A/R Methodological Tool

"Tool for estimation of changes in soil organic carbon stocks due to the implementation of A/R CDM project activities"

(Version 01)

1. SCOPE, APPLICABILITY AND PARAMETERS

Scope

This tool estimates the annual change in soil organic carbon (SOC) stocks of land within the boundary of an afforestation or reforestation activity under the CDM (A/R CDM) project activity.

Applicability

The tool is applicable to areas of land that are eligible for A/R CDM project activity and where all the following conditions on soils and soil management are met:

(a) The area of land does not contain organic soils[1] (e.g. peat-land);

(b) The land does not fall into wetland[2] category;

(c) Litter shall remain on site and not be removed in the A/R CDM project activity; and

(d) Ploughing/ripping/scarification attributable to the A/R CDM project activity, if any, is:

(i) Done in accordance with appropriate soil conservation practices, e.g. follows the land contour;

(ii) Limited to the first five years from the year of initial site preparation;

(iii) Not repeated, if at all, within a period of 20 years.

Parameters

This tool provides a procedure to determine the following parameter:

Parameter	Unit	Description
ΔSOC_t	t C	Annual change in soil organic carbon stock for year *t*

2. PROCEDURE

Project participants shall apply the following steps:

Step 1: For the purposes of this tool, the project area shall be stratified[3] according to:

(a) Soil type;

(b) Pre-project land use: e.g. grassland, long-term cultivated cropland, short-term cultivated

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[1] "Organic soils" as defined e.g. in the *Good Practice Guidance for Land Use, Land-use Change and Forestry* (IPCC, 2003).

[2] "Wetlands", "settlements", "cropland" and "grassland" are land categories as defined in the *Good Practice Guidance for Land Use, Land-use Change and Forestry* (IPCC, 2003).

[3] This stratification is limited to the application of this tool only.

cropland; improved grassland, moderately degraded grassland and/or severely degraded grassland;

(c) Pre-project management activity: e.g. full-, reduced-, no-till;

(d) Pre-project inputs: e.g. use of residues, manure, fertilizers;

(e) Fraction of area to be subjected to ploughing/ripping/scarification in the project;

(i) Not more than 10%;

(ii) More than 10%;

(f) Year of site preparation.

Step 2: Initial soil organic carbon stock shall be estimated as follows:

$$SOC_{INITIAL,i} = SOC_{REF,i} * f_{LU,i} * f_{MG,i} * f_{IN,i} \quad \textbf{(1)}$$

where:

$SOC_{INITIAL,i}$	Soil organic carbon stock at the beginning of an A/R CDM project activity in stratum *i*; t C ha^{-1}
$SOC_{REF,i}$	Reference soil organic carbon stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation – normally forest) by climate region and soil type, in the stratum *i*; t C ha^{-1}
$f_{LU,i}$	Stock change factor for land-use in stratum *i*; dimensionless
$f_{MG,i}$	Stock change factor for management regime in stratum *i*; dimensionless
$f_{IN,i}$	Stock change factor for input of organic matter in stratum *i*; dimensionless

The values of SOC_{REF}, $f_{LU,i}$, $f_{MG,i}$, and $f_{IN,i}$ shall be selected from the following sources in order of preference (i.e. the first-mentioned source is the most preferred):

(a) Peer-reviewed scientific publications relating to local conditions;

(b) Relevant national inventories (e.g. soil inventory, forest inventory, or GHG inventory);

(c) Country/region-specific data;

(d) Tables 1-4 of this tool.

Step 3: For each stratum which is subjected to ploughing/ripping/scarification attributable to project activity within the first five years from the year of first site preparation and for which the total area disturbed is greater than 10% of the area of the stratum, the following carbon loss shall be accounted:

$$SOC_{LOSS,i} = SOC_{INITIAL,i} * 0.1 \quad \textbf{(2)}$$

For all other strata:

$$SOC_{LOSS,i} = 0 \quad \textbf{(3)}$$

where:

$SOC_{LOSS,i}$	Loss of soil organic carbon caused by ploughing/ripping/scarification under the A/R CDM project activity, in stratum *i*; t C ha^{-1}
0.1	The approximate proportion of SOC lost within the first five years from the year of site preparation

Step 4: The annual change in soil organic carbon stock in project scenario until the steady state in soil organic carbon content is is reached (assumed in 20 years from the time of the first site preparation) is estimated as:

$$\Delta SOC_{t,i} = 0 \quad \text{for } t < t_{PREP,i} \text{ or } t > t_{PREP,i} + 20; \tag{4}$$

$$\Delta SOC_{t,i} = \frac{SOC_{LOSS,i}}{1\ year} \quad \text{for } t = t_{PREP,i}; \text{ and} \tag{5}$$

$$\Delta SOC_{t,i} = \frac{SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i})}{20\ years} \quad \text{for } t_{PREP,i} < t \leq (t_{PREP,i} + 20 \text{ or } t_{END}, \text{ whichever is earlier}) \tag{6}$$

where:

$\Delta SOC_{t,i}$	The annual change in soil organic carbon stock in stratum *i*; t C ha^{-1}
$t_{PREP,i}$	The year in which initial site preparation takes place, for stratum *i*
t_{END}	The last year of the last crediting period
$SOC_{LOSS,i}$	Loss of soil organic carbon caused by site preparation under the A/R CDM project activity, in stratum *i*; t C ha^{-1}
$SOC_{REF,i}$	Reference soil organic carbon stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation – normally forest) by climate region and soil type, in the stratum *i*; t C ha^{-1}
$SOC_{INITIAL,i}$	Soil organic carbon stock at the beginning of an A/R CDM project activity in stratum *i*; t C ha^{-1}

Step 5: Considering uncertainties and inherent limitation of the precision of a factor-based estimation used under this tool, the value of soil organic carbon stock change in a year shall not be accounted as more than 0.8 tC/ha, that is:

If $\Delta SOC_{t,i} > 0.8$ t C ha^{-1} then $\Delta SOC_{t,i} = 0.8$ t C ha^{-1} **(7)**

Step 6: The annual change in SOC for the project is calculated as:

$$\Delta SOC_{PROJECT,t} = \sum_i A_i * \Delta SOC_{t,i} \tag{8}$$

where:

$\Delta SOC_{PROJECT,t}$	The annual change in soil organic carbon stocks for the project; t C/yr
A_i	The area of stratum *i*; ha
$\Delta SOC_{t,i}$	The annual change in soil organic carbon stocks in stratum *i*; t C ha^{-1} yr^{-1}

Table 1[4]

DEFAULT REFERENCE (UNDER NATIVE VEGETATION) SOIL ORGANIC C STOCKS (SOCREF) FOR MINERAL SOILS (TONNES C HA-1 IN 0-30 CM DEPTH)						
Climate region	**HAC soils**[1]	**LAC soils**[2]	**Sandy soils**[3]	**Spodic soils**[4]	**Volcanic soils**[5]	
Boreal	68	NA	10	117	20	
Cold temperate, dry	50	33	34	NA	20	
Cold temperate, moist	95	85	71	115	130	
Warm temperate, dry	38	24	19	NA	70	
Warm temperate, moist	88	63	34	NA	80	
Tropical, dry	38	35	31	NA	50	
Tropical, moist	65	47	39	NA	70	
Tropical, wet	44	60	66	NA	130	
Tropical montane	88*	63*	34*	NA	80*	

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

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

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

[4] Soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols)

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

[4] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, 2006)

Table 2[5]

RELATIVE STOCK CHANGE FACTORS (FLU, and FMG) (OVER 20 YEARS) FOR DIFFERENT MANAGEMENT ACTIVITIES ON CROPLAND					
Factor value type	**Level**	**Temperature regime**	**Moisture regime**	**IPCC defaults**	**Description and criteria**
Land use (FLU)	Long-term cultivated	Temperate/ Boreal	Dry	0.80	Area has been continuously managed for crops for more than 20 years
			Moist	0.69	
		Tropical	Dry	0.58	
			Moist/Wet	0.48	
		Tropical montane	n/a	0.64	
Land use (FLU)	Short-term cultivated (< 20 yrs) or set aside (< 5 years)	Temperate/ Boreal and Tropical	Dry	0.93	Area has been managed for crops for less than 20 years and/or the area is cropland that has been in a fallow state for less than 5 years at any point during the last 20 years
			Moist/Wet	0.82	
		Tropical montane	n/a	0.88	
Tillage (FMG)	Full	All	Dry and Moist/Wet	1.00	Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g. <30%) of the surface is covered by residues
Tillage (FMG)	Reduced	Temperate/ Boreal	Dry	1.02	Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30% coverage by residues at planting
			Moist	1.08	
		Tropical	Dry	1.09	
			Moist/Wet	1.15	
		Tropical montane	n/a	1.09	
Tillage (FMG)	No-till	Temperate/ Boreal	Dry	1.10	Direct seeding without primary tillage, with only minimal soil disturbance in the seeding zone. Herbicides are typically used for weed control
			Moist	1.15	
		Tropical	Dry	1.17	
			Moist/Wet	1.22	
		Tropical montane	n/a	1.16	

[5] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, 2006)

Table 3[6]

RELATIVE STOCK CHANGE FACTORS (FI) (OVER 20 YEARS) FOR DIFFERENT MANAGEMENT ACTIVITIES ON CROPLAND					
Factor value type	**Level**	**Temperature regime**	**Moisture regime**	**IPCC defaults**	**Description**
Input (FI)	Low	Temperate/ Boreal	Dry	0.95	Low residue return occurs when there is removal of residues (via collection or burning), or frequent bare-fallowing, or production of crops yielding low residues (e.g. vegetables, tobacco, cotton), or no mineral fertilization or N-fixing crops. removal of residues (via collection or burning)
			Moist	0.92	
		Tropical	Dry	0.95	
			Moist/ Wet	0.92	
		Tropical montane	n/a	0.94	
Input (FI)	Medium	All	Dry and Moist/ Wet	1.00	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g. manure) is added. Also requires mineral fertilization or N-fixing crop in rotation
Input (FI)	High with-out manure	Temperate/ Boreal and Tropical	Dry	1.04	Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied (see row below)
			Moist/ Wet	1.11	
		Tropical montane	n/a	1.08	
Input (FI)	High – with manure	Temperate/ Boreal and Tropical	Dry	1.37	Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure
			Moist/ Wet	1.44	
		Tropical montane	n/a	1.41	

[6] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, 2006)

Table 4[7]

RELATIVE STOCK CHANGE FACTORS (OVER 20 YEARS) FOR GRASSLAND MANAGEMENT				
Factor	**Level**	**Climate regime**	**IPCC default**	**Definition**
Land use (FLU)	All	All	1.0	All permanent grassland is assigned a land-use factor of 1
Management (FMG)	Non-degraded grassland	All	1.0	Represents non-degraded and sustainably managed grassland, but without significant management improvements
Management (FMG)	Moderately degraded grassland	Temperate/Boreal	0.95	Represents overgrazed or moderately degraded grassland, with somewhat reduced productivity (relative to the native or nominally managed grassland) and receiving no management inputs
		Tropical	0.97	
		Tropical Montane	0.96	
Management (FMG)	Severely degraded	All	0.7	Lands are identified as degraded lands using the "Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities"
Management (FMG)	Improved grassland	Temperate /Boreal	1.14	Represents grassland which is sustainably managed with moderate grazing pressure and that receives at least one improvement (e.g. fertilization, species improvement, irrigation)
		Tropical	1.16	
		Tropical Montane	1.17	
Input (FI)	Low/Medium	All	1.0	All grassland without input of fertilizers is assigned an input factor of 1
	High	All	1.11	Grasslands with direct application of fertilizers - organic or inorganic

[7] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, 2006)

History of the document

Version	Date	Nature of revision(s)
01	EB 55, Annex # 30 July 2010	To be considered at EB 55.
Decision Class: Regulatory **Document Type**: Tool **Business Function**: Methodology		