Food and Agriculture Organization of the United Nations

Sustainable soil management: is it a feasible contribution to the climate change agenda? Challenges and prospects of SOC (from measuring to sequestration)

Ronald Vargas

Secretary - Global Soil partnership

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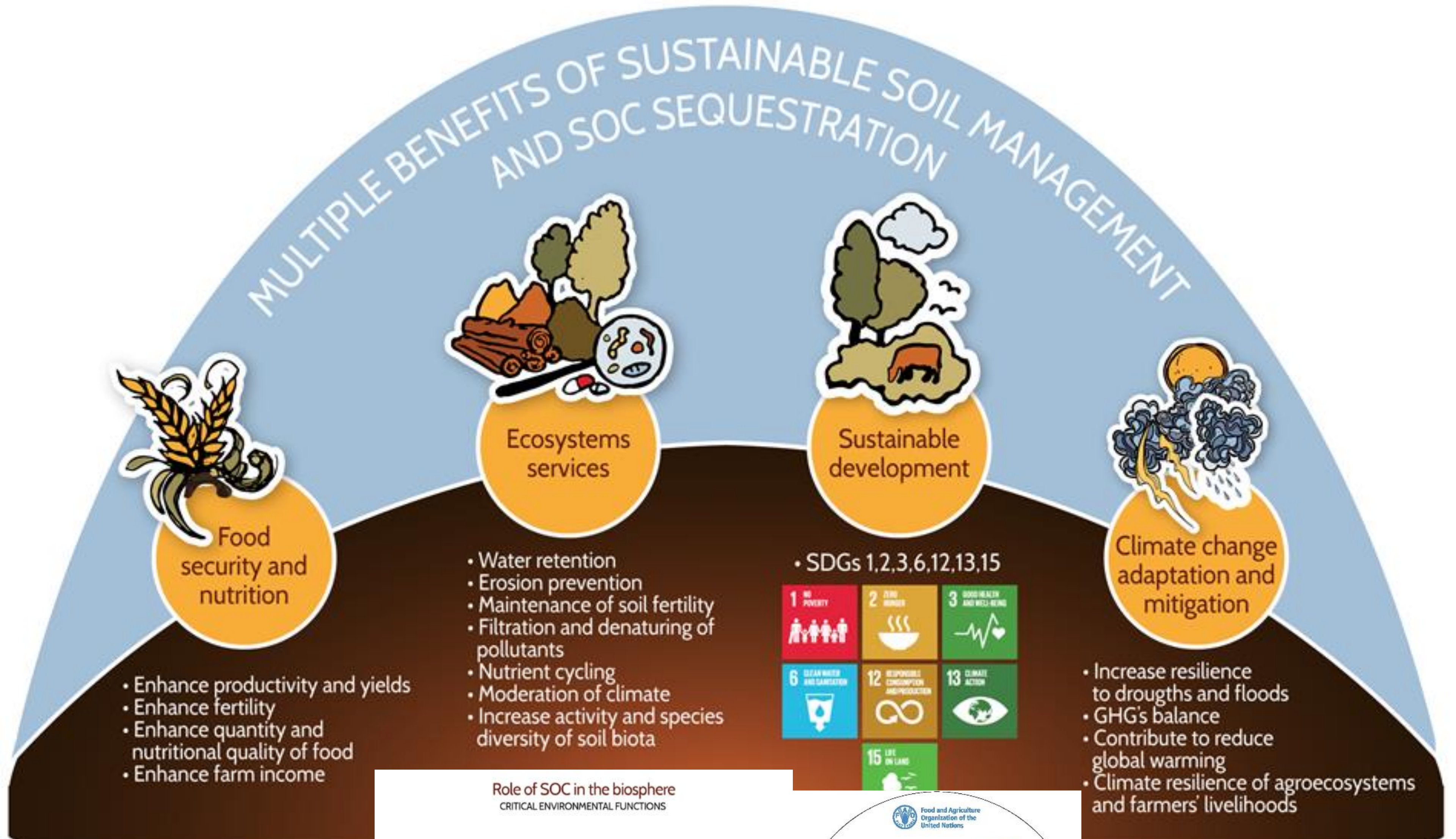
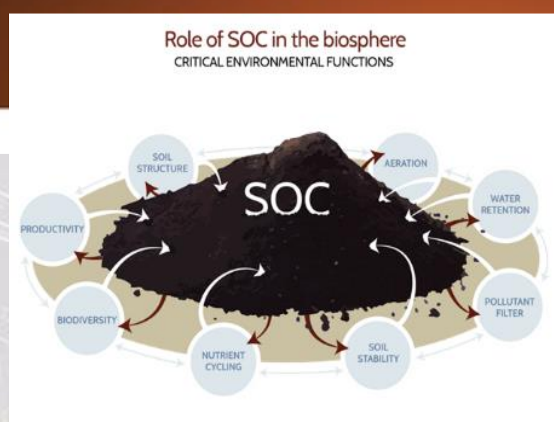
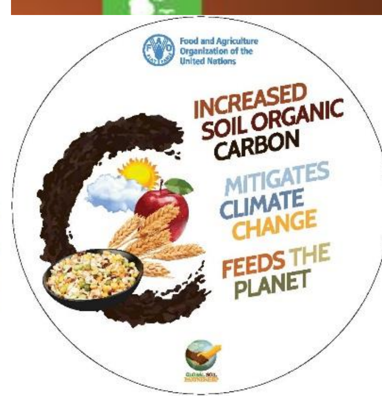

MULTIPLE BENEFITS OF SUSTAINABLE SOIL MANAGEMENT
AND SOC SEQUESTRATION
Food security and nutrition
• Enhance productivity and yields
• Enhance fertility
• Enhance quantity and nutritional quality of food
• Enhance farm income
Ecosystems services
• Water retention
• Erosion prevention
• Maintenance of soil fertility
• Filtration and denaturing of pollutants
• Nutrient cycling
• Moderation of climate
• Increase activity and species diversity of soil biota
Sustainable development
• SDGs 1,2,3,6,12,13,15
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
6 CLEAN WATER AND SANITATION
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
15 LIFE ON LAND
Climate change adaptation and mitigation
• Increase resilience to droughts and floods
• GHG's balance
• Contribute to reduce global warming
• Climate resilience of agroecosystems and farmers' livelihoods

Role of SOC in the biosphere
CRITICAL ENVIRONMENTAL FUNCTIONS
SOC
SOIL STRUCTURE
AERATION
WATER RETENTION
POLLUTANT FILTER
SOIL STABILITY
NUTRIENT CYCLING
BIODIVERSITY
PRODUCTIVITY

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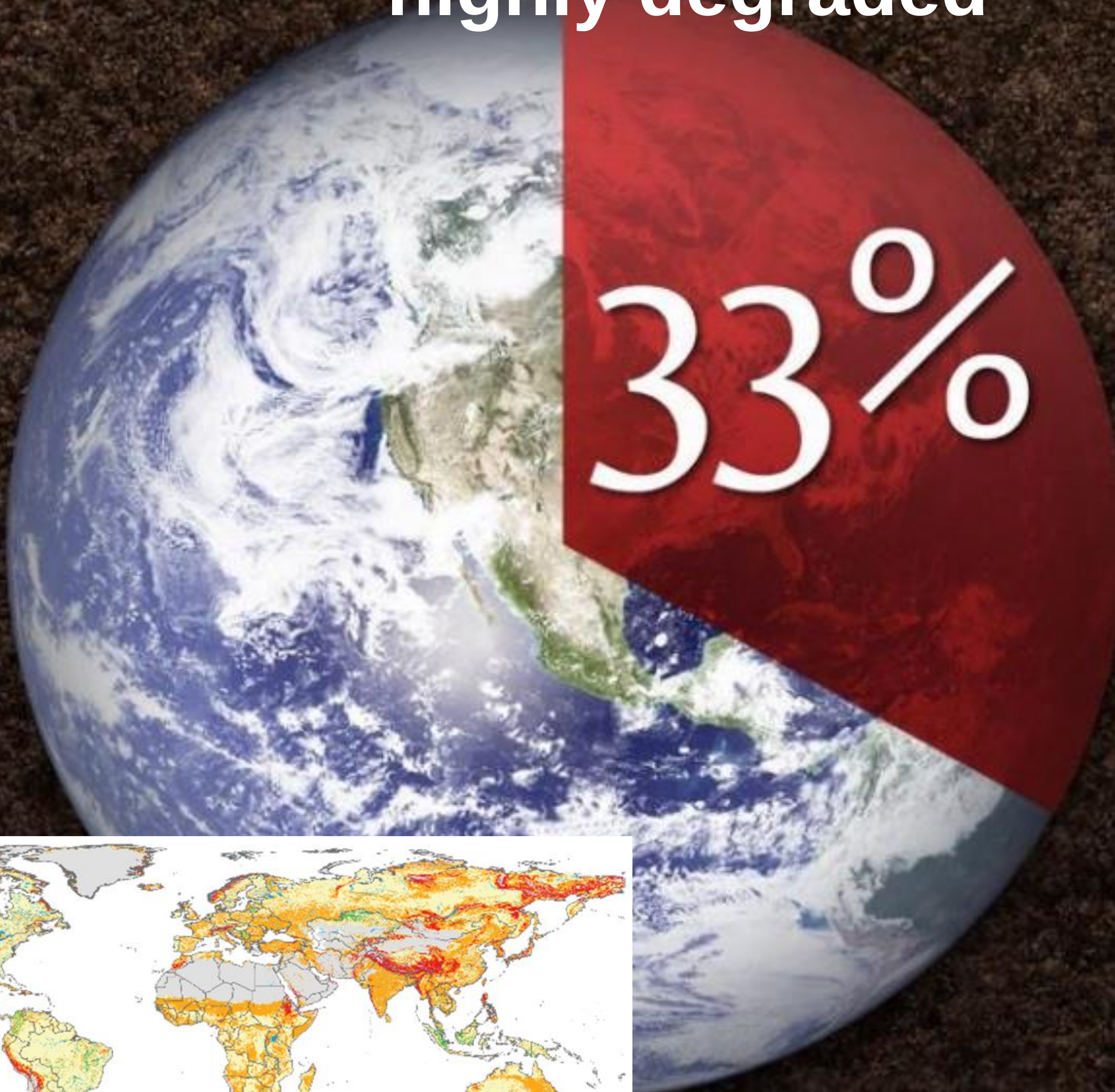
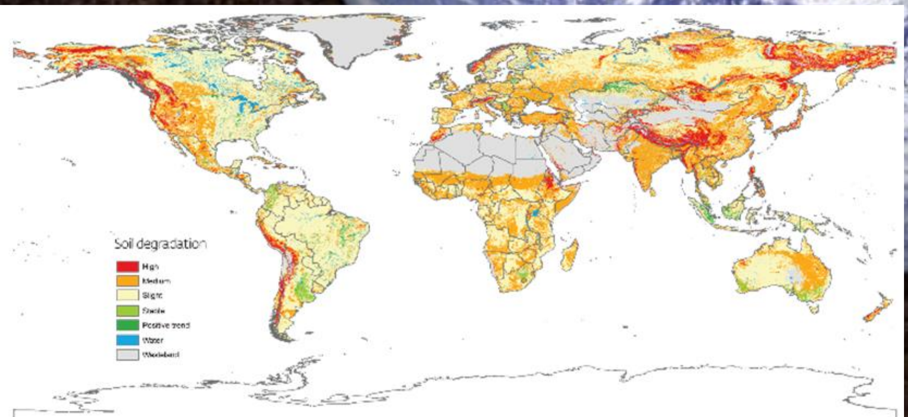
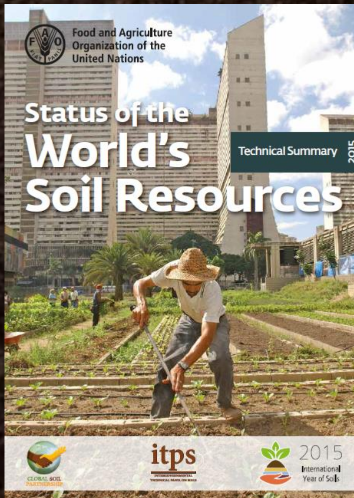
INCREASED SOIL ORGANIC CARBON
MITIGATES CLIMATE CHANGE
FEEDS THE PLANET

Today, 33% of our soils are moderately to highly degraded

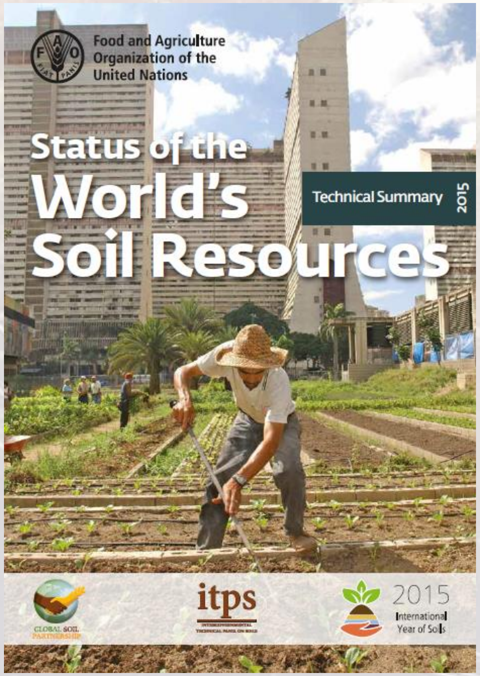


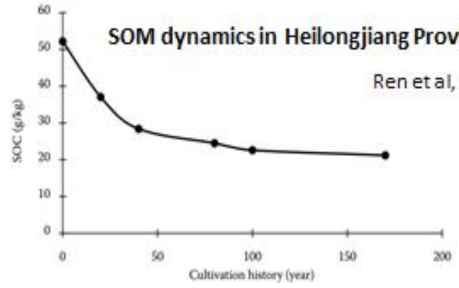


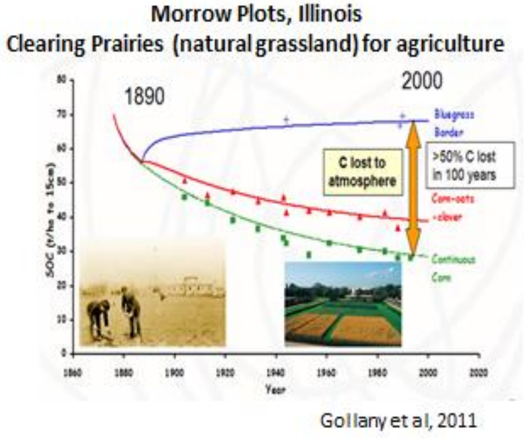


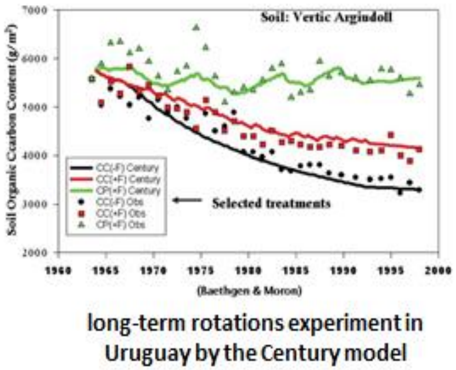
SOC loss is the second biggest threat to soil functions

Carbon emissions from LULCC represent the second largest anthropogenic source of carbon into the atmosphere.

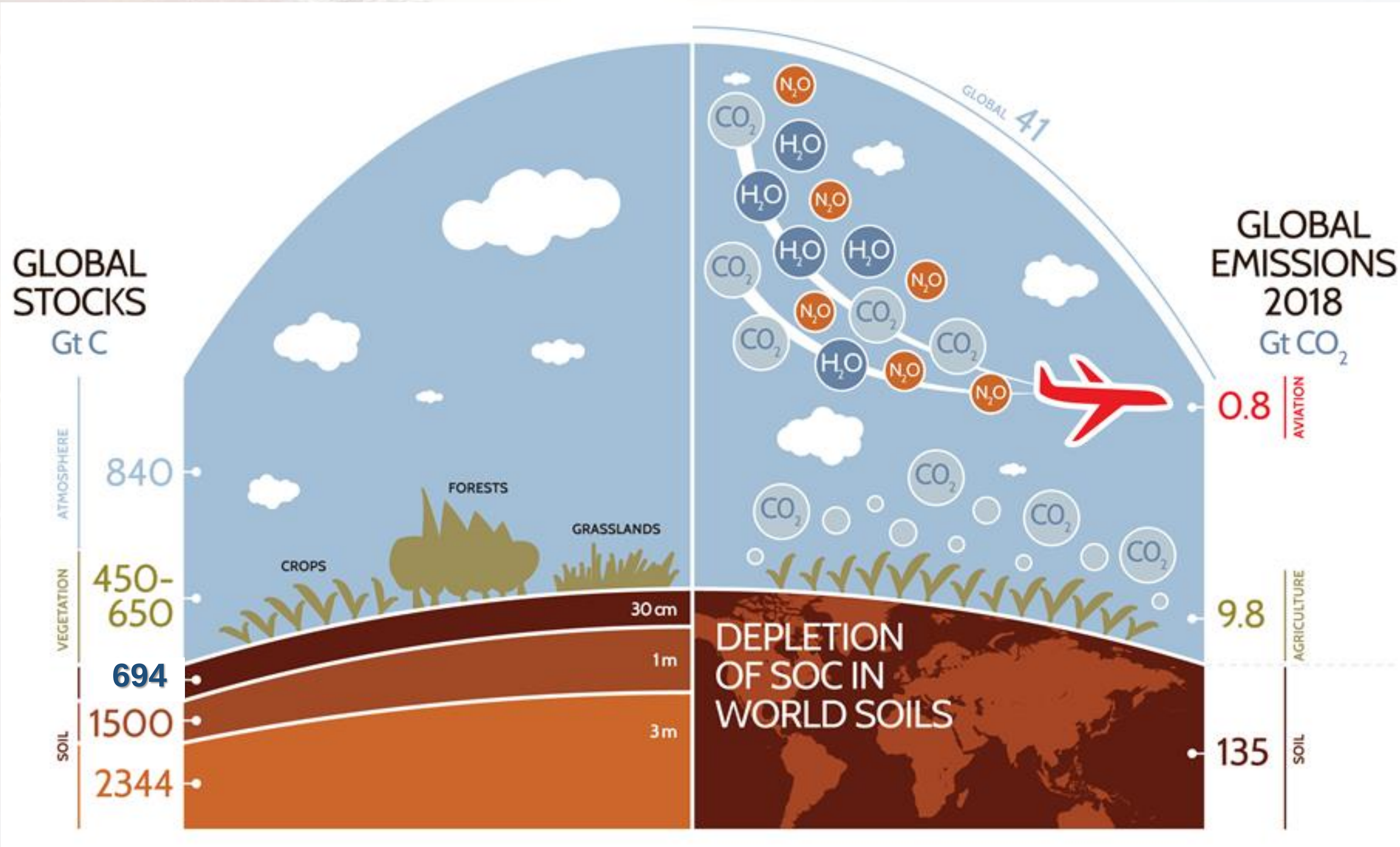




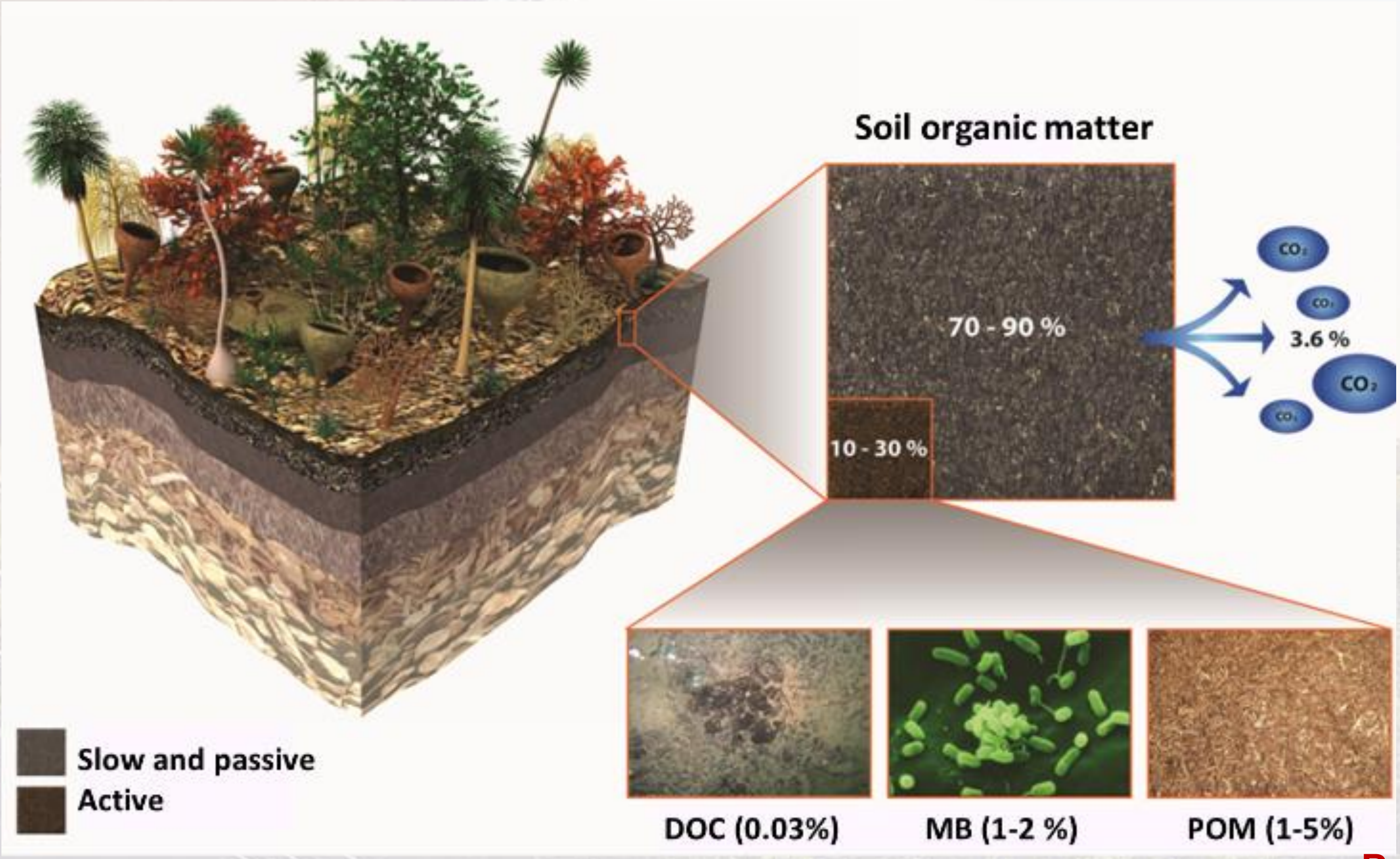




Degradation is related to emissions



Soil organic matter is made up of carbon mostly



Active

- **Key role in ecosystem functions.**
- **Primary source of carbon and nutrients.**
- **Sustains most of the biological activity of soils.**

Slow and passive

- **key role in carbon sequestration.**
- **Physical, chemical and biochemical protection of carbon.**

Particulate Organic Matter is a highly sensitive indicator of change caused by land use and management practices than Total Organic Carbon

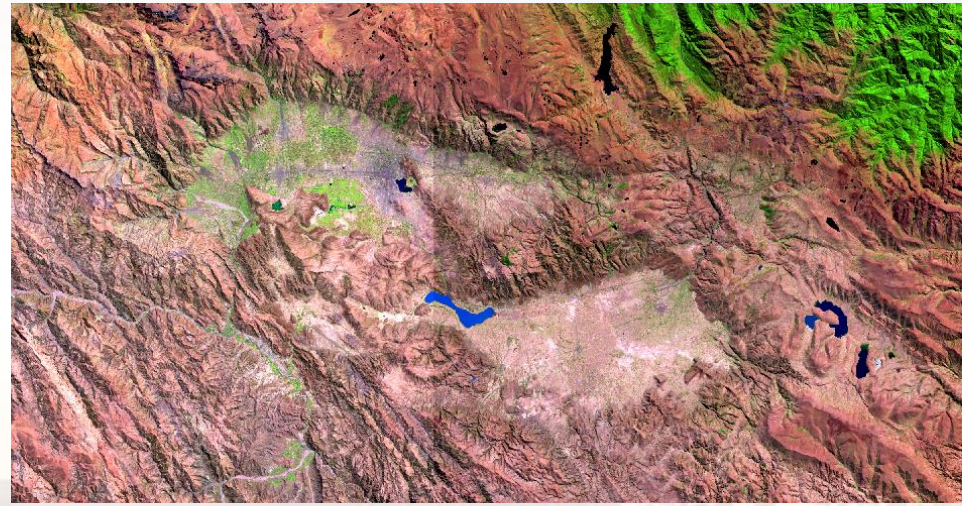
Carbon may be present in thousands of organic compounds and remain in soils from minutes to millions of years

Measuring SOC---an easy task?

Can remote sensing be useful for measuring, mapping, monitoring SOC?

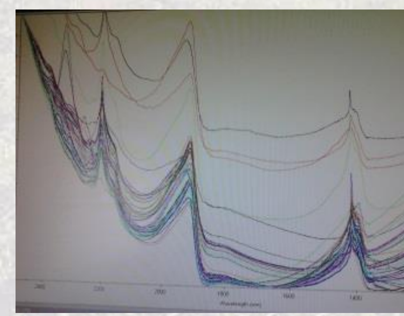
Can remote sensing replace field survey?

A satellite image represents the land surface/cover….. not the soil



Proxy but cannot be used to monitor SOC stocks or stock changes

Soil spectroscopy is complementary/alternative to lab analysis, but still require some samples and a very intensive CALIBRATION



Costs vs. reliability/uncertainty
RS/PS helps reducing sampling intensity
Are we looking for perfection? What about MRV and tiers?

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Status and challenges for mapping, monitoring and MRV of SOC

What is MRV?

M = **Measurement** (or estimation), sometime "**Measuring**" or "**Monitoring**"
R = **Reporting** (at different level: national, international,…)
V = **Verification (sometime Verifying)** includes **Quality Control (QC) and Quality Assurance (QA)**

A MRV system refers to any process or system which aims to assess and monitor the impacts of mitigation measures and/or the support provided (measuring) and to document this information in a transparent way (reporting), so that it can be examined for accuracy (verification).

MRV of national inventory (e.g. sources and sinks of GHG)

MRV of project (CDM, …)

MRV of policy (e.g. NAMA, mitigation measures)

MRV of a REDD-plus activities

MRV of implementation (e.g. financial flow)

… MRV of soil carbon …
or better **MRV of soil C sequestration and GHG fluxes related to soil management**

Bernoux, 2017

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The Guidelines evolved concomitantly with UNFCCC/KP and PA needs and decisions

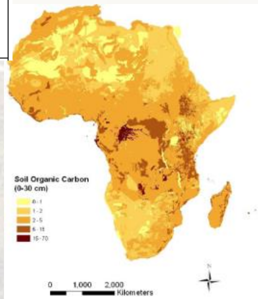
But some invariant principles for AFOLU

Default carbon stocks

Tier 1 methods are designed to be the simplest to use, for which equations and default parameter values (e.g., emission and stock change factors) are provided in this volume.

TABLE 2.3
DEFAULT REFERENCE (UNDER NATIVE VEGETATION) SOIL ORGANIC C STOCKS (SOC_{REF}) FOR MINERAL SOILS
(TONNES C HA^{-1} IN 0-30 CM DEPTH)

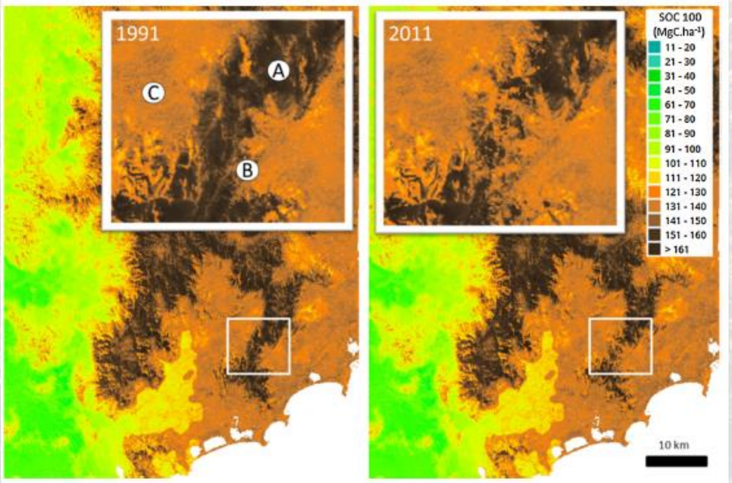
Climate region	HAC soils[1]	LAC soils[2]	Sandy soils[3]	Spodic soils[4]	Volcanic soils[5]	Wetland soils[6]
Boreal	68	NA	10#	117	20#	146
Cold temperate, dry	50	33	34	NA	20#	87
Cold temperate, moist	95	85	71	115	130	
Warm temperate, dry	38	24	19	NA	70#	88
Warm temperate, moist	88	63	34	NA	80	
Tropical, dry	38	35	31	NA	50#	86
Tropical, moist	65	47	39	NA	70#	
Tropical, wet	44	60	66	NA	130#	
Tropical montane	88*	63*	34*	NA	80*	



Henri et al., BGD, 2009

Tier 2 can use the same methodological approach as Tier 1 but applies emission and stock change factors that are based on country- or region-specific data, for the most important land-use categories.

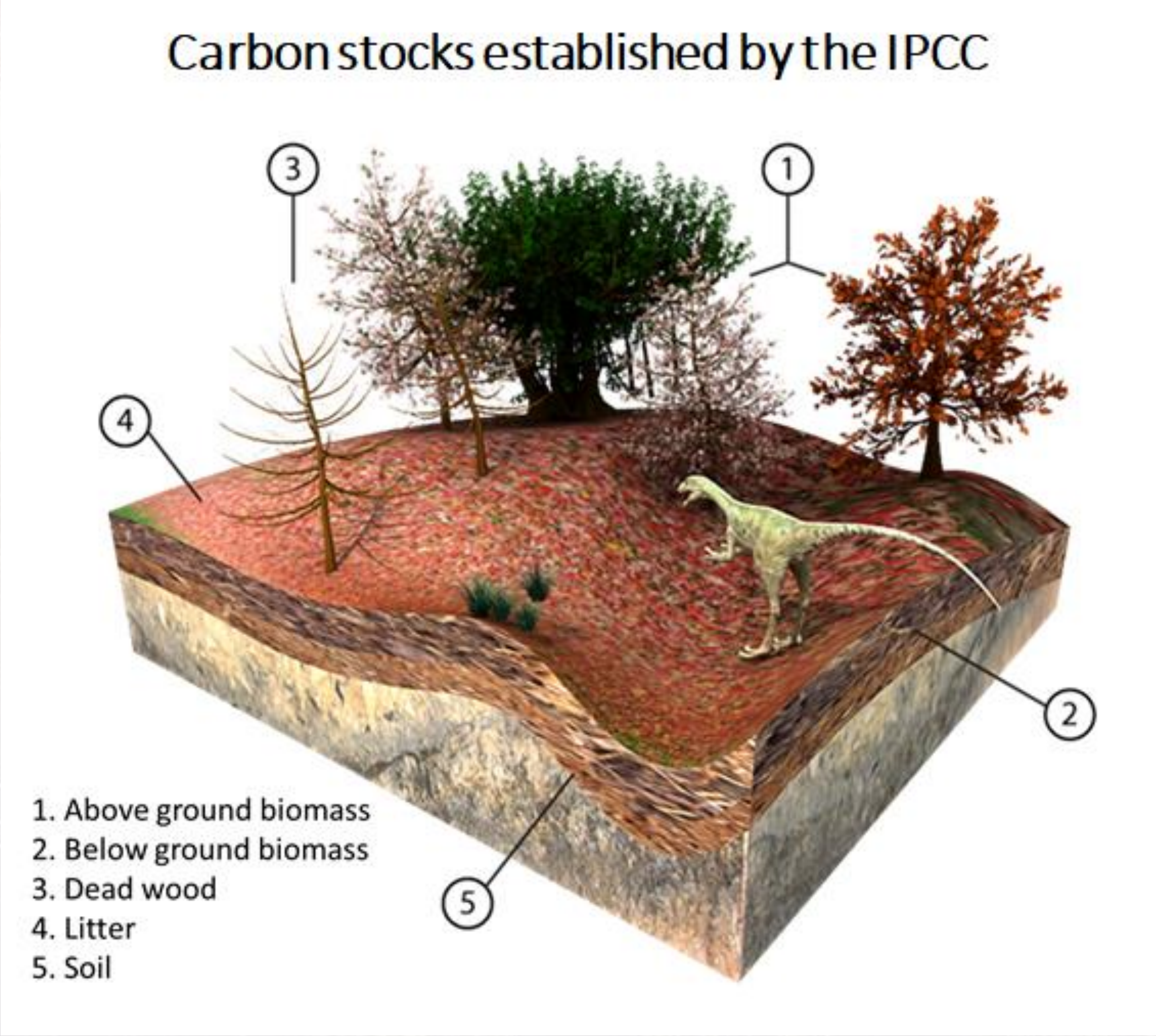
Tier 3, higher order methods are used, including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national level.



Grinand et al., IJAEOG, 2017

Bernoux, 2017

One of the main challenges of the MRV system lies in the estimation of soil GHG emissions due to the complexity of quantifying/estimating SOC concentration



Are countries ready to report following MRV guidelines? Are we getting useful information about SOC dynamics that could be used for decision making?

Countries capacities should be enhanced so that they will be able to produce their own SOC stocks including monitoring dynamics……

SDG Target 15.3

By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

SD Indicator 15.3.1

Land Productivity | **Land Cover** | **Soil Organic Carbon**

SOC Stocks above and Below Ground

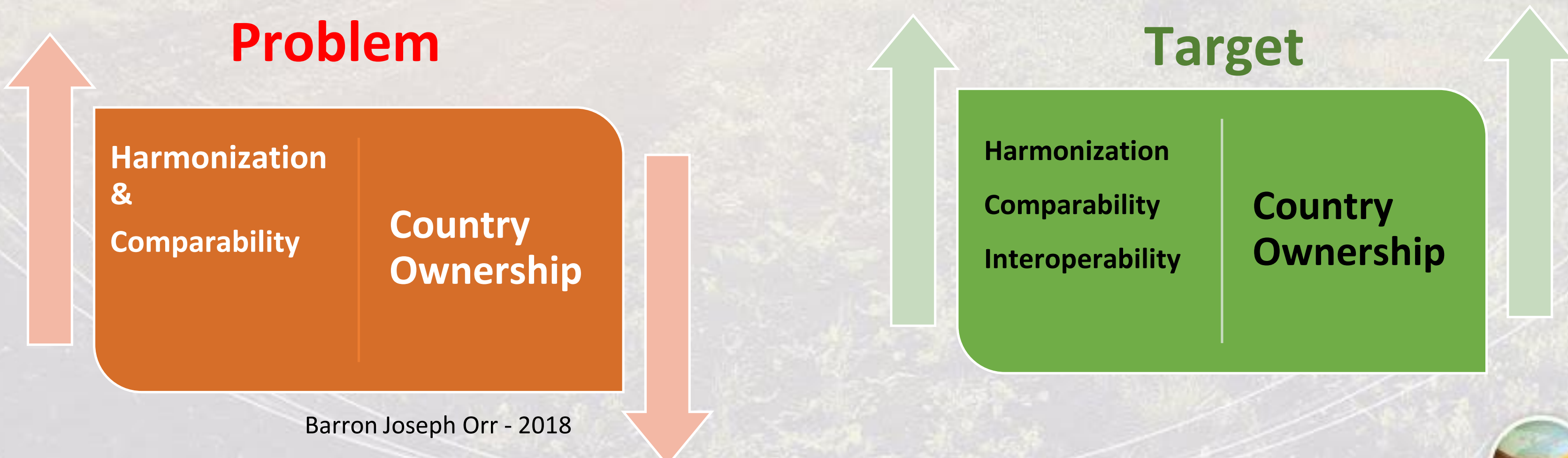
Indicator 15.3.1 focuses primarily on the use of three sub-indicators, including land cover and land cover change, land productivity, and carbon stocks above and below ground. However, many countries currently lack the;

- **Methodologies**
- **Data**
- **Capacities**

to monitor and report on land degradation.

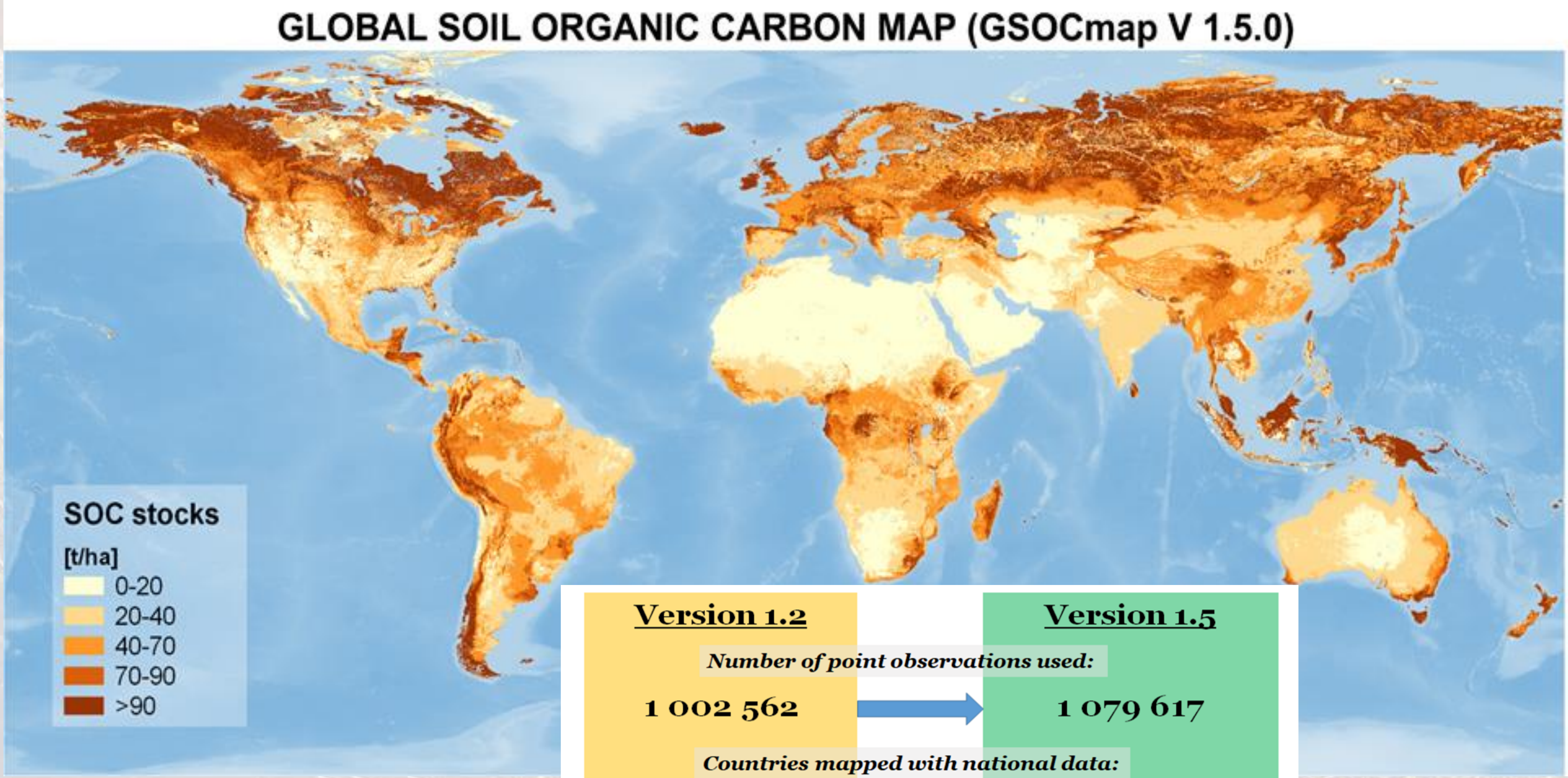
Challenges & Gaps

1. Harmonisation
2. Baseline Soil organic Carbon Stocks
3. Existence and freshness of ground data
4. Technical Guidance, default data for reporting
5. Quality Standards and guidelines
6. Uncertainty



Barron Joseph Orr - 2018

GSOC map 1.5 (June 2019)



Version 1.2		Version 1.5
	Number of point observations used:	
1 002 562	→	1 079 617
	Countries mapped with national data:	
75 countries	→	85 countries
	World area covered with national maps:	
67.9 %	→	73.0 %

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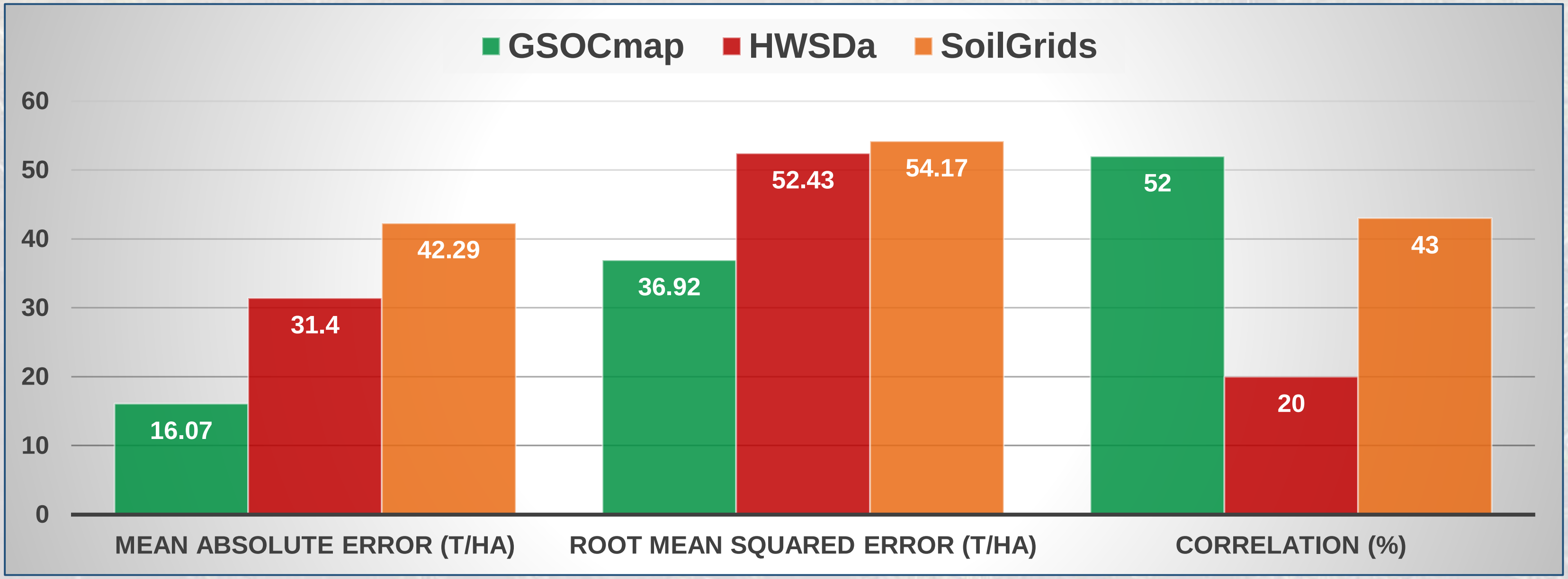
Validation and Uncertainty

- Mean Absolute Error (MAE): **16.07 t/ha**
- Root Mean Squared Error (RMSE): **36.92 t/ha**
- Correlation with ground data: **52%**

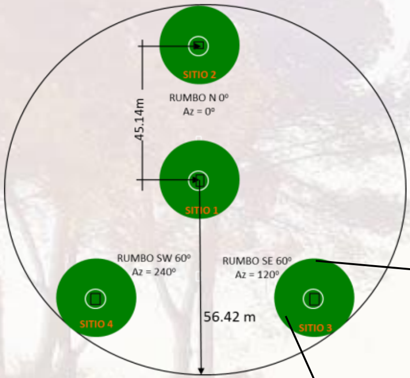


Measuring SOC stocks vs SOC stocks changes

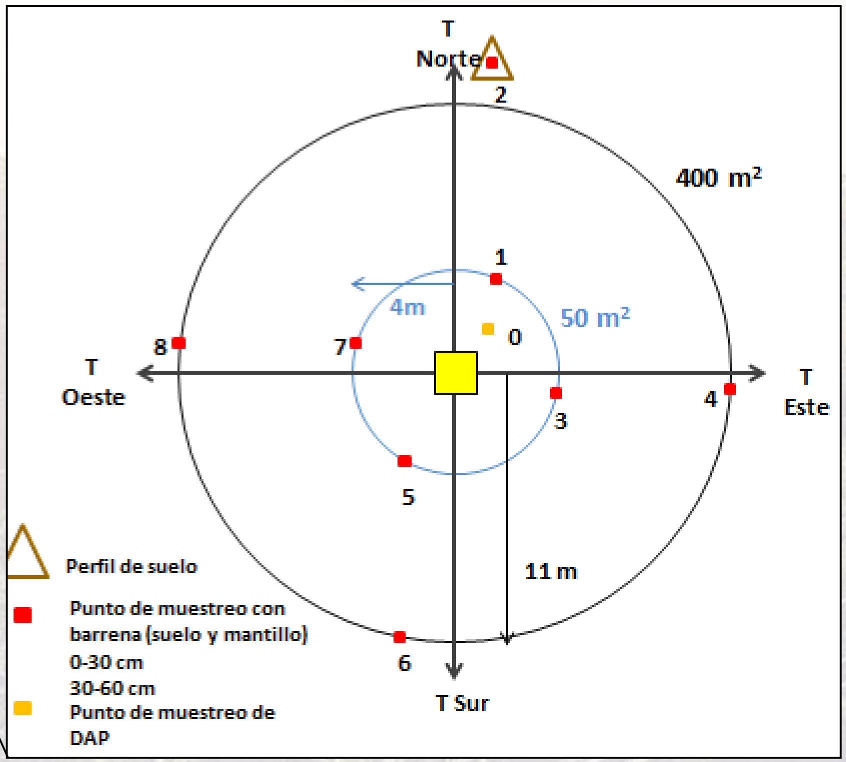
- For measuring SOC stock changes: first we need a **BASELINE** (a global survey following a standard protocol and unique timespan for sampling and measuring SOC).
- GSOCmap constitutes a Zerobase SOC.
- Once you have the baseline, a Protocol for Monitoring SOC (Monitoring System) changes in time should be designed. Few countries in the world has one, e.g. Mexico.
- Measurements are at national level following an strict protocol for sampling, soil data collection, sampling treatment, soil laboratory analysis, processing, mapping.
- Usually every 5 years using Total carbon as the indicator, combined with other soil properties (bulk density).
- Instead, if for small projects to demonstrate SOC sequestration, other indicators such as POM could be used.
- A Global Soil Organic Carbon Monitoring System should be established based on countries monitoring systems (or at least with few representative measurements).
- **SOC cannot be adequately monitored without measured data.**

SOC Monitoring in Mexico

Primary sampling unit
(Conglomerate/cluster: 1ha)



- One of the main inputs for MRV is the data collected by CONAFOR's INFyS.
- The INFyS starts from a systematic design, (in 10% of the cgls, soil information is collected).



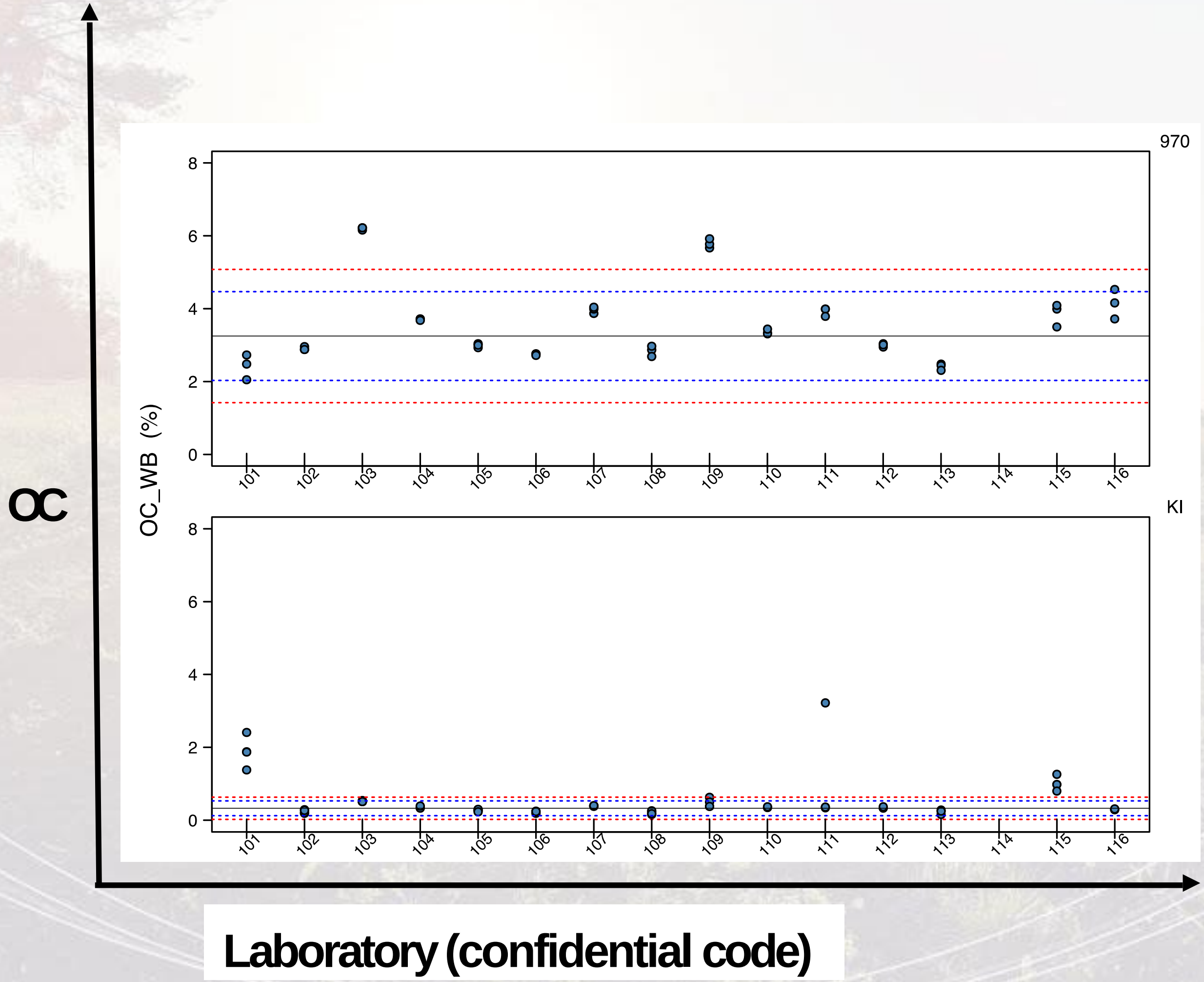
Secondary sampling unit (Site 3)

National Forestry and Soil Inventory (INFyS) of the National Forestry Commission (CONAFOR)

Sampling Cycle 3 (2015-2019)

Global Soil Laboratory Network (GLOSOLAN)

Soil laboratories are the first source of data

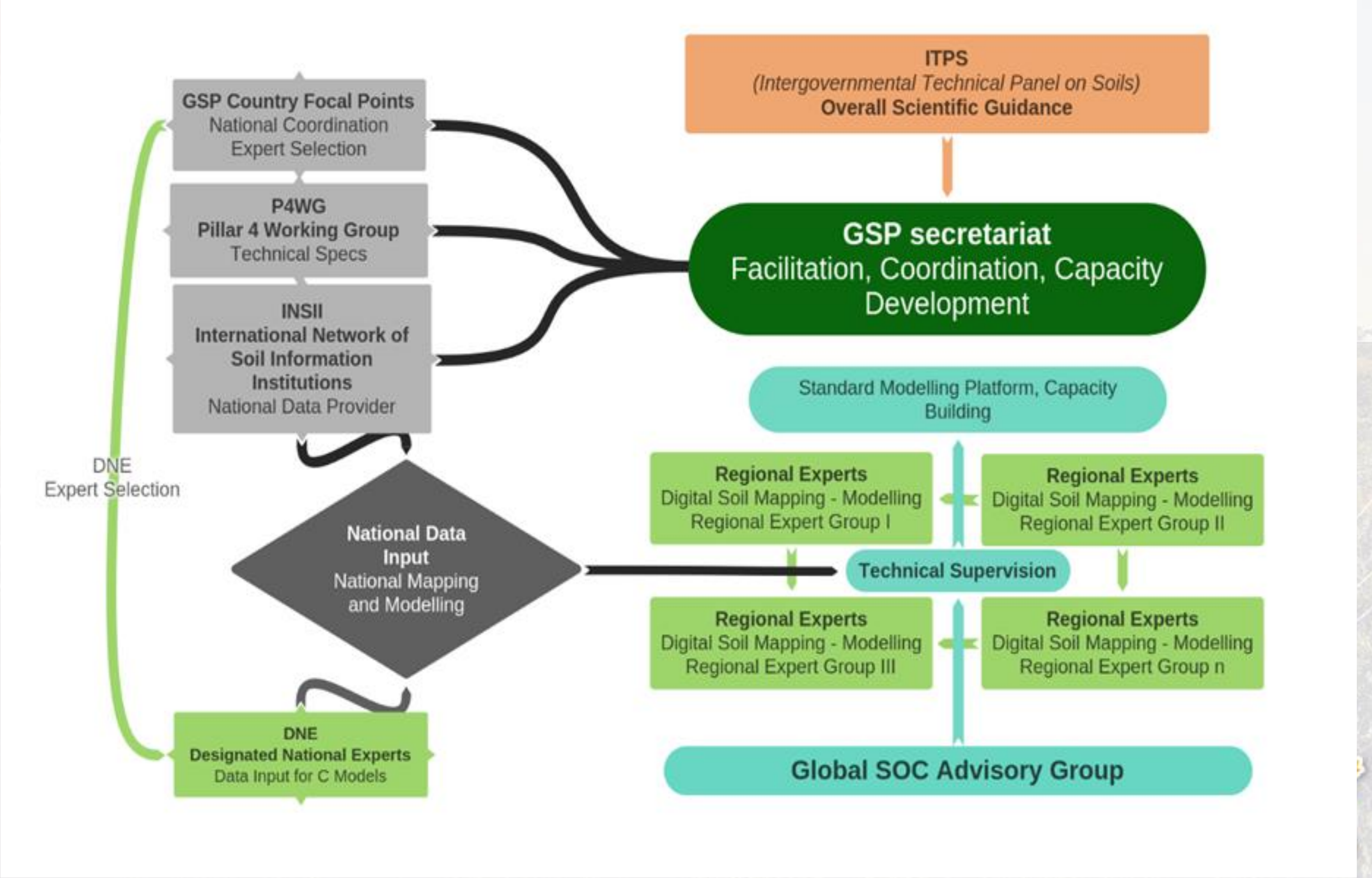


Example provided by SEALNET 2.0 (ring test, South-East Asia)

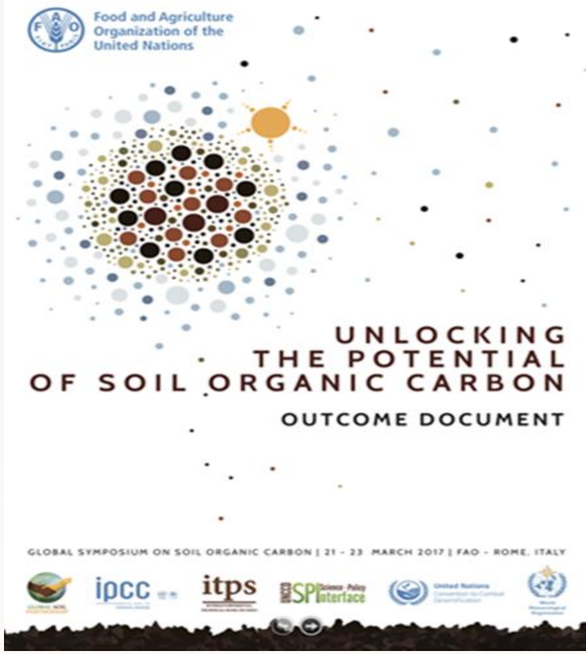
Why is challenging?

- **Error associated with the experimental design.**
- **Collection in the field.**
- **Pretreatment of soil samples and storage.**
- **Analytical methods that are used in the laboratory (qualitative and quantitative methods).**
- **Discrepancies to measure SOC.**
- **Edaphoclimatic factors of SOC accumulation and loss.**
- **Spatial-temporal variability.**
- **Statistical bias.**
- **Soil sampling at global level was not oriented to quantify C stocks.**

Global assessment of soil organic carbon sequestration potential (GSOC seq)



Preventing further SOC losses and, where feasible, providing incentives to increase SOC stocks

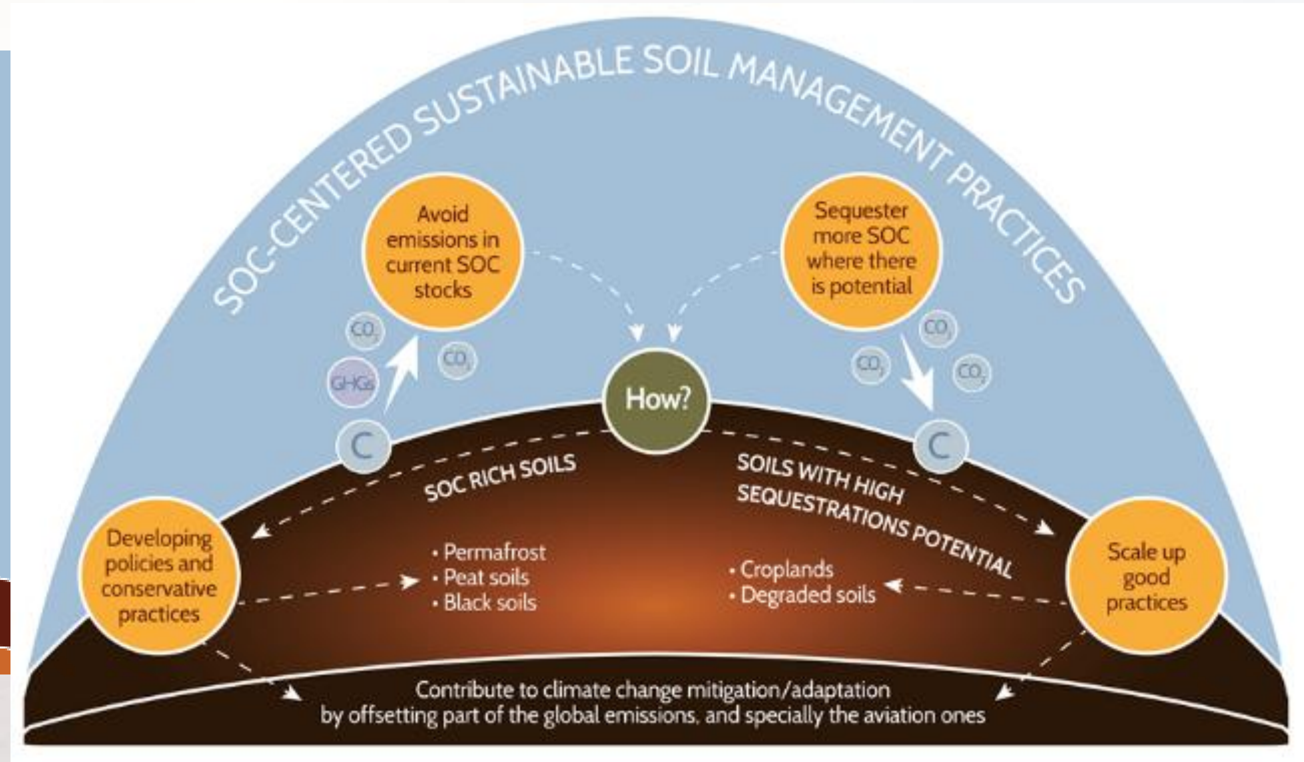


Quesungual system

Integration of cropping and preservation of trees, shrubs and grasses (agroforestry), vegetation cover, incorporation of organic matter, and minimum soil tillage

- **SOM content increased from 2% to 3.3% over 20 years.**
- **Equivalent to an increase from 15 to 25 tonnes of carbon per hectare in the first 10 cm of the soil.**
- **Soil moisture was increased by 20% and resistance towards erosion and landslides was improved.**

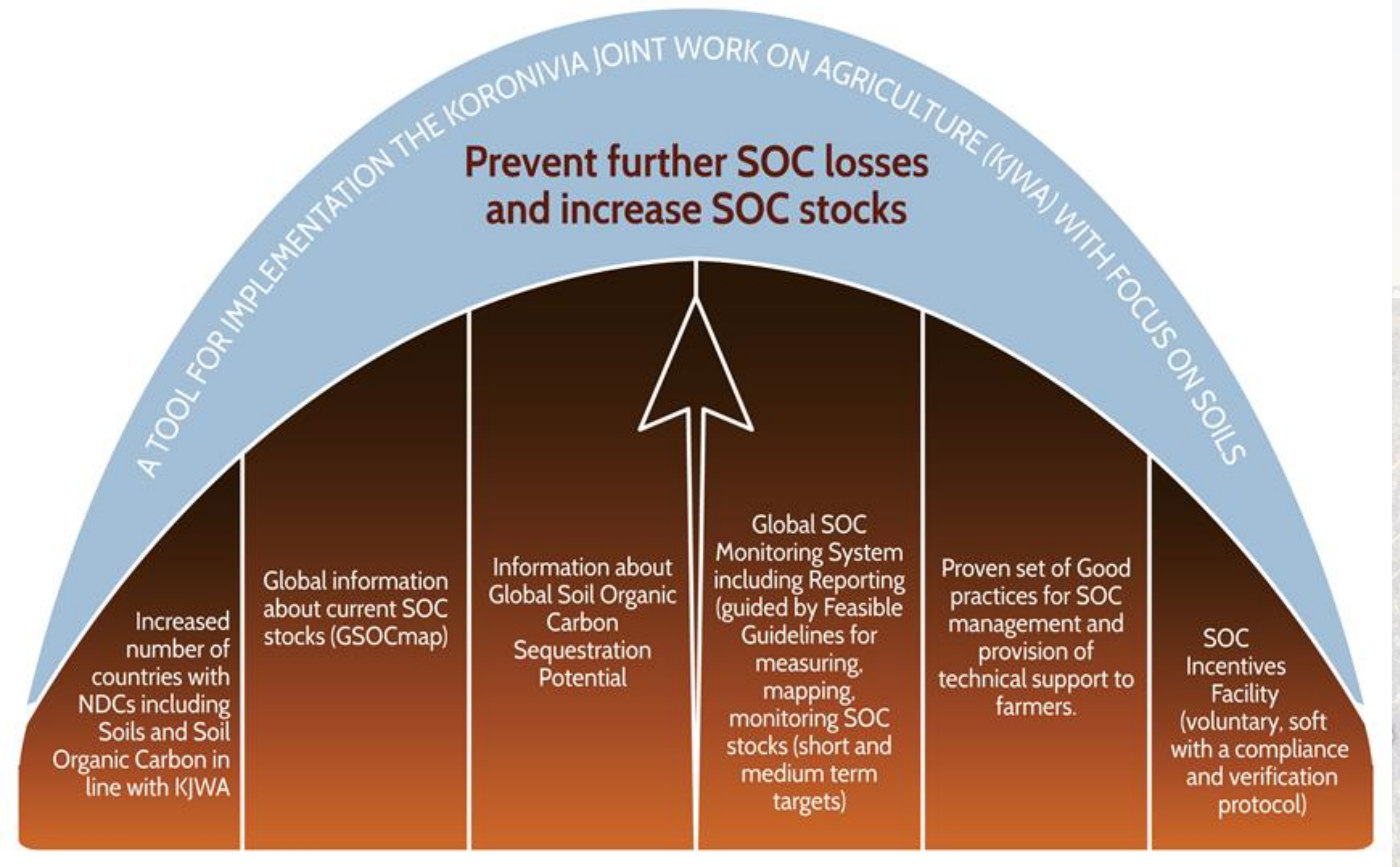
RECSOIL



A tool/facility to implement the Koronivia decision on Agriculture (focus on agricultural soils).

RECSOIL

- Permanence
- Leakage
- Additionality



CONCLUSIONS

- **Investing on sustainable soil management, brings multiple benefits, thus we need to measure impact with few indicators (not only total SOC).**
- **Calculate** current SOC stocks with less uncertainty following **harmonised methodologies** and agreed **standards** for sampling, measuring and monitoring SOC (improve GSOCmap).
- **Report, use and submit** these data for global assessments, and international commitments (**National GHG inventories and SDG 15.3.1**).
- Determine the **Global SOC Sequestration Potential** based on national efforts.

CONCLUSIONS

- Scale up **GOOD PRACTICES** to maintain current stocks and sequester more carbon (where feasible)**.** **Financial Incentives for <u>farmers (voluntary carbon markets)</u>** are crucial if to really invest on SOC-centered sustainable soil management.
- Establish **a Global SOC monitoring System** based on national contributions.
- **Strengthen capacities of member countries** to be able to measure, map, monitor and especially to implement policies for preventing SOC losses and enhance SOC sequestration.

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