

Estimating C-stock Changes in Agricultural Soils

IPCC Tier 1 Approach for
Cropland and Grassland Management

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Land Use and Management Categories

Cropland Management (CM)

System of practices on land on which agricultural crops are grown and on land temporarily set-aside from crop production.

Includes arable and tillable land, rice fields, and agro-forestry systems*:

- *annual crops*
cereals, oils seeds, vegetables, root crops, forages
- *perennial crops*
trees and shrubs in combination with herbaceous crops, orchards, vineyards and plantations
- *temporary fallow land*
land set at rest for one or several years before being cultivated again

* from: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5.1

Land Use and Management Categories

Grassland Management (GM)

System of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced. Generally has vegetation dominated by perennial grasses*:

- *extensively managed rangelands and savannahs*
animal stocking rates and fire regimes are main management variables
- *intensively managed continuous pasture*
with fertilization, irrigation, species changes
- *hay land*

* from: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 6

IPCC Tier Levels

Tier 1

- Changes in C-stocks based on C-stock after management change relative to the reference condition.
- Changes are computed over inventory time period.

Tier 2

- Extension of Tier 1 allowing country-specific data.
- Using default equations for mineral and organic soils.

Tier 3

- Advanced estimation system (model) capturing annual variability in fluxes.
- May include estimates of changes in inorganic C pools.

from: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

IPCC Tier 1

Tier 1 method employs

- *basic method*
- and
- *default emission factors*

provided in the IPCC Guidelines*.

Tier 1 method usually uses activity data that are spatially coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.

* from: IPCC Good Practice Guidance for LULUCF, Box 3.1.1

Tier 1 Method: Annual Changes in Soil C-Stock - ΔC_{Soil}

$$\Delta C_{Soil} = \Delta C_{Mineral} - L_{Organic} + \Delta C_{Inorganic} \rightarrow \text{Tier 3}$$

Annual change in organic carbon stocks
in mineral soils:

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

Annual loss of carbon from drained
organic soils:

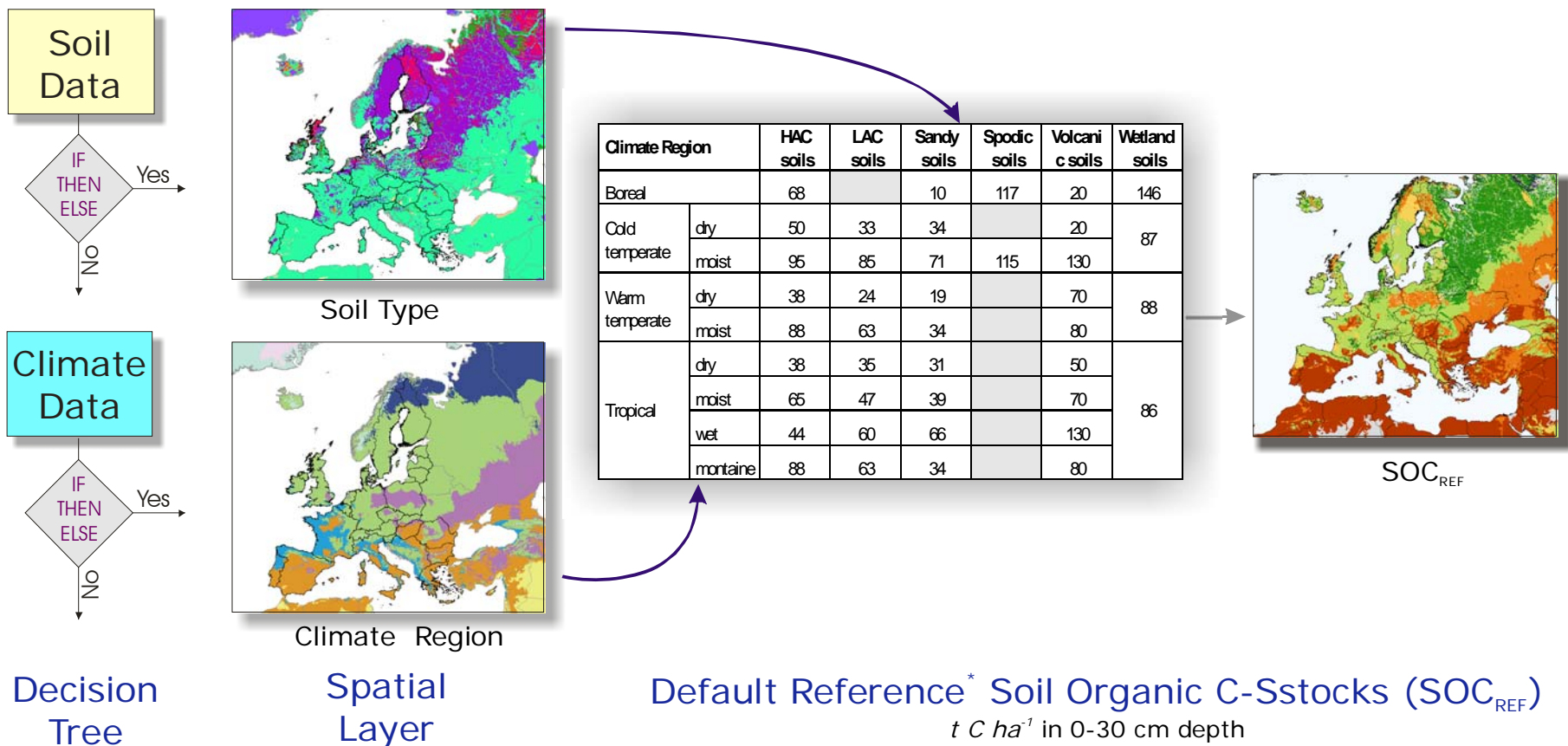
$$L_{Organic} = \sum_c (A \cdot EF)_c$$

where

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

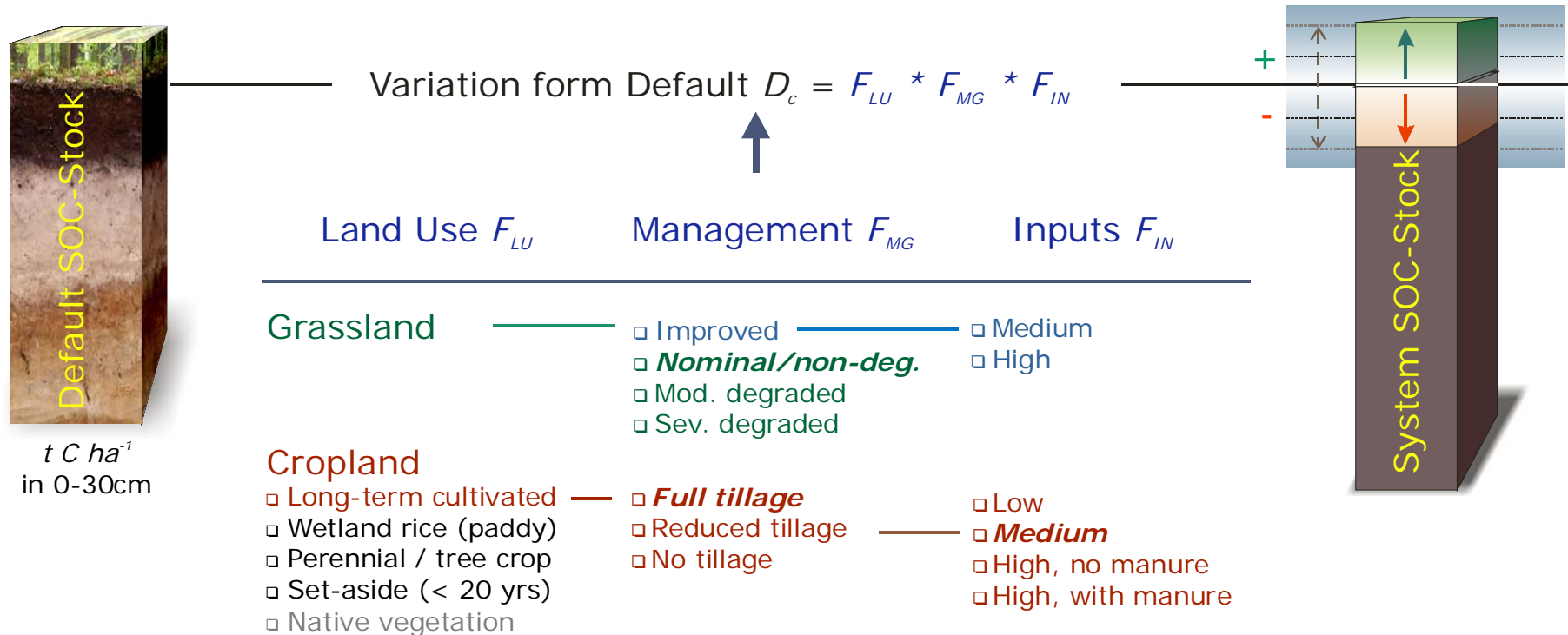
SOC_0	soil organic carbon stock in the last year of an inventory time period
SOC_{0-T}	soil organic carbon stock at the beginning of an inventory time period
T	number of year over inventory period; T is used instead of D if $T \geq 20$ years
D	default time period for transition to equilibrium (20 years)
A	land area of stratum defined by climate, soil and management history
EF	emission factor climate type c
c,s,i	climate region (c), soil type (s), management system (i)

Mineral Soil: Default Reference SOC Stock - SOC_{REF}



IPCC Tier 1 Method for Defining **Default Reference Soil Organic Carbon Stocks**

Mineral Soil: Land System Factors – $F_{LU, MG, I}$

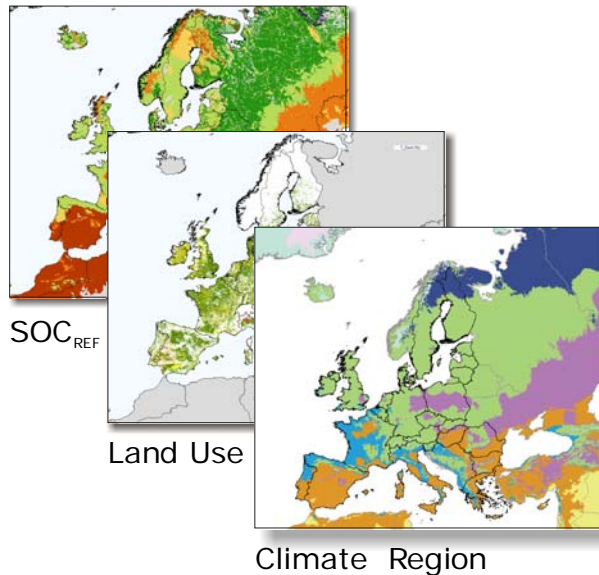


IPCC Tier 1 Method for Defining System **Soil Organic Carbon Stocks**

Mineral Soil: Example $\Delta C_{\text{Mineral}}$

$$\Delta \text{SOC}_{\text{mineral}} = (\text{SOC}_{2010} - \text{SOC}_{1990})/20$$

$$\text{SOC}_{\text{year}} = \Sigma(\text{SOC}_{\text{REF}} * F_{\text{LU}} * F_{\text{MG}} * F_{\text{I}} * \text{Area})$$



Factor	Orchard	Climate Regime	Default Value
F_{LU}	Long-term cultivated	temp&moist	0.48-0.80
	Paddy rice		1.10
	Permanent/tree crop		1.00
	Set-aside	temp&moist	0.82-0.93
F_{MG}	Full		1.00
	Reduced	temp&moist	1.02
	No till	temp&moist	1.10
F_{I}	Low	temp&moist	0.95
	Medium		1.00
	High, without manure	temp&moist	1.04
	High, with manure	temp&moist	1.37

Climate	Temperate, dry
SOC _{REF}	t C ha ⁻¹ 94.00

Year 0-T	Level	Value
F_{LU}	long-term cultivated	0.80
F_{MG}	full tillage	1.00
F_{I}	high, without manure	1.04
SOC ₁₉₉₀	t C ha ⁻¹	78.21

Year 0	Level	Value
F_{LU}	long-term cultivated	0.80
F_{MG}	reduced tillage	1.02
F_{I}	high, without manure	1.04
SOC ₂₀₁₀	t C ha ⁻¹	79.77

Change SOC (20 years)	1.56
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after: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 5.5

Organic Soils: Soil Emission - $L_{Organic}$

Tier 1

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

- Assign an annual emission factor (EF) that estimates the losses of C following drainage.
- Identify area (A) of drained and managed organic soils under each climate type (climate temperature regime).
- For each climate type multiply area with associated emission factor $(A \cdot EF)_c$
- Sum emissions from all areas ($L_{Organic}$).

Activity Data Approaches: Area

Approach 1

- Total area are provided at only two points in time for climate, soil and land use management system.
- No quantification of specific transitions in land use and management over inventory period (only aggregate or net change).

Approach 2 & 3

- Total area and specific transitions between each land management system provided.
- C-stock changes computed on a land parcel basis.

Soil C-Stock Summary

Accounting Rule

- Net-net Accounting
Requires assessment of situation in the base year (1990).

Tier for estimating emissions and removals

- Mineral Soils
Changes in C-stocks after management change relative to reference condition.
- Organic Soils
Emission and removals of C in form of CO₂ flux.

Reporting Method

- Geographic information on areas subject to CM and GM activity
given point in time (A1); changes between categories (A2); spatially explicit (A3)

Data Concerns

Base Year

- Land Use Category in reference year 1990 uncertain.
- Stability of status in reference year.

Tier Land Use System

- IPCC Land Use Categories mixed with types of land cover.
- F_{MG} and F_l are main source of C-stock changes on CC.

Associated Areas

- Area from statistics based on administrative units.
- Aggregation unit (field or stratum of management system).

Estimating C-Stock Changes for CM and GM: **How?**

Assess Data Needs

- Reasoning whether CM and GM are a key source.
- Start with Tier 1 method.

Evaluate Available Data

- Data from international organizations or national surveys, e.g. FAO, Eurostat, European Environment Agency, JRC.
- Stratification by soil + climate (+ management).

Bridge Missing Data

- Model land use for base year.
- Apply proxy data and reasoned assumptions.

For cropland: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. CM: 5.2.3 and 5.3.3; GM: 6.2.3 and 6.3.3