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Reporting requirements on change in carbon stocks in **Dead Wood, Litter and Mineral Soils**

For Land “remaining” in a land-use category and land “conversion to” a new land use

6th workshop style training, 22-24 October 2018, Ankara

“Technical Assistance for Developed Analytical Basis for Land Use, Land Use Change and Forestry (LULUCF) Sector”

Project identification no. EuropeAid/136031/IH/SER/TR



Soil related pools

- **Two soil types** (general classification criteria for soils), different methods:

- Mineral soils
- Organic soils

- **Four C pools**

- Dead Organic Matter (DOM)
 - Dead Wood (> 10 cm(>....<))
 - Litter (< 10 cm)
- Soil Organic Matter (SOM)
- Inorganic C (only under Tier 3)

Links among living and dead organic matter C pools

EXAMPLE OF A SIMPLE MATRIX (TIER 2) FOR THE IMPACTS OF DISTURBANCES ON CARBON POOLS

From: \ To:	Above-ground biomass	Below-ground biomass	Dead wood	Litter	Soil organic matter	Harvested wood products	Atmo-sphere	Sum of row (must equal 1)
Above-ground biomass	A		B	C	D	E	F	1
Below-ground biomass								1
Dead wood								1
Litter								1
Soil organic matter								1

Reporting - Mandatory categories and pools under the Convention

TIER 1		FL		CL		GL		WL		SL		OL	
		FLrFL	LcFL	CLrCL	LcCL	GLrGL	LcGL	WLrWL	LcWL	SLrSL	LcSL	OLrOL	LcOL
DOM	DW				X ²		X ²		0		0		0
	L				X ²		X ²		0		0		0
SOM	mineral		Y	Y	Y	Y	Y		Y		0		Y ³
	organic	Y	Y	Y	Y	Y	Y		Y		0		

TIER 2		FL		CL		GL		WL		SL		OL	
		FLrFL	LcFL	CLrCL	LcCL	GLrGL	LcGL	WLrWL	LcWL	SLrSL	LcSL	OLrOL	LcOL
DOM	DW	Y	Y		X ²		X ²		0		0		0
	L	Y	Y		X ²		X ²		0		0		0
SOM	mineral	Y	Y	Y	Y	Y	Y		Y		0		Y
	organic	Y	Y	Y	Y	Y	Y		Y		0		

To take note:

- Soil emissions/ removals have to be estimated (Y = mandatory to be reported)(to note: FLremFL)
- Why to be prepared to report DOM and SOM on Forestland under Tier 2 (assuming FL is key category)
- DOM in conversions to CL, GL is “Lost in the year of conversion” as “instantaneous oxidation”
- To note “0” for “loss in forest conversions” to WL, SL, OL for DW pool (if “no change” reported in FL rem FL), LT to be reported (since default estimate is provided)



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Change in carbon stocks in Dead Organic Matter (**Dead Wood and Litter**)

For Land “remaining” in a land-use category and land “conversion to” a new land use

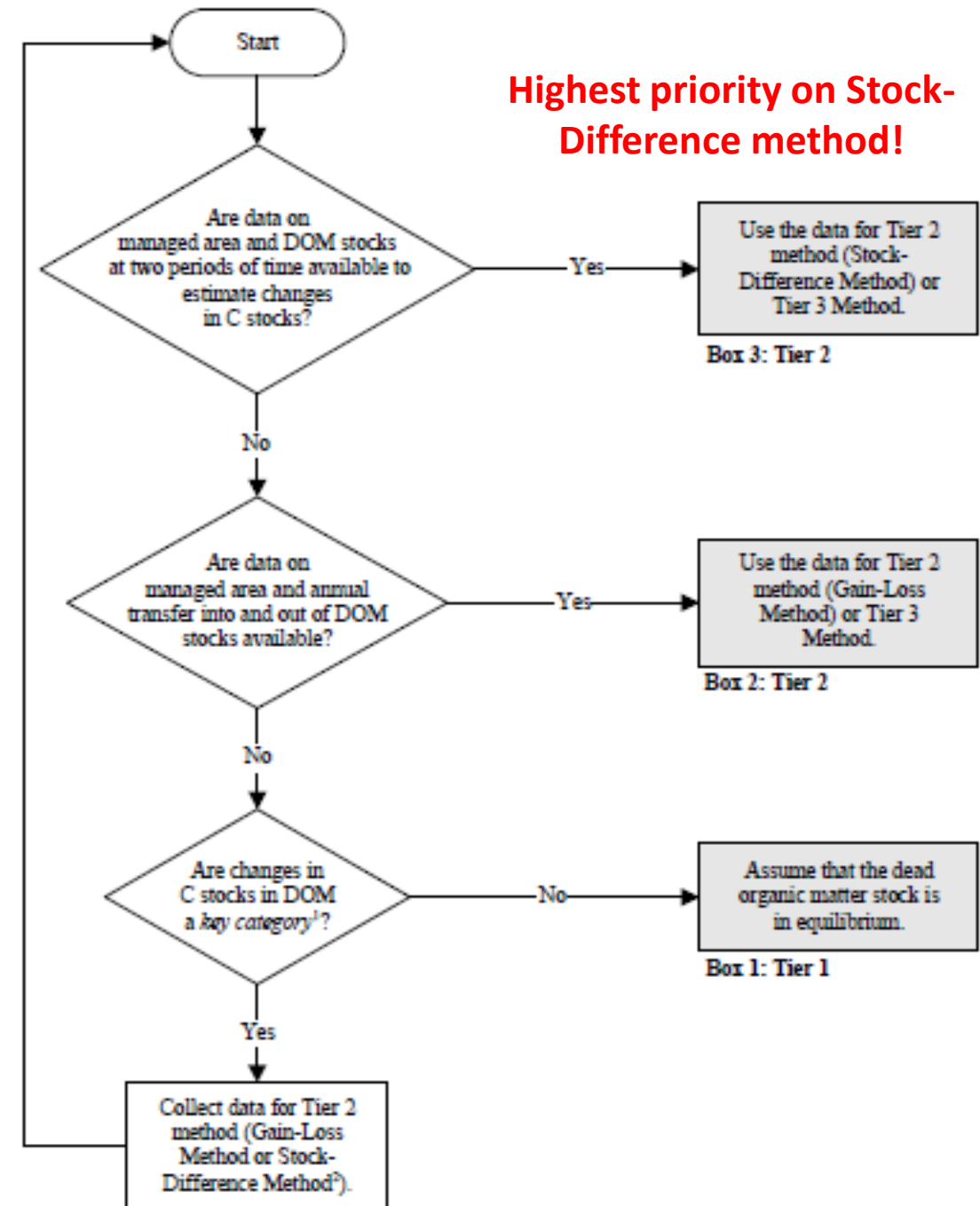
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- Methodological choice: decision tree for identification of **appropriate tier** to estimate **changes in carbon stocks in DOM (dead wood and litter)** by land-use category



DOM Tier 1 method for “LU remaining LU”: no change

DOM Tier 2 methods for “LU remaining LU”

EQUATION 2.17

ANNUAL CHANGE IN CARBON STOCKS IN DEAD ORGANIC MATTER

$$\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{LT}$$

EQUATION 2.18

ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD OR LITTER (GAIN-LOSS METHOD)

$$\Delta C_{DOM} = A \cdot \{(DOM_{in} - DOM_{out}) \cdot CF\}$$

DOM_{in} – $L_{mortality}$, L_{slash} , L_{dist}
 DOM_{out} – intrapools transfers, decomposition, emissions by disturbances

EQUATION 2.19

ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD OR LITTER (STOCK-DIFFERENCE METHOD)

$$\Delta C_{DOM} = \left[A \cdot \frac{(DOM_{t_2} - DOM_{t_1})}{T} \right] \cdot CF$$

CF for litter = 0.37 (default value)

DOM in “LU conversions”

Conceptual approach to estimate CSC in DOM for all tiers

EQUATION 2.23

ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD AND LITTER DUE TO LAND CONVERSION

$$\Delta C_{DOM} = \frac{(C_n - C_o) \cdot A_{on}}{T_{on}}$$

Co = dead wood/litter stock, under the old land-use category, to C ha-1

Cn = dead wood/litter stock, under the new land-use category, to C ha-1

T_{on} = time period of the transition from old to new land-use category, yr. The Tier 1 default is 20 years for carbon stock increases and 1 year for carbon losses.

Tier 1 assumption to estimate CSC in DOM in “LU conversions”

- ***are zero after the conversion*** in non-forest land categories, i.e., they contain no carbon;
- DOM is **emitted directly to the atmosphere** in the conversion year;
- **biomass killed (not harvested) is emitted directly to the atmosphere** during a land-use conversion event, i.e. it is not added to dead wood and litter pools;
- for land converted ***from forest, all DOM carbon losses occur in the year of land-use conversion;***
- conversion to Forest Land results in ***build-up of litter and dead wood carbon pool starting from zero,***
- built-up of DOM occurs in ***linear manner by default assumption of 20 years***

Tier 2 assumption to estimate CSC in DOM

In Eq. 2.23, “**Co**” would take into account each of following, separately:

- **old DOM** (steady-state or actual value, if measured),
- **fresh input from biomass killed** (not harvested), and
- **any carbon lost** from dead wood and litter pools during conversion year, e.g. slash burning.

“**Cn**” would take over the C amount at the initiation of new land use (assuming leftovers from previous land use pools by linear or more complex dynamics)

Tier 1 default carbon stock estimates for litter (Table 2.2) - broad-scale estimates with considerable uncertainty when applied at the country level.



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Change in carbon stocks in mineral soils

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Estimation of C stock in mineral soils

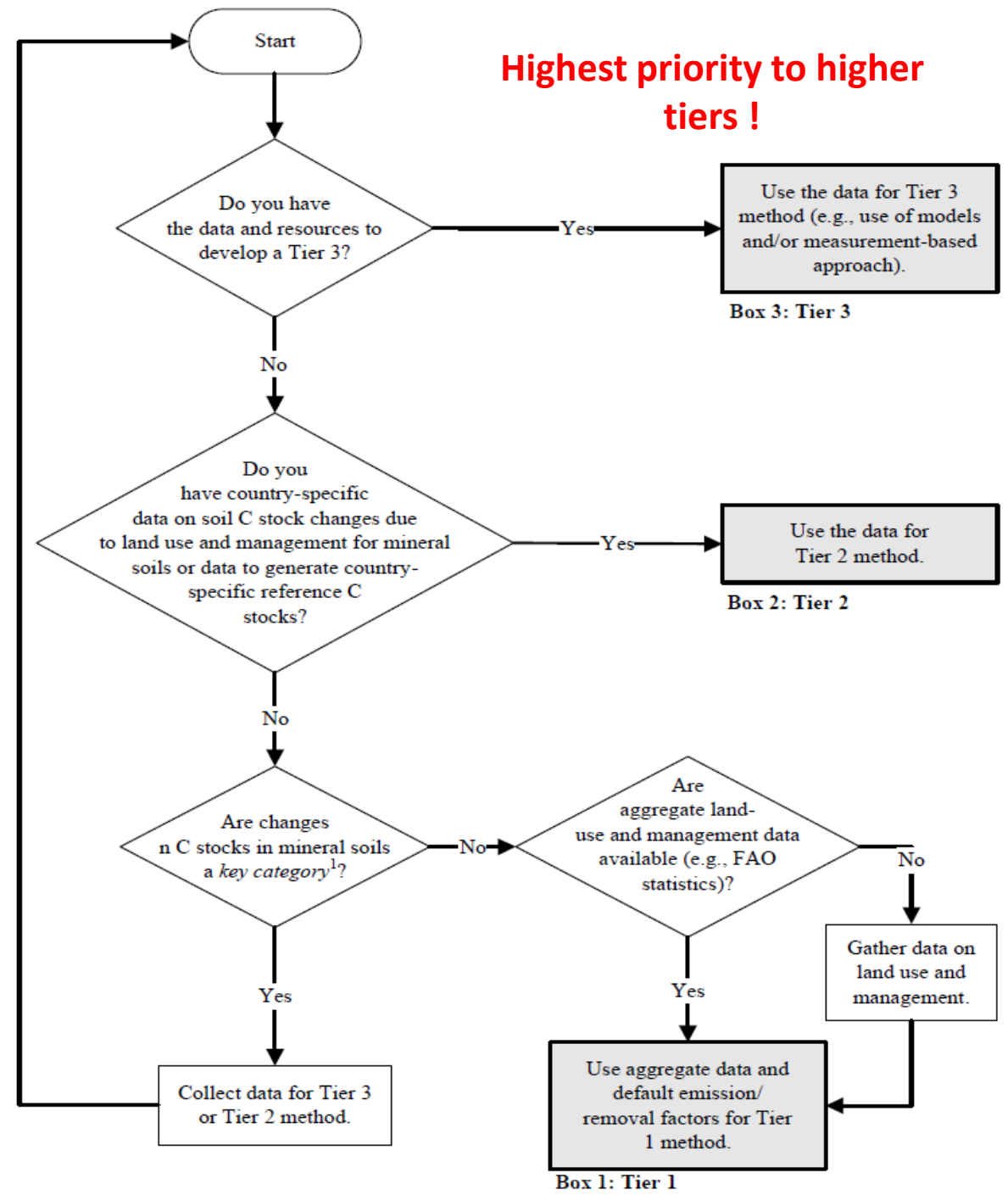
- For GHG inventory reporting purpose IPCC recommends working the C stocks and CSC changes from stocks (***not direct measurements of emission***, e.g. CO₂ effluxes)
- Definition of soils organic matter pool
 - depth
 - organic matter content (organic? or mineral?)
 - stratification criteria (at least: eco-zones, management) = activity data is needed (consistent with LU categories)

Estimation of C stock in mineral soils

- Tier 1 and 2 product of:
 - Soil depth (0.3 m - IPCC)
 - Area (1ha)
 - Stoneness (%)
 - Soil apparent density (kg/m³)
 - C content (%) or humus content (%) (in humus: C/N=12, C/Humus = 53%)
- Tier 3
 - No defined depth
 - Process based (decay of organic matter) (first order decomposition)

- Methodological choice: decision tree for identification of **appropriate tier** to estimate **changes in carbon stocks in mineral soils** by land-use category

Mineral soils are a carbon pool that is influenced by land-use and management activities.
IPCC default depth of 30 cm



Soil C estimation method

EQUATION 2.24

ANNUAL CHANGE IN CARBON STOCKS IN SOILS

$$\Delta C_{Soils} = \Delta C_{Mineral} - L_{Organic} + \Delta C_{Inorganic}$$

- ΔC_{Soils} = annual change in carbon stocks in soils, tC yr⁻¹
- $\Delta C_{Mineral}$ = annual change in organic carbon stocks in mineral soils, tC yr⁻¹
- $L_{Organic}$ = annual loss of carbon from drained organic soils, tC yr⁻¹
- $\Delta C_{Inorganic}$ = annual change in inorganic carbon stocks from soils, tC yr⁻¹ (assumed = 0 unless using a Tier 3 approach)
- conversion factor of humus to C is 0.58 (rather constant)

Mineral soils Tier 1: Default Method

- change in soil C stocks over a finite period of time;
- change is computed based on **C stock change due to management relative to the carbon stock in a reference condition** (= native vegetation that is not degraded or improved)
- CO₂ emissions resulting from the combustion of dead organic matter **during fire are not reported, nor are the increases** in dead organic matter carbon stocks in the years following fire;
- Tier 1 follows the assumptions:
 - (i) Over time, soil organic C **reaches a spatially-averaged, stable value** specific to the soil, climate, land-use and management practices; and
 - (ii) change during the transition to a new equilibrium SOC **occurs in a linear** fashion

EQUATION 2.25

ANNUAL CHANGE IN ORGANIC CARBON STOCKS IN MINERAL SOILS

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$$SOC = \sum_{c,s,i} (SOC_{REF_{c,s,i}} \cdot F_{LU_{c,s,i}} \cdot F_{MG_{c,s,i}} \cdot F_{I_{c,s,i}} \cdot A_{c,s,i})$$

(Note: T is used in place of D in this equation if T is ≥ 20 years, see note below)

- SOC_0 = soil organic carbon stock in **the last year of an inventory time period**, tC
- $SOC_{(0-T)}$ = soil organic carbon stock **at the beginning of the inventory time period**, tC
- T = **number of years** over a single inventory time period, yr
- D = default time period for transition between equilibrium SOC values, yr (commonly 20 yr)
- SOC_{REF} = the reference carbon stock, tC ha⁻¹ (default value provided)
- F_{LU}/F_{ND} = stock change factor for **land-use systems** or sub-system for a particular land-use/natural disturbance regimes, dimensionless
- F_{MG} = stock change factor for **management regime**, dimensionless
- F_I = stock change factor for **input of organic matter**, dimensionless
- **Default SOC_{REF} and F_{LU} , F_{IN} , F_{MG}** tabled in 2006 IPCC Guidelines

Mineral soils Tier 2

- Linked to land representation Approach 2 or 3 – **ability to track land use and management at detailed spatial level**
- Modification of Tier 1 parameters by country data on:
 - ***Defining management systems***
 - ***Climate regions and soil types***
 - ***Reference C stocks*** (e.g. SOC_{REF} for any native lands (i.e., non-degraded, unimproved lands under native vegetation))
 - Derive own country specific ***stock change factors*** (FLU, FMG, FI)



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Change in carbon stocks in organic soils

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Organic soils

EQUATION 2.26

ANNUAL CARBON LOSS FROM DRAINED ORGANIC SOILS (CO₂)

$$L_{Organic} = \sum_c (A \bullet EF)_c$$

- $L_{Organic}$ = annual carbon loss from drained organic soils, tC yr⁻¹
- A = land area of drained organic soils in climate type c , ha
- EF = land use specific emission factor for climate type c , tC ha⁻¹ yr⁻¹

Organic soils Tier 2

- a derivation of **country-specific emission factors or subsidence data**
- **specification of climate regions** considered more suitable for the country
- a finer, more detailed **classification of management systems** attributed to a land-use category

Tier 1 for “conversions to Settlements”

Emission factors selection (ch. 8.3.3.2)

- (i) for the proportion of the settlement area that is paved over, assume product of F_{LU} , F_{MG} and F_I is 0.8 times the corresponding product for the previous land use (i.e., 20% of the soil carbon relative to the previous land use will be lost as a result of disturbance, removal or relocation);
- (ii) for the proportion of the settlement area that is turfgrass, use the appropriate values for improved grassland from Table 6.2, Chapter 6;
- (iii) for the proportion of the settlement area that is cultivated soil (e.g., used for horticulture) use the no-till F_{MG} values from Table 5.5 (Chapter 5) with F_I equal to 1; and
- (iv) for the proportion of the settlement area that is wooded assume all stock change factors equal 1.