tonnes C / ha)	Annual change in carbon stocks in mineral soils (tonnes C / yr)	
Land unit code	Initial land use	Land use during reporting year	National statistics or international data sources	Tables 2.3 / 5.2 WS	Default value is 20	IPCC defaults or country -specific	IPCC defaults or country -specific	IPCC defaults or country -specific	SOC(0) = SOCref * Flu (0) * Fmg(0) * Fi(0)		ΔCmineral = ((SOC(0) - SOC(c)) * A) / D	
			A	SOCref	D	Flu(0)	Fmg(0)	Fi(0)	SOC(0)	SOC(c)	ΔCmineral	
2	Cropland Pe...	agroforestry... / Managed F... / Restoration...	100	65	20	1	1	1	65	54.43133	52.84337	
Total			100								52.84337	

Stock-Difference Method (IPCC Eq. 2.5)

Can be selected in the **Land Representation Manager** for each C pool (biomass/DOM/SOM) of each unit of land



SOM Organic Rewetted

Biomass change (G&L) | Biomass change (SD) | Biomass change (Abrupt) | DOM (G&L 1/1) | DOM (SD 1/1) | SOM Mineral (Approach 1 - Information item) | SOM Mineral (Approaches 2 and 3) | SOM Mineral (SD) | SOM Organic Drained

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Cropland

Subcategory: 3.B.2.a - Cropland Remaining Cropland

Sheet: Annual net C stock change in soil organic matter of mineral soils (Stock difference method)

2020

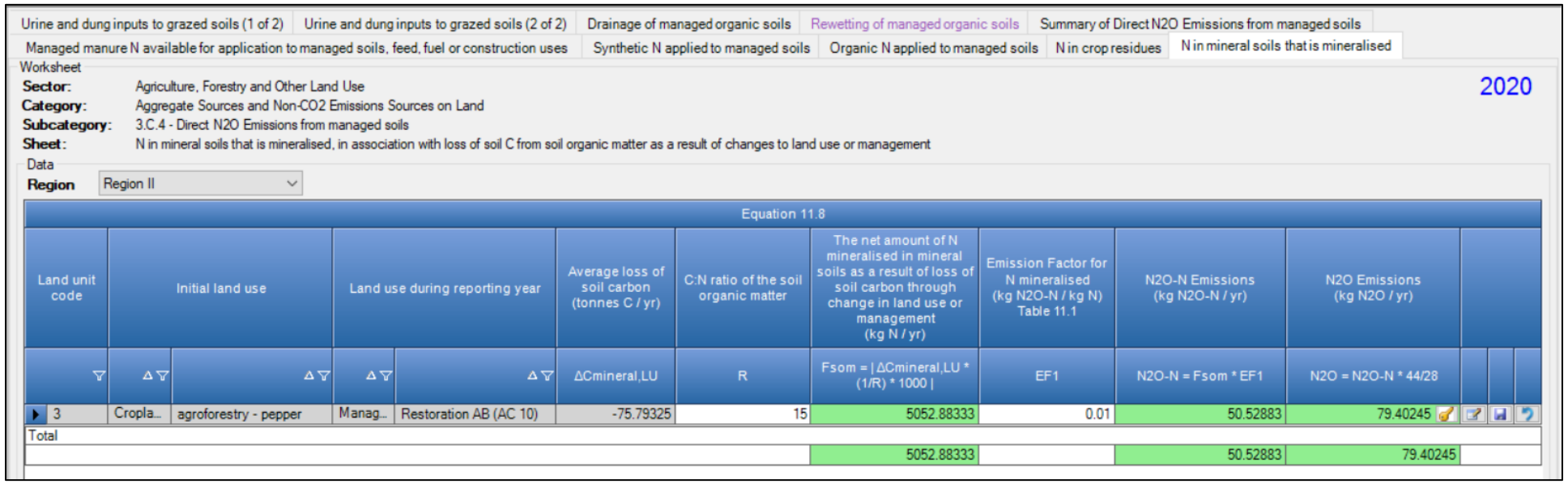
Data

Region Region IV - **Approach 2**

Land use category					Equation 2.5					
					Area (ha)	Soil organic carbon stock in mineral soils at time 0 (tonnes C / ha)	Soil organic carbon stock in mineral soils at time 0-T (tonnes C / ha)	Number of years over a single inventory time period (Year)	Annual change in carbon stocks in mineral soils (tonnes C / yr)	
Land unit code	Initial land use		Land use during reporting year		National statistics or international data sources	National statistics or international data sources	National statistics or international data sources		ΔCmineral = ((SOC(0) - SOC(0-T)) / T	
					A	SOC(0)	SOC(0-T)	T	ΔCmineral	
SD	Cropland Ann...	Rotation A	Cropland Per...	Rotation P	500	94	90	8	0.5	
Total					500				0.5	

Calculation is performed with C density –i.e. tC/ha- at time t_2 *(current inventory year)* and t_1 *(a previous year)* and scaled up to the entire area of the unit of land at time t_2

Direct N_2O emissions from managed soils (IPCC Eq. 11.8)



Urine and dung inputs to grazed soils (1 of 2) | Urine and dung inputs to grazed soils (2 of 2) | Drainage of managed organic soils | Rewetting of managed organic soils | Summary of Direct N2O Emissions from managed soils

Managed manure N available for application to managed soils, feed, fuel or construction uses | Synthetic N applied to managed soils | Organic N applied to managed soils | N in crop residues | N in mineral soils that is mineralised

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Aggregate Sources and Non-CO2 Emissions Sources on Land

Subcategory: 3.C.4 - Direct N2O Emissions from managed soils

Sheet: N in mineral soils that is mineralised, in association with loss of soil C from soil organic matter as a result of changes to land use or management

2020

Data

Region Region II

Equation 11.8

Land unit code	Initial land use		Land use during reporting year		Average loss of soil carbon (tonnes C / yr)	C:N ratio of the soil organic matter	The net amount of N mineralised in mineral soils as a result of loss of soil carbon through change in land use or management (kg N / yr)	Emission Factor for N mineralised (kg N2O-N / kg N) Table 11.1	N2O-N Emissions (kg N2O-N / yr)	N2O Emissions (kg N2O / yr)			
					ΔCmineral,LU	R	Fsom = | ΔCmineral,LU * (1/R) * 1000 |	EF1	N2O-N = Fsom * EF1	N2O = N2O-N * 44/28			
3	Cropla...	agroforestry - pepper	Manag...	Restoration AB (AC 10)	-75.79325	15	5052.88333	0.01	50.52883	79.40245			
Total													
							5052.88333		50.52883	79.40245			

Activity Data are automatically transferred from relevant worksheets where SOC losses in mineral soils are estimated

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Indirect N_2O emissions from managed soils (E.g. 11.10) *leaching/runoff*

N2O from Atmospheric Deposition of N Volatilised from Managed Soils | N2O from N leaching/runoff from Managed Soils

Worksheet

Sector: Agriculture, Forestry and Other Land Use
Category: Aggregate Sources and Non-CO2 Emissions Sources on Land
Subcategory: 3.C.5 - Indirect N2O Emissions from managed soils
Sheet: N2O from N leaching/runoff from Managed Soils

2020

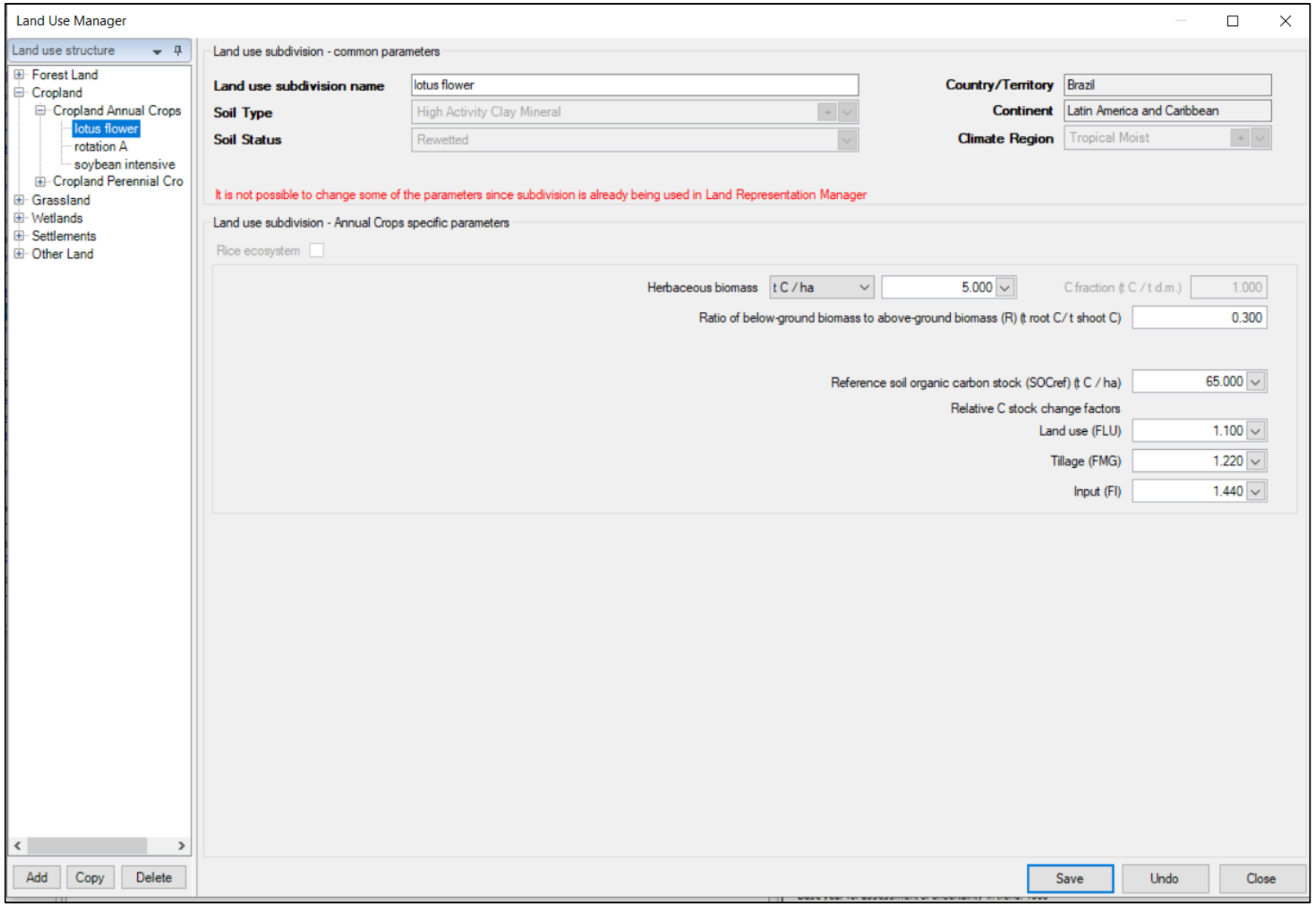
Data

Region Region II

		Equation 11.10										
		Annual amount of synthetic fertilizer N applied to soils (kg N / yr)	Amount of animal manure, compost, sewage sludge and other organic N additions applied to soils (kg N / yr)	Amount of urine and dung N deposited by grazing animals (kg N / yr)	Amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils (kg N / yr)	Amount of N mineralised in mineral soils associated with loss of soil C from SOM as a result of changes to land use or management (kg N / yr)	Amount of N mineralised in organic soils associated with loss of soil C from soil organic matter as a result of changes to land use or management (kg N / yr)	Fraction of all N added to/mineralised in managed soils that is lost through leaching and runoff [kg N / (kg of N additions)]	Emission factor for N2O emissions from N leaching and runoff [kg N2O-N/(kg N leaching/runoff)]	Amount of N2O–N produced from leaching and runoff of N additions to managed soils (kg N2O-N/yr)	N2O Emissions (kg N2O/yr)	
Land use category	Land use subdivision	Fsn	Fon	Fprp	Fcr	Fsom	N from Fos	FracLEACH-(H)	EF5	N2O-N=(Fsn + Fon + Fprp + Fcr + Fsom + (N from Fos)) * FracLEACH-(H) * EF5	N2O = N2O-N * (44/28)	
		Fsn	Fon	Fprp	Fcr	Fsom	N from Fos	FracLEACH-(H)	EF5	N2O-N	N2O	
Forest Land	Restoration AB (AC 10)					5052.88333	0	0.3	0.0075	11.36899	17.86555	
Total												
		0	0	0	0	5052.88333	0			11.36899	17.86555	

Activity Data are automatically transferred from category *3.C.4 - Direct N_2O emissions from managed soils*

CH_4 emissions from rewetted/created wetlands in inland mineral soils



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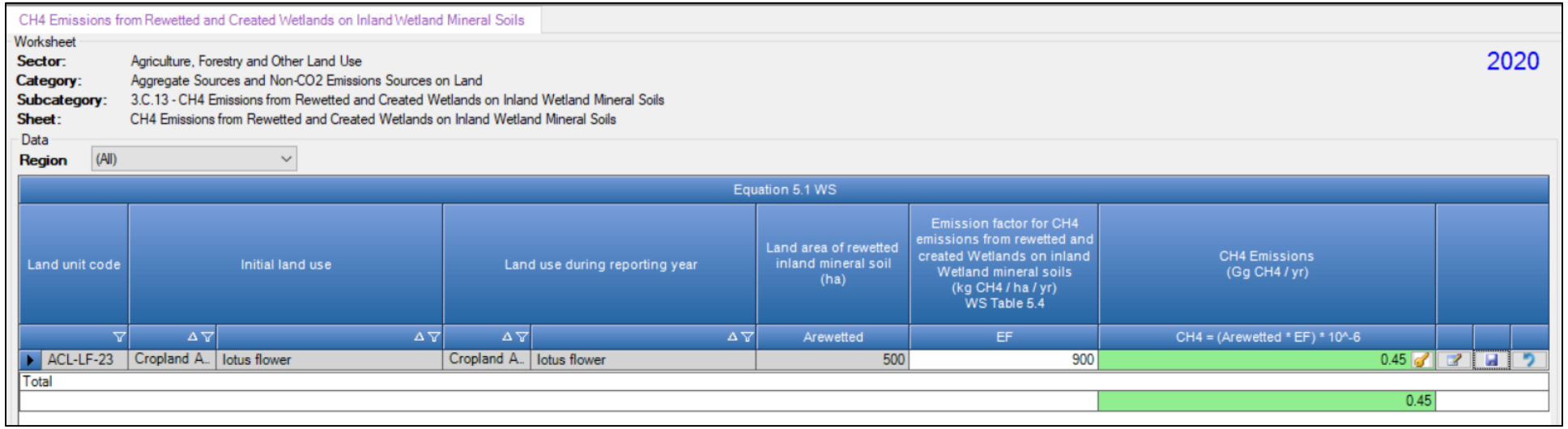
CH_4 emissions from rewetted/created wetlands in inland mineral soils (IPCC Eq. 5.1 WS)



CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils

Worksheet

Sector: Agriculture, Forestry and Other Land Use

Category: Aggregate Sources and Non-CO2 Emissions Sources on Land

Subcategory: 3.C.13 - CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils

Sheet: CH4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils

2020

Data

Region (All)

Equation 5.1 WS

Land unit code	Initial land use		Land use during reporting year		Land area of rewetted inland mineral soil (ha)	Emission factor for CH4 emissions from rewetted and created Wetlands on inland Wetland mineral soils (kg CH4 / ha / yr) WS Table 5.4	CH4 Emissions (Gg CH4 / yr)			
					Arewetted	EF	CH4 = (Arewetted * EF) * 10^-6			
ACL-LF-23	Cropland A..	lotus flower	Cropland A..	lotus flower	500	900	0.45			
Total							0.45			

*All elements sourced from the **2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands** are clearly identifiable because of the liliac color used.*

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Thank you

https://www.ipcc-nggip.iges.or.jp/index.html

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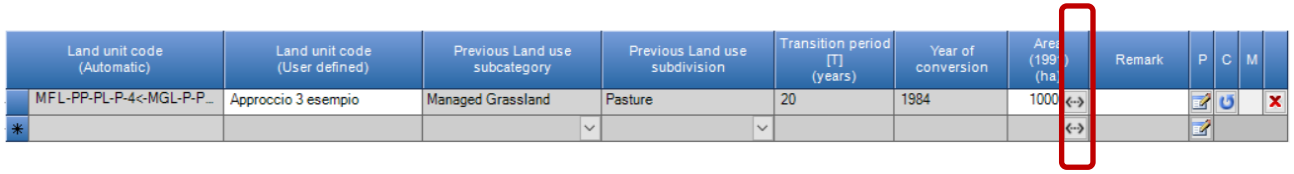
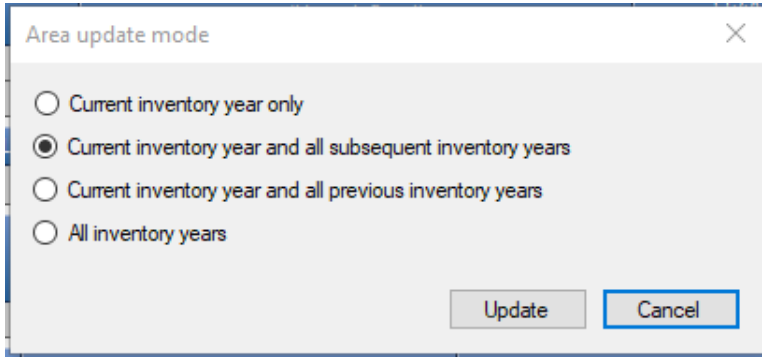
LRM – Land Representation Tab



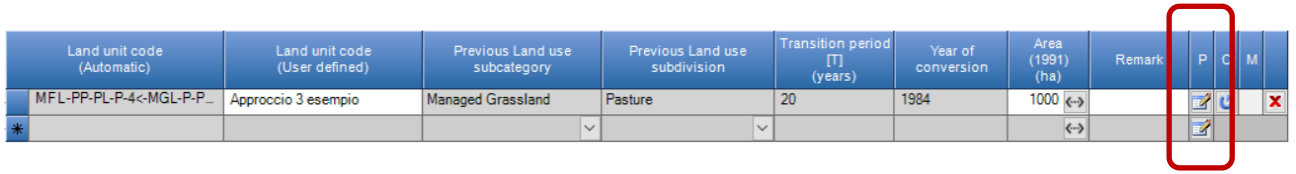
Land unit code (Automatic)	Land unit code (User defined)	Previous Land use subcategory	Previous Land use subdivision	Transition period [T] (years)	Year of conversion	Area (1990) (ha)	Remark	P	C	M
MFL-PP-PL-P-4<-MGL-P-P...	Approccio 3 esempio	Managed Grassland	Pasture	20	1984	1000				

Additional functionalities

- **Area entry**: once area of a unit of land is input the user may select the portion of the time series to which that are is to be assigned to the unit



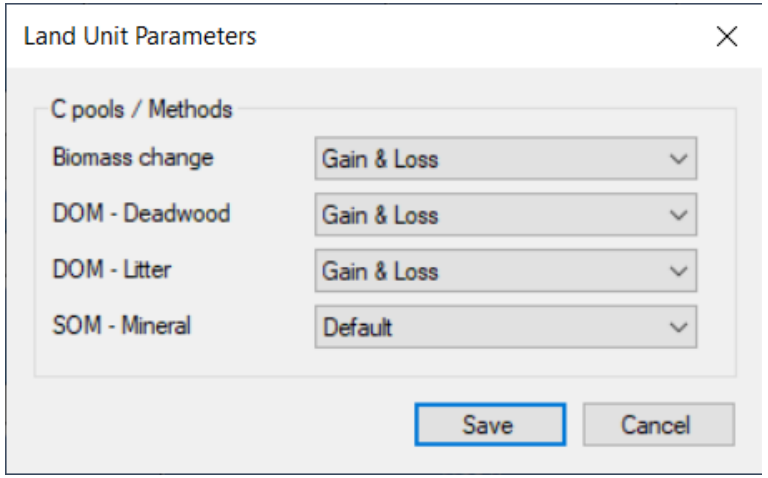
LRM – Land Representation Tab



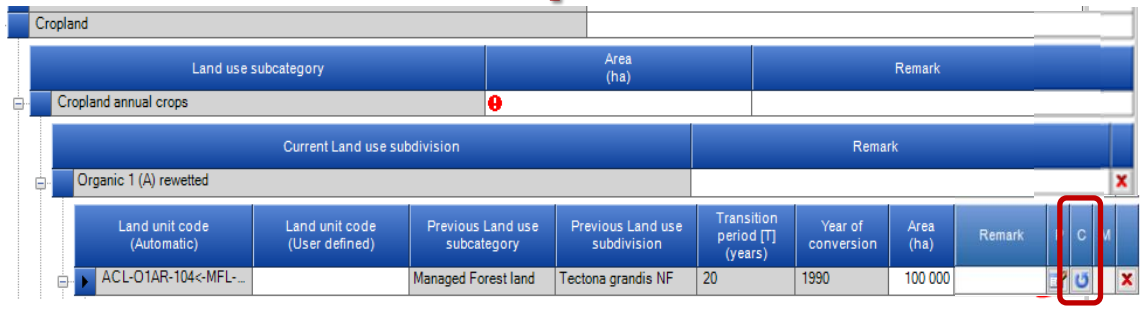
Land unit code (Automatic)	Land unit code (User defined)	Previous Land use subcategory	Previous Land use subdivision	Transition period [T] (years)	Year of conversion	Area (1991) (ha)	Remark	P	C	M
MFL-PP-PL-P-4<-MGL-P-P...	Approccio 3 esempio	Managed Grassland	Pasture	20	1984	1000				

Additional functionalities

- **Button "P"** (Pools) to assign to each C pool the method to estimate C stock changes i.e. **IPCC default method** vs **Stock-Difference method**

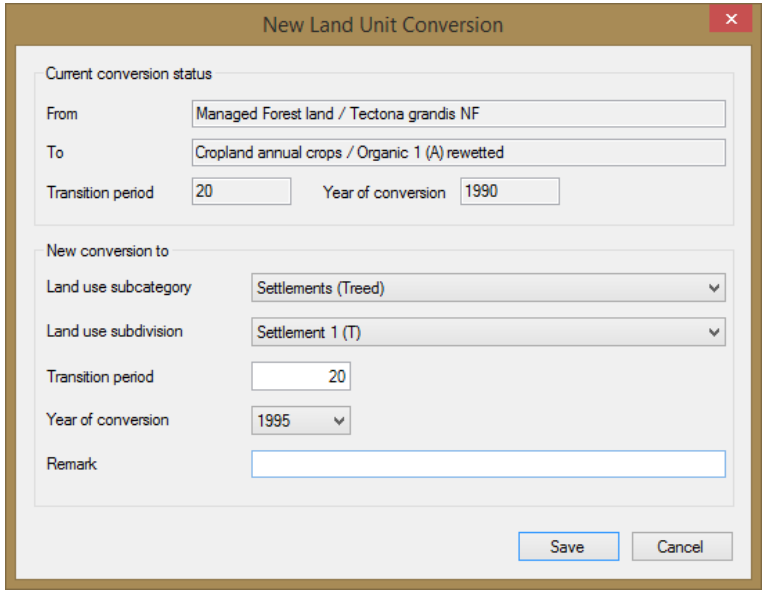


LRM – Land Representation Tab



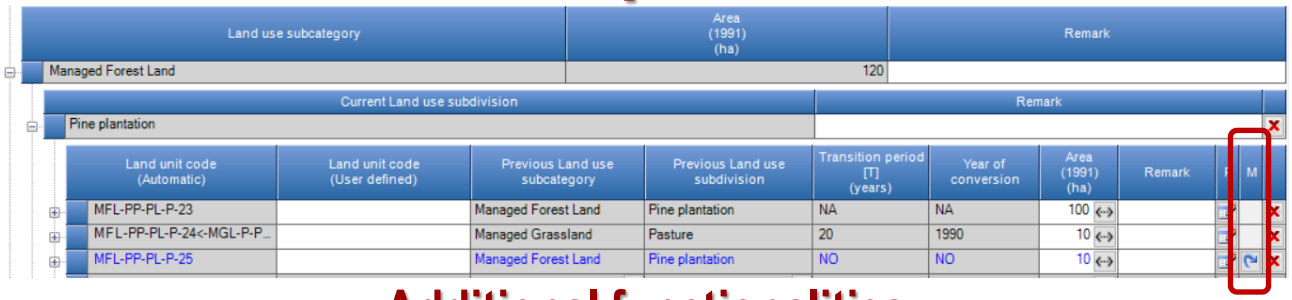
Additional functionalities

Button "C" (Conversion) to input a further conversion to a unit of land that is still undergoing a conversion *(no 20-year period passed since the previous conversion)*



It is available in Approach 3 land representation only

LRM – Land Representation Tab



Land use subcategory	Area (1991) (ha)	Remark
Managed Forest Land	120	

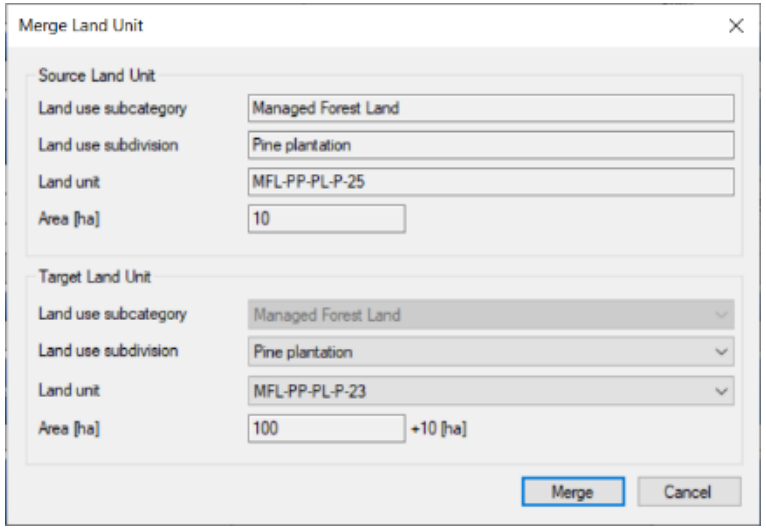
Current Land use subdivision	Remark
Pine plantation	

Land unit code (Automatic)	Land unit code (User defined)	Previous Land use subcategory	Previous Land use subdivision	Transition period [T] (years)	Year of conversion	Area (1991) (ha)	Remark	M
MFL-PP-PL-P-23		Managed Forest Land	Pine plantation	NA	NA	100		
MFL-PP-PL-P-24<-MGL-P-P...		Managed Grassland	Pasture	20	1990	10		
MFL-PP-PL-P-25		Managed Forest Land	Pine plantation	NO	NO	10		

Additional functionalities

Button "M" (Merge) to merge a unit of land that has completely undergone through the transition period.

Merging is allowed with any other unit with identical land use (category/subcategory/subdivision) as well as with identical climate/vegetation zone and soil type.



It is available in Approaches 2 and 3 land representation only