A/R Methodological Tool

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

(Version 01.1.0)

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

1. This tool can be used for estimation of change in carbon stock in soil organic carbon (SOC) due to implementation of an A/R CDM project activity.

Definitions

2. This tool uses the following specific definition:

"Soil disturbance" is an anthropogenic activity that results in release of soil organic carbon into the atmosphere, e.g. ploughing, ripping, scarification, digging of pits and trenches, stump removal, drainage of soil, etc.

Applicability

3. This tool is applicable when the areas of land, the baseline scenario, and the project activity meet the following conditions:

(a) The areas of land to which this tool is applied:

(i) Do not fall into wetland[1] category; or

(ii) Do not contain organic soils as defined in "Annex A: glossary" of the IPCC GPG LULUCF 2003;

(iii) Are not subject to any of the land management practices and application of inputs as listed in the Tables 1 and 2;

(b) The A/R CDM project activity meets the following conditions:

(i) Litter remains on site and is not removed in the A/R CDM project activity; and

(ii) Soil disturbance attributable to the A/R CDM project activity, if any, is:

- In accordance with appropriate soil conservation practices, e.g. follows the land contours;
- Limited to soil disturbance for site preparation before planting and such disturbance is not repeated in less than twenty years.

[1] "Wetlands" as a land category is defined in *Annex A: Glossary* of *IPCC, Good Practice Guidance for Land Use, Land-use Change and Forestry (IPCC, GPG-LULUCF).*

Assumptions

4. This tool applies the following assumptions for estimation of change in SOC stock:

   (a) Site preparation and planting take place within a year of each other;

   (b) Implementation of an A/R CDM project activity increases the SOC content of the lands from the pre-project level to the level that is equal to the steady-state SOC content under native vegetation;

   (c) The increase in SOC content in the project scenario takes place at a constant rate over a period of 20 years from the year of planting.

Parameters

5. This tool provides steps to determine the following parameter:

Parameter	Unit	Description
$\Delta SOC_{AL,t}$	t CO_2-e	Change in SOC stock in areas of land meeting the above applicability conditions, in year *t*

II. ESTIMATING CHANGE IN SOC STOCK

6. To estimate the change in SOC stock in the project scenario, the areas of land meeting the applicability conditions of the tool are stratified[2] according to:

   (a) Climate region and soil types given in Table 3;

   (b) Pre-project management activities on croplands given in Tables 4 and 5; and

   (c) Pre-project management activities on grasslands given in Table 6.

7. The initial SOC stock at the start of the project is estimated as follows:

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

where:

$SOC_{INITIAL,i}$	SOC stock at the beginning of the A/R CDM project activity in stratum *i* of the areas of land; t C ha^{-1}
$SOC_{REF,i}$	Reference SOC 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 applicable to stratum *i* of the areas of land; t C ha^{-1}
$f_{LU,i}$	Relative stock change factor for baseline land-use in stratum *i* of the areas of land; dimensionless
$f_{MG,i}$	Relative stock change factor for baseline management regime in stratum *i* of the areas of land; dimensionless

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

$f_{IN,i}$	Relative stock change factor for baseline input regime (e.g. crop residue returns, manure) in stratum *i* of the areas of land; dimensionless
i	*1, 2, 3,* … strata of areas of land; dimensionless

8. The values of $SOC_{REF,i}$, $f_{LU,i}$, $f_{MG,i}$, and $f_{IN,i}$ are taken from the Tables 3–6 of this tool, unless transparent and verifiable information can be provided to justify different values.

9. For each stratum of the areas of land which is subjected to soil disturbance attributable to project activity and for which the total area disturbed, over and above the area disturbed in the baseline (if any), is greater than 10% of the area of the stratum, the following carbon loss is 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 SOC caused by soil disturbance attributable the A/R CDM project activity, in stratum *i* of the areas of land; t C ha^{-1}
0.1	The approximate proportion of SOC lost within the first five years from the year of site preparation
i	*1, 2, 3,* … strata of areas of land; dimensionless

10. The rate of change in SOC stock in project scenario until the steady-state SOC content is reached is estimated as follows:

$$dSOC_{t,i} = 0 \quad \text{for } t < t_{PREP,i} \quad \textbf{(4)}$$

$$dSOC_{t,i} = -\frac{SOC_{LOSS,i}}{1\ year} \quad \text{for } t = t_{PREP,i} \quad \textbf{(5)}$$

$$dSOC_{t,i} = \frac{SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i})}{20\ years} \quad \text{for } t_{PREP,i} < t \le t_{PREP,i} + 20 \quad \textbf{(6)}$$

where:

$dSOC_{t,i}$	The rate of change in SOC stock in stratum *i* of the areas of land, in year *t*; t C ha^{-1} yr^{-1}
$t_{PREP,i}$	The year in which first soil disturbance takes place in stratum *i* of the areas of land
$SOC_{LOSS,i}$	Loss of SOC caused by soil disturbance attributable the A/R CDM project activity, in stratum *i* of the areas of land; t C ha^{-1}

$SOC_{REF,i}$	Reference SOC 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 applicable to stratum *i* of the areas of land; t C ha^{-1}
$SOC_{INITIAL,i}$	SOC stock at the beginning of the A/R CDM project activity in stratum *i* of the areas of land; t C ha^{-1}
i	*1, 2, 3*, … strata of areas of land; dimensionless
t	*1, 2, 3,* … years elapsed since the start of the A/R CDM project activity

11. Considering uncertainties and inherent limitation of the precision of a factor-based estimation used in this tool, value of the rate of change of SOC stock is not accounted as more than 0.8 t C ha^{-1} yr^{-1}, that is:

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

12. The change in SOC stock for all the strata of the areas of land, in year *t*, is calculated as:

$$\Delta SOC_{AL,t} = \frac{44}{12} * \sum_i A_i * dSOC_{t,i} * 1year \quad (8)$$

where:

$\Delta SOC_{AL,t}$	Change in SOC stock in areas of land meeting the applicability conditions of this tool, in year *t*; t CO_2-e
A_i	The area of stratum *i* of the areas of land; ha
$dSOC_{t,i}$	The rate of change in SOC stocks in stratum *i* of the areas of land; t C ha^{-1} yr^{-1}
i	*1, 2, 3,* … strata of areas of land; dimensionless

Table 1: Baseline cropland management practices under which the tool is not applicable

Temperature / Moisture Regime	Land use	Management	Inputs
Boreal	Long-term cultivated cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure High with manure
Temperate, cold, dry	Long-term cultivated cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	Medium High without manure
Temperate, cold, moist	Long-term cultivated cropland	Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure High with manure
Temperate, warm, dry	Long-term cultivated cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	Medium High without manure
Temperate, warm, moist	Long-term cultivated cropland	Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure High with manure
Tropical, dry	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	Medium High without manure High with manure
		No-till	All cases
Tropical, moist	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High without manure High with manure

Temperature / Moisture Regime	Land use	Management	Inputs
		No-till	High without manure High with manure
Tropical, montane	Long-term cultivated cropland	No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High without manure High with manure
		No-till	Medium High without manure High with manure
Tropical, wet	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High without manure High with manure
		No-till	High without manure High with manure

Table 2: Baseline grassland management practices under which the tool is not applicable

Temperature / Moisture Regime	Management	Inputs
Boreal	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, cold, dry	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, cold, moist	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, warm, dry	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, warm, moist	Improved	All
	Non-degraded	All
	Moderately degraded	High
Tropical, dry	Improved	All
	Non-degraded	All
Tropical, moist	Improved	All
	Non-degraded	All
	Moderately degraded	High
Tropical, montane	Improved	All
	Non-degraded	All
	Moderately degraded	High
Tropical, wet	Improved	All
	Non-degraded	High
	Moderately degraded	High

Table 3: Default reference SOC stocks (SOC_{REF}) for mineral soils[3] (tC ha^{-1} in 0-30 cm depth)

Climate region	HAC soils[(a)]	LAC soils[(b)]	Sandy soils[(c)]	Spodic soils[(d)]	Volcanic soils[(e)]
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,	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

[(a)] 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);

[(b)] 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);

[(c)] 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);

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

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

[3] Adapted from *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

Table 4: Relative stock change factors for different management activities on cropland (net effect over a period of 20 years) [4]

Factor type	Level	Temperature regime	Moisture regime	Factor value	Description and criteria
Land use (f_{LU})	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 (f_{LU})	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 five years at any point during the last 20 years
			Moist/Wet	0.82	
		Tropical montane	n/a	0.88	
Manage-ment (f_{MG})	Full tillage	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
Manage-ment (f_{MG})	Reduced tillage	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	

[4] Ibid.

Table 5: Relative stock change factors for different levels of nutrient input on cropland (net effect over a period of 20 years)[5]

Factor type	Level	Temperature regime	Moisture regime	Factor value	Description and criteria
Input (f_{IN})	Low	Temperate/ Boreal	Dry	0.95	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
			Moist	0.92	
		Tropical	Dry	0.95	
			Moist/ Wet	0.92	
		Tropical montane	n/a	0.94	
Input (f_{IN})	Medium	All	Dry and Moist/ Wet	1.00	All crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g. manure) is added. Additionally, mineral fertilization or N-fixing crop rotation is practised
Input (f_{IN})	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
			Moist/ Wet	1.11	
		Tropical Montane	n/a	1.08	

[5] Ibid.

Table 6: Relative stock change factors (f_{LU}, f_{MG}, and f_{IN}) for grassland management (net effect over a period of 20 years) [6]

Factor type	Level	Climate regime	Factor value	Description
Land use (f_{LU})	All	All	1.00	All permanent grassland is assigned a land-use factor of 1
Management (f_{MG})	Non-degraded grassland	All	1.00	Non-degraded and sustainably managed grassland, but without significant management improvements
Management (f_{MG})	Moderately degraded grassland	Temperate/Boreal	0.95	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 (f_{MG})	Severely degraded	All	0.70	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"
Input (f_{IN})	Low/Medium	All	1.00	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

III. REFERENCES

IPCC, 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>.

IPCC, 2003. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, prepared by the National Greenhouse Gas Inventories Programme, Jim Penman, Michael Gytarsky, Taka Hiraishi, Thelma Krug, Dina Kruger, Riitta Pipatti, Leandro Buendia, Kyoko Miwa, Todd Ngara (eds). Published: IGES, Japan. <http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html>.

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[6] Ibid.

History of the document

Version	Date	Nature of revision(s)
01.1.0	EB 60, Annex 12 15 April 2011	The amendment: (i) Changes the units of the output parameter $\Delta SOC_{AL,t}$ from *tC* to tCO_2 in order align the tool with other tools; (ii) Restricts the application of the tool to land subjected to certain land-use and management practices in the baseline; and (iii) Applies some editorial changes/corrections to improve clarity. Due to the overall modification of the document, no highlights of the changes are provided.
01	EB 55, Annex 21 30 July 2010	Initial adoption.
Decision Class: Regulatory **Document Type**: Tool **Business Function**: Methodology		