Food and Agriculture Organization of the United Nations

Introduction to RECSOIL: Recarbonization of global soils

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Introduction to the RECSOIL initiative

1. What is RECSOIL?
2. Importance of soil organic carbon (SOC)
3. RECSOIL tools for SOC
4. RECSOIL tools and Land Degradation Neutrality (LDN)
5. RECSOIL phases
    A. Phase I – selection of project areas
    B. Phase II – identification of stakeholders and priorities
    C. Phase III – capacity building
    D. Phase IV – stratification and monitoring plan
    E. Phase V – baseline assessment
    F. Phase VI – implementation and monitoring
    G. Phase VII – final analysis

Part 1

Part 2

Part 1 - Introduction

What is RECSOIL?

- It´s an innovative **initiative** with the objective of improving soil health through the **maintenance** and **increase** of SOC stocks.
- It is a mechanism whereby farmers are **encouraged/compensated** to adopt **sustainable practices** to increase yields.
- Farmers receive **technical support** and **financial incentives** (national and international project funds, donors)

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Soils have become one of the world's most vulnerable resources in the face of climate change and increased demand for food production…

…But also …part of the solution!

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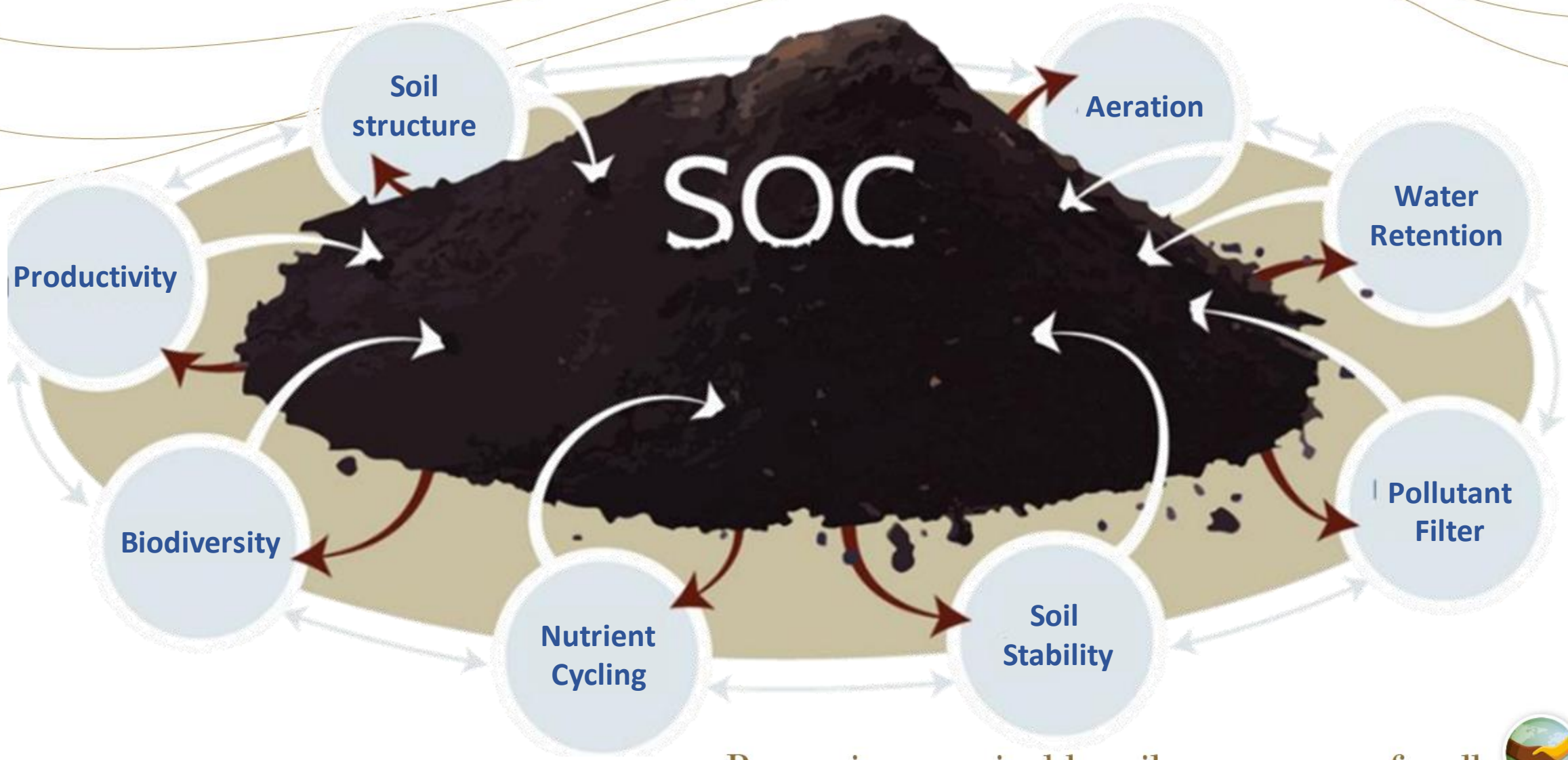
Role of SOC on soil health and properties



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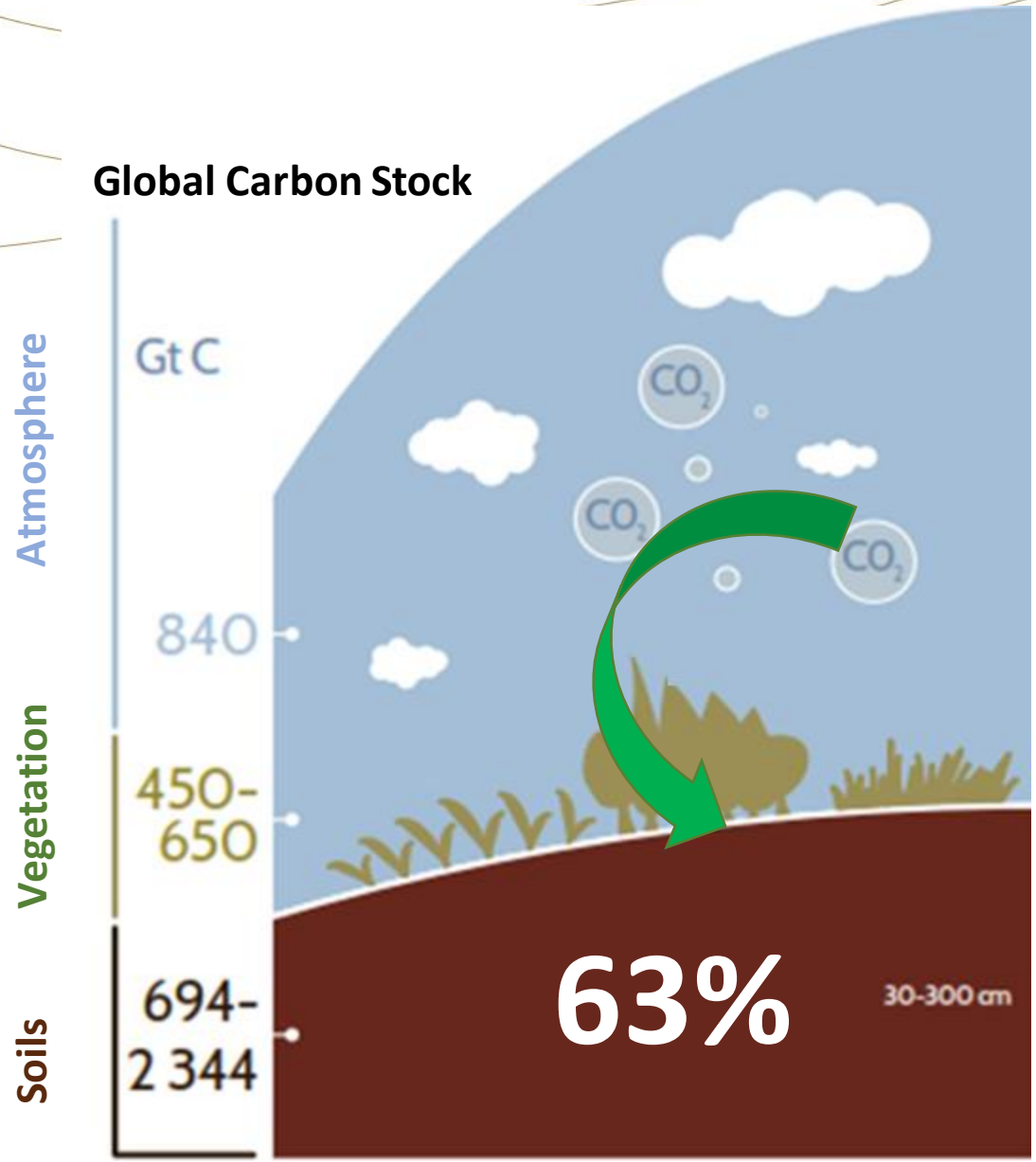
Why is soil organic carbon (SOC) so important?



- SOC represents the largest Carbon pool of terrestrial ecosystems
- Due to its magnitude, small increases in SOC can transform soils from C sources to net C sinks (Paustian *et al.*, 2016)
- CO_2 sequestration through sustainable soil management (SSM) stands out as one of the most effective strategies to mitigate greenhouse gases emissions (GHG) (Smith *et al*, 2008; Lal *et al.*, 2018; IPCC, 2019; Smith *et al.*, 2020).

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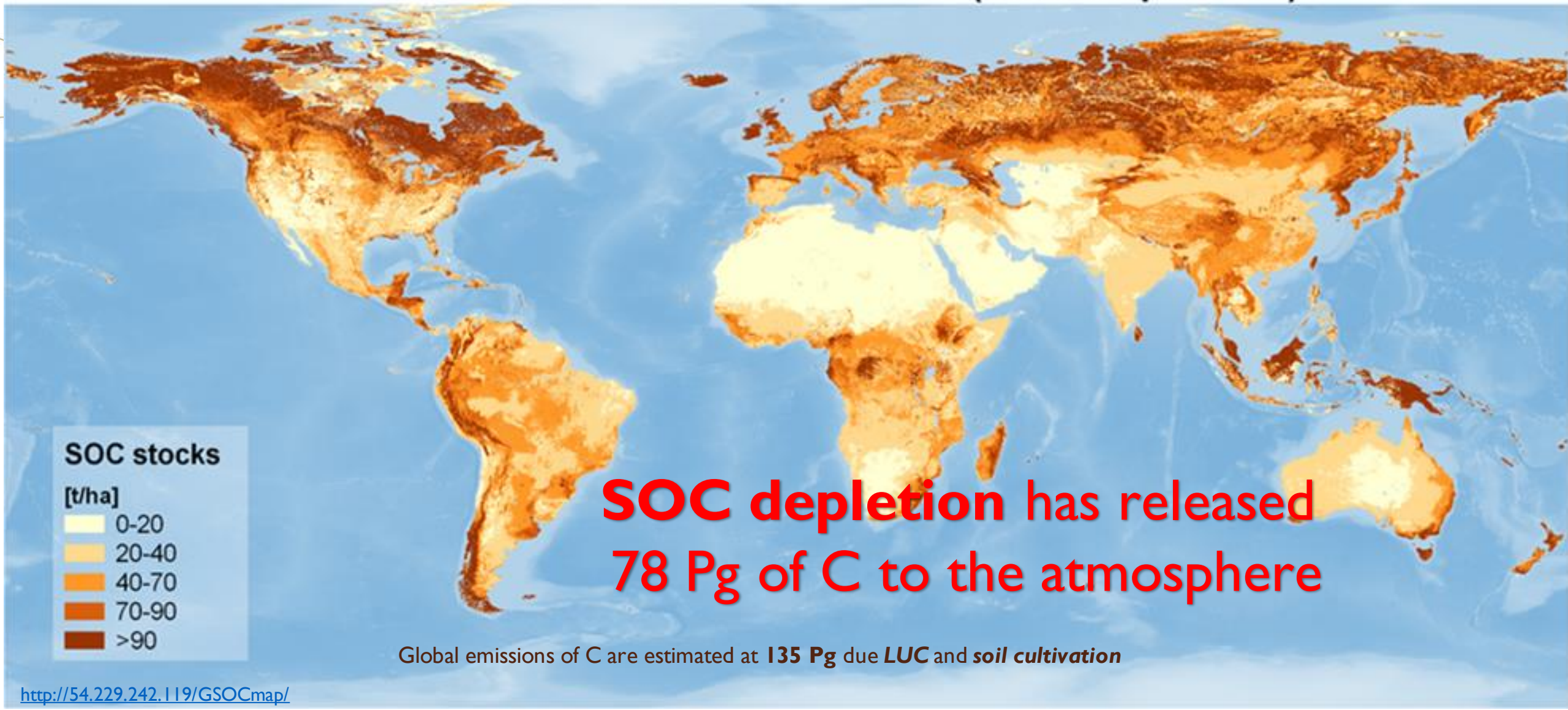
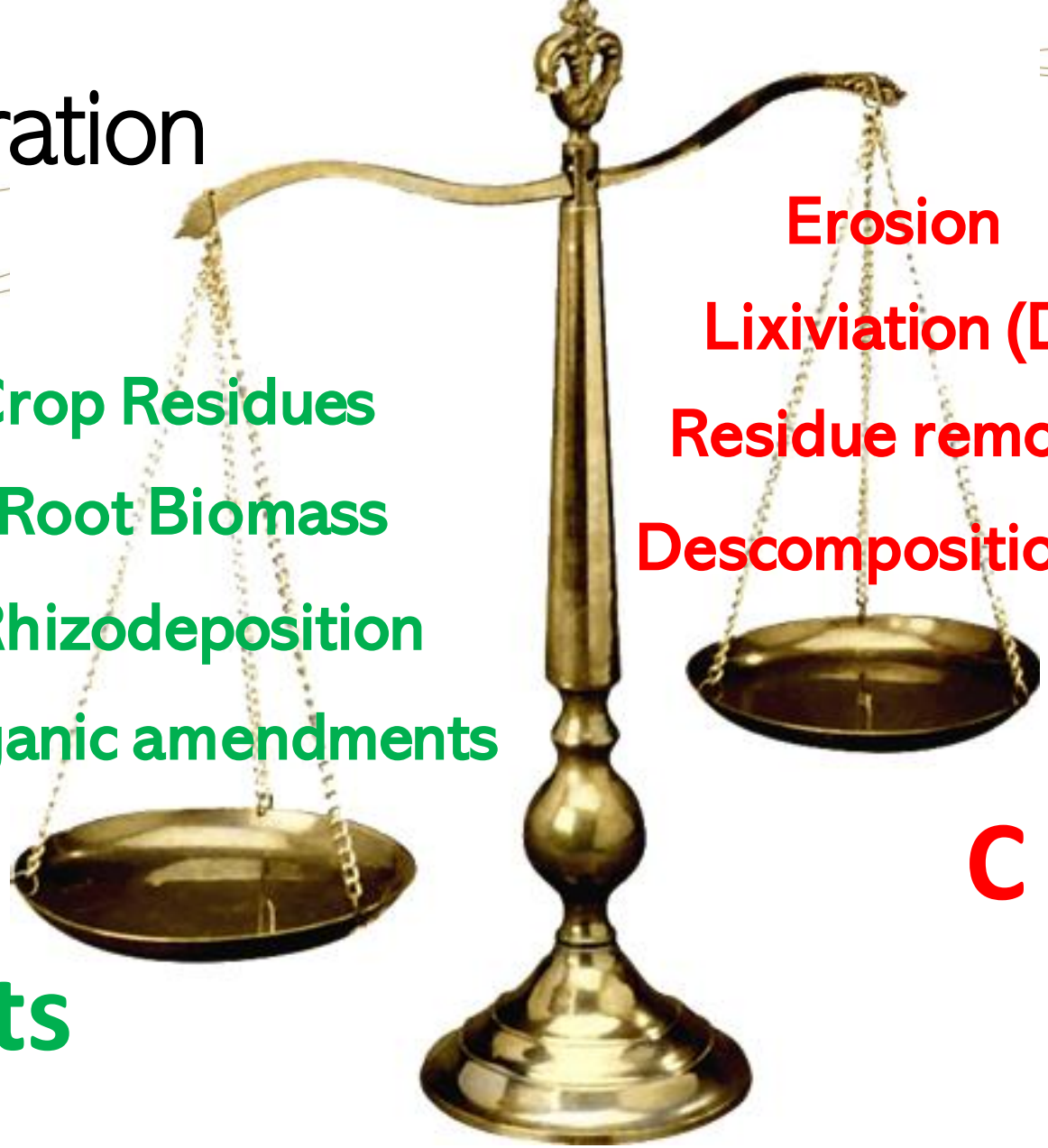
Why sequester carbon in soils?



SOC Sequestration



Crop Residues

Root Biomass

Rhizodeposition

Organic amendments

C inputs

Erosion

Lixiviation (DOC)

Residue removal – burning

Descomposition/mineralization

C outputs

Adapted from Lal, 2020

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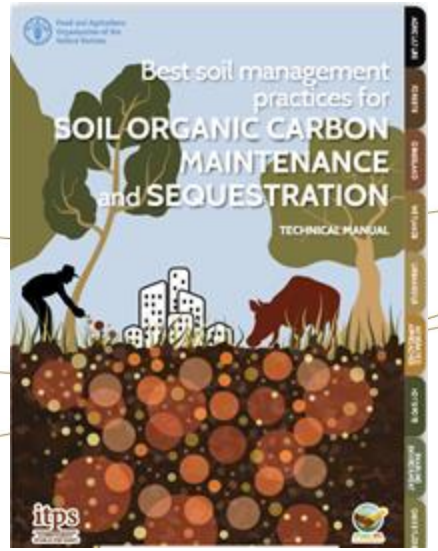
SOC dynamics…. Land use, soil type, climate, vegetation, topography, management practices

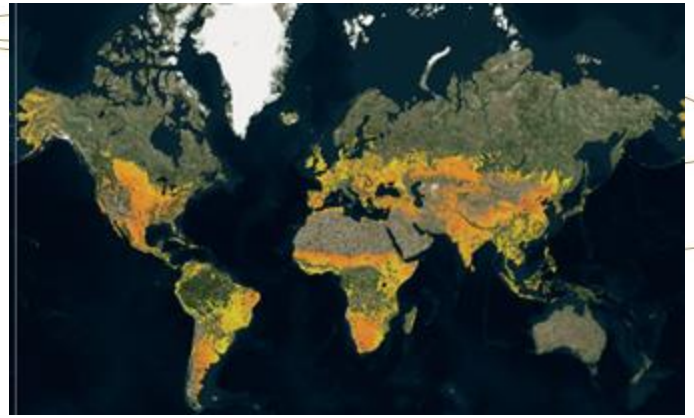
The potential exists… now we must bring it down to earth… How?

Salta, Argentina

RECSOIL – Tools, Projects and Networks - FAO GSP



Technical Manual: Recommended Practices



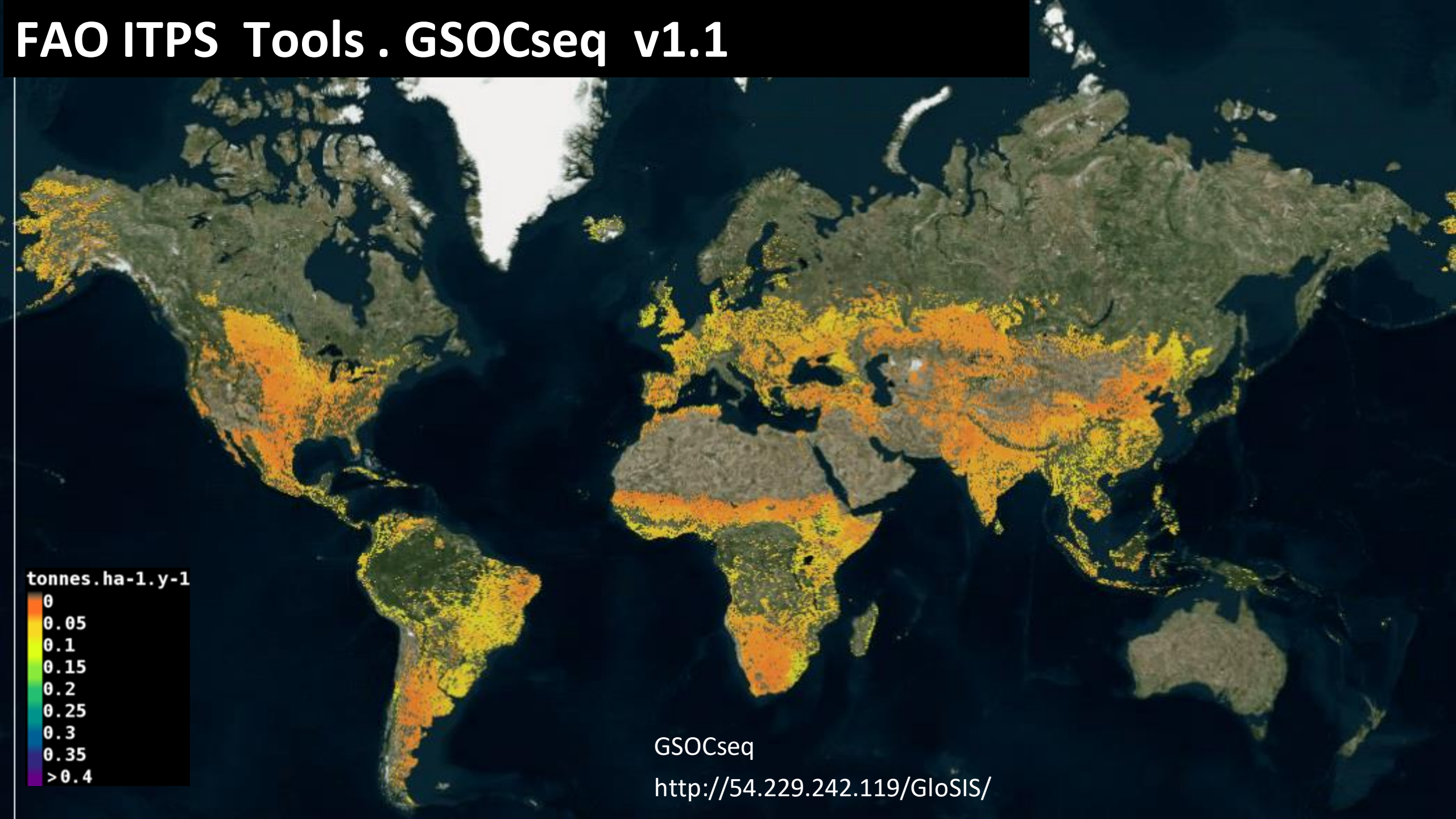
GSOC and GSOCseq Maps and Capacity Development

SSM and GSOC MRV Protocols

Standard Operating Procedures (SOPs)

Harmonization of Laboratory Procedures e.g. for SOC

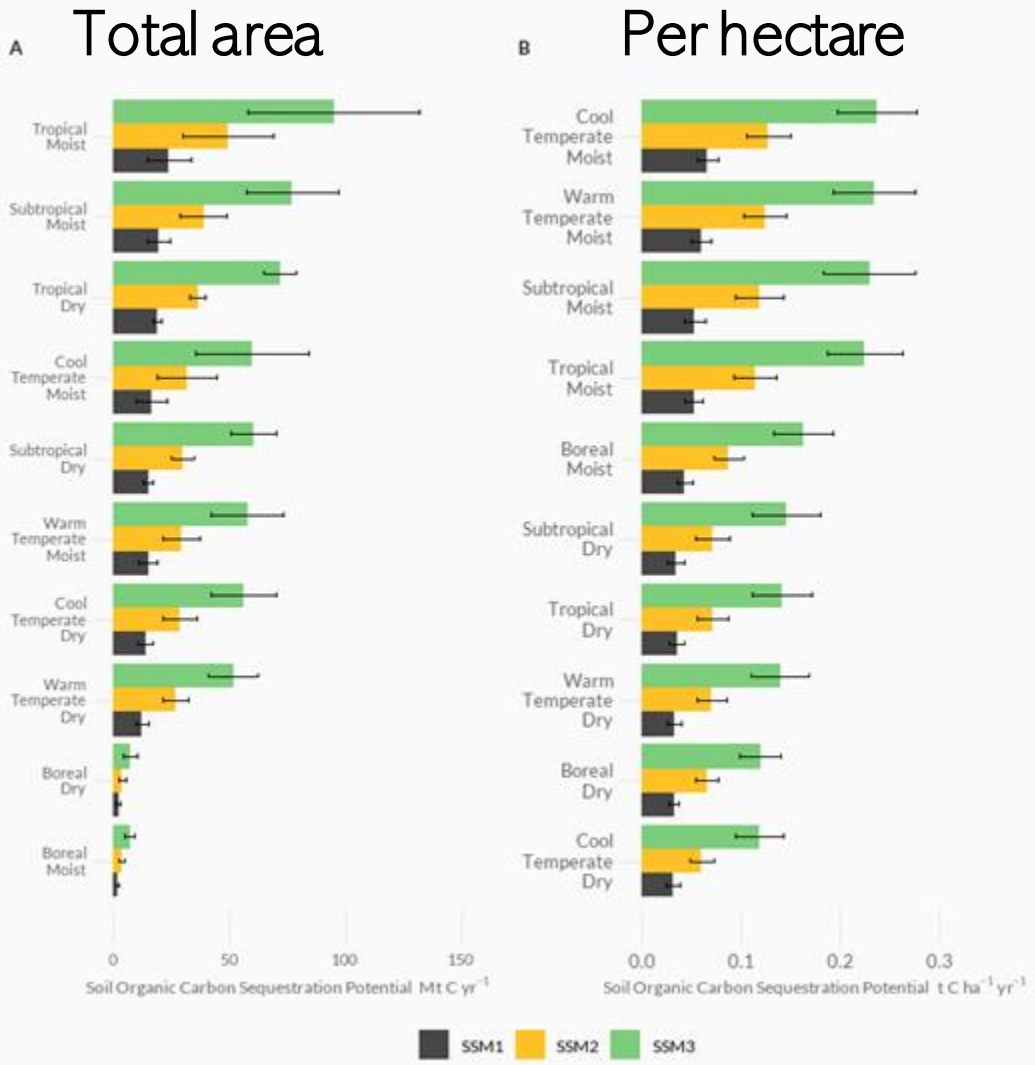
FAO ITPS Tools . GSOCseq v1.1

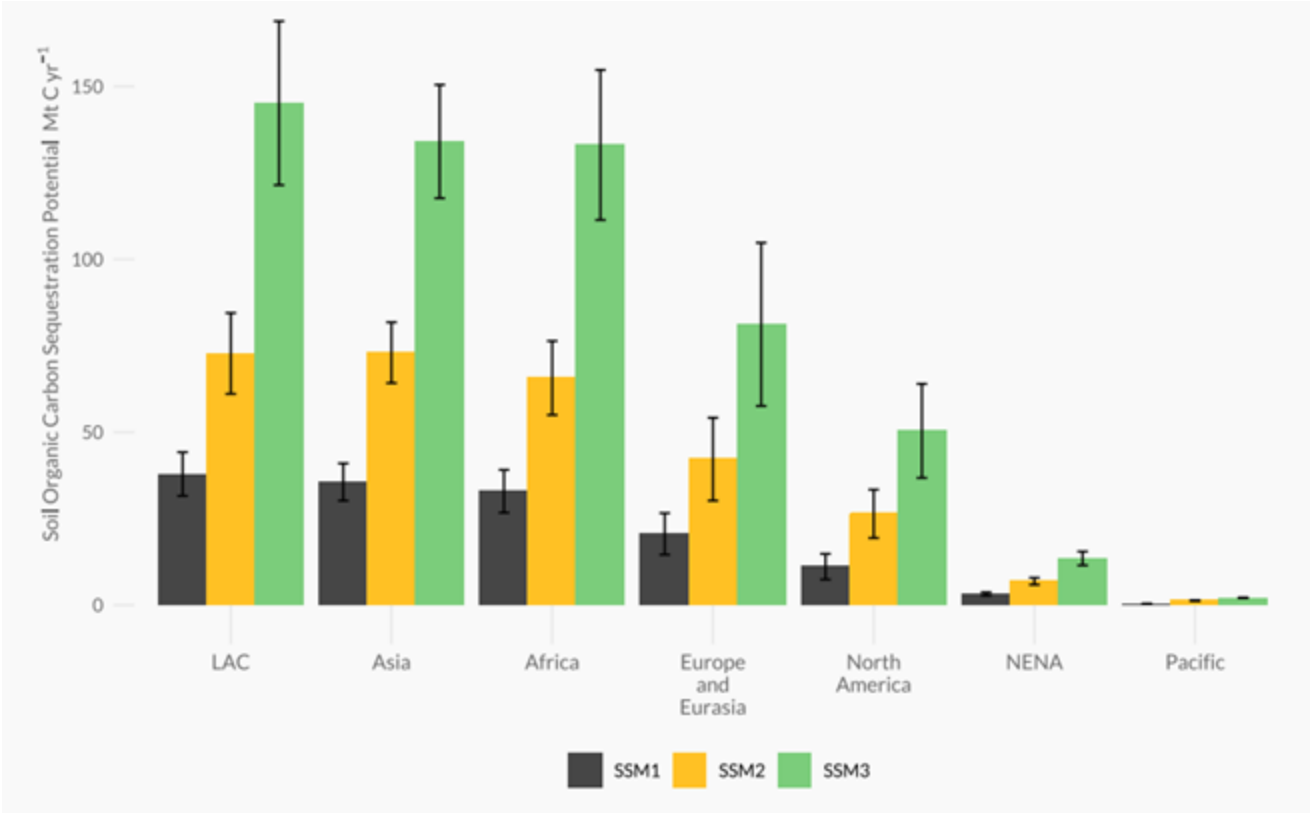


GSOCseq

http://54.229.242.119/GloSIS/

GSOCseq - Which Climates and Regions have greater SOC Sequestration Potential?





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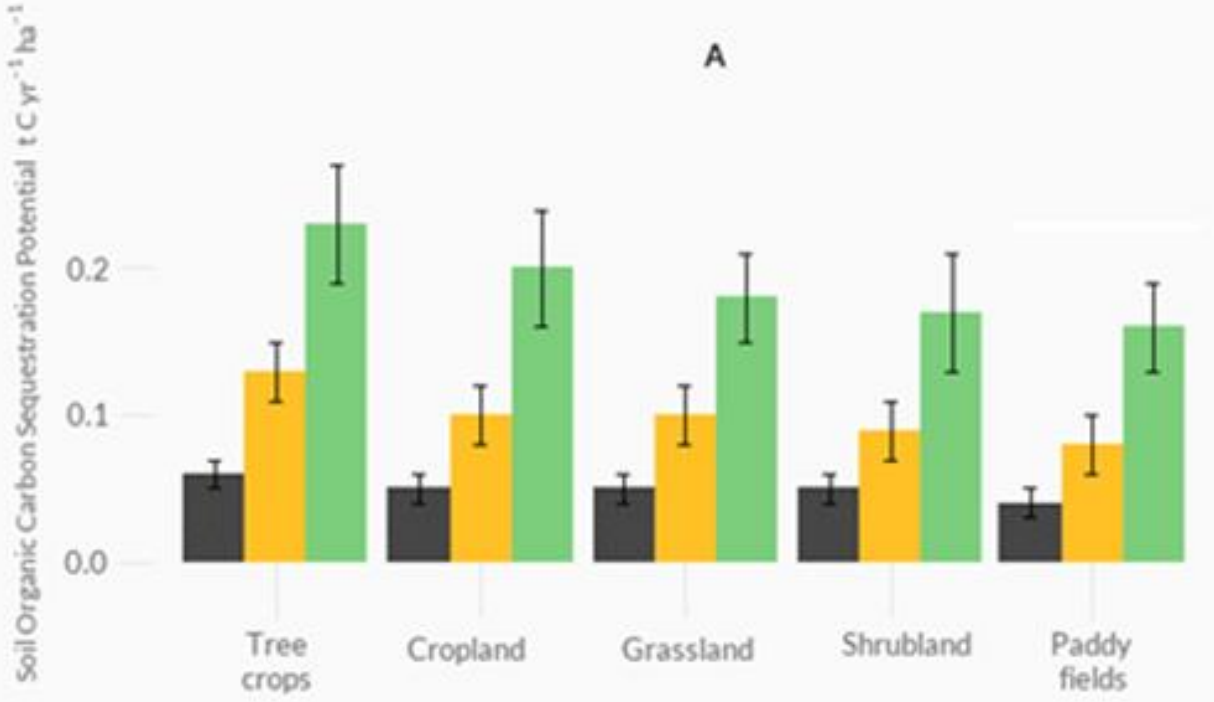
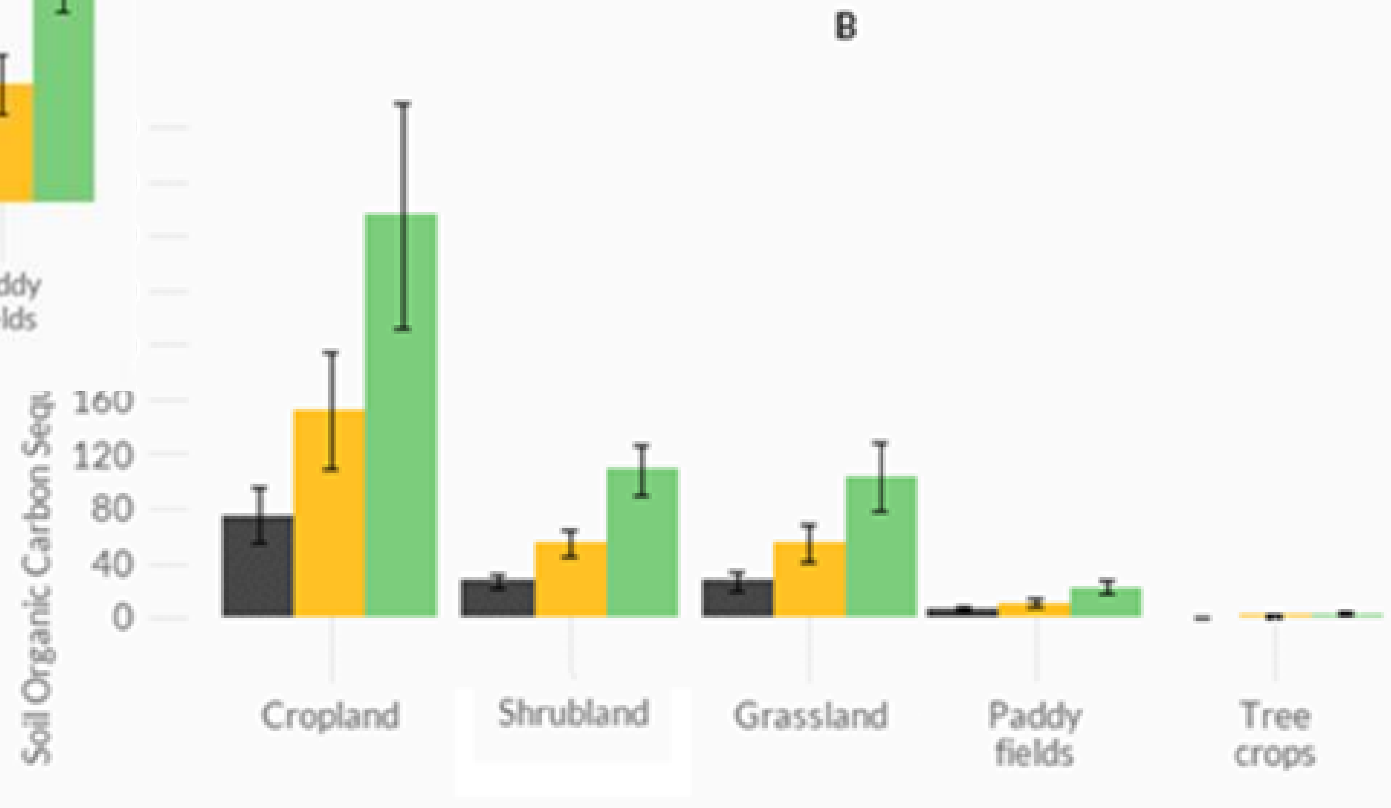
GSOCseq - Which Land Uses have greater SOC Sequestration Potential?

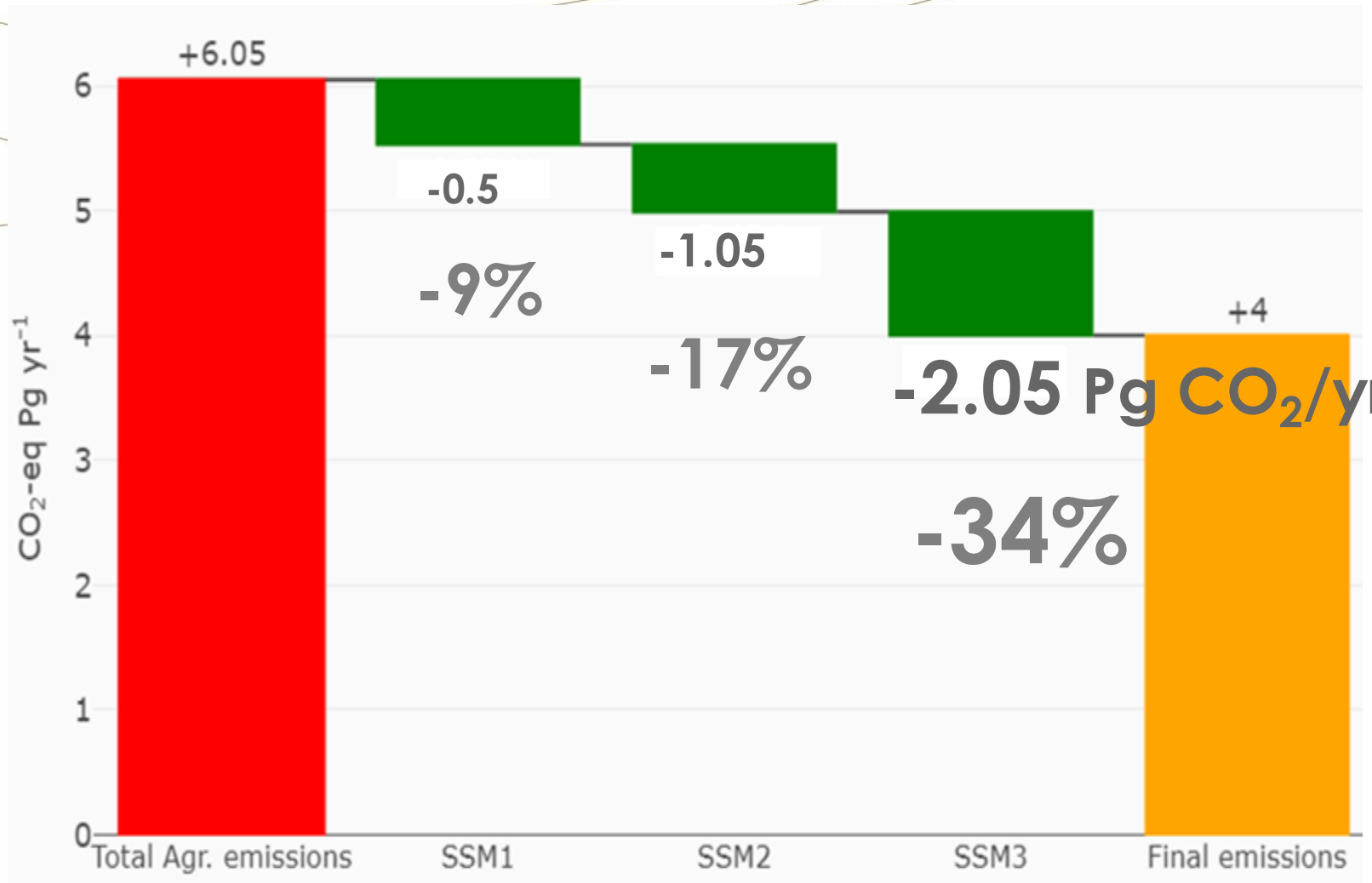
Per hectare



Total area



GHG mitigation potential from C sequestration



We also need to work in other mitigation strategies:

**Total Agricultural Emissions from FAOSTAT (2019)*

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Soil carbon sequestration can also address the three Rio conventions

United Nations
Framework Convention on Climate Change

Stabilize GHGs in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (Art.2)

United Nations
Convention to Combat Desertification

Combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification (Art. 2)

Convention on Biological Diversity

Conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources (Art. 1)

Sanz et al 2017

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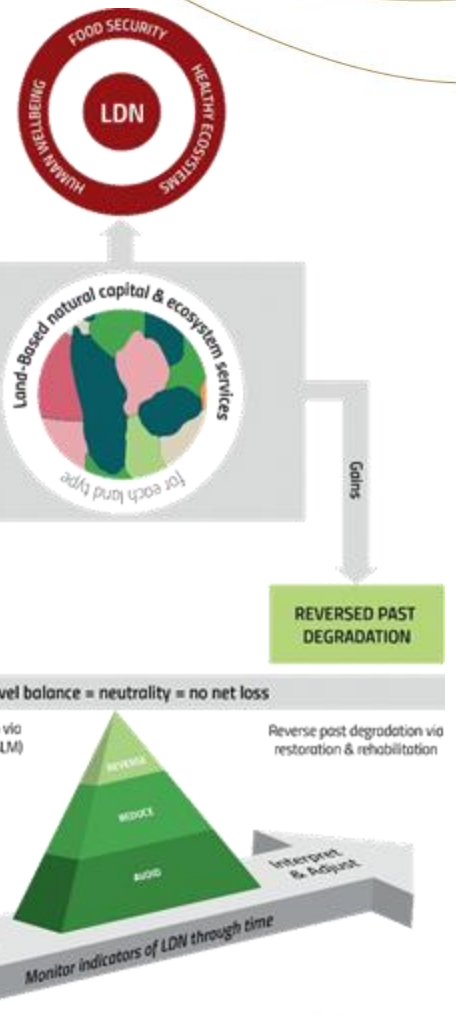
What is considered in Land Degradation Neutrality (LDN) monitoring?

United Nations
Convention to Combat Desertification

Combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification (Art. 2)

The UNCCD's objectives for LDN include:

- Maintaining or improving the sustainable delivery of ecosystem services
- Maintaining or improving land productivity to enhance global food security
- Increasing the resilience of land and the populations dependent on it
- Seeking synergies with other social, economic, and environmental objectives
- Reinforcing and promoting responsible and inclusive land governance



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

INDICATOR 15.3.1

PROPORTION OF LAND THAT IS DEGRADED OVER TOTAL LAND AREA

SUB-INDICATORS:

- PRODUCTIVITY
- LAND COVER
- SOIL ORGANIC CARBON

LDN
Land Degradation Neutrality
Target Setting Programme

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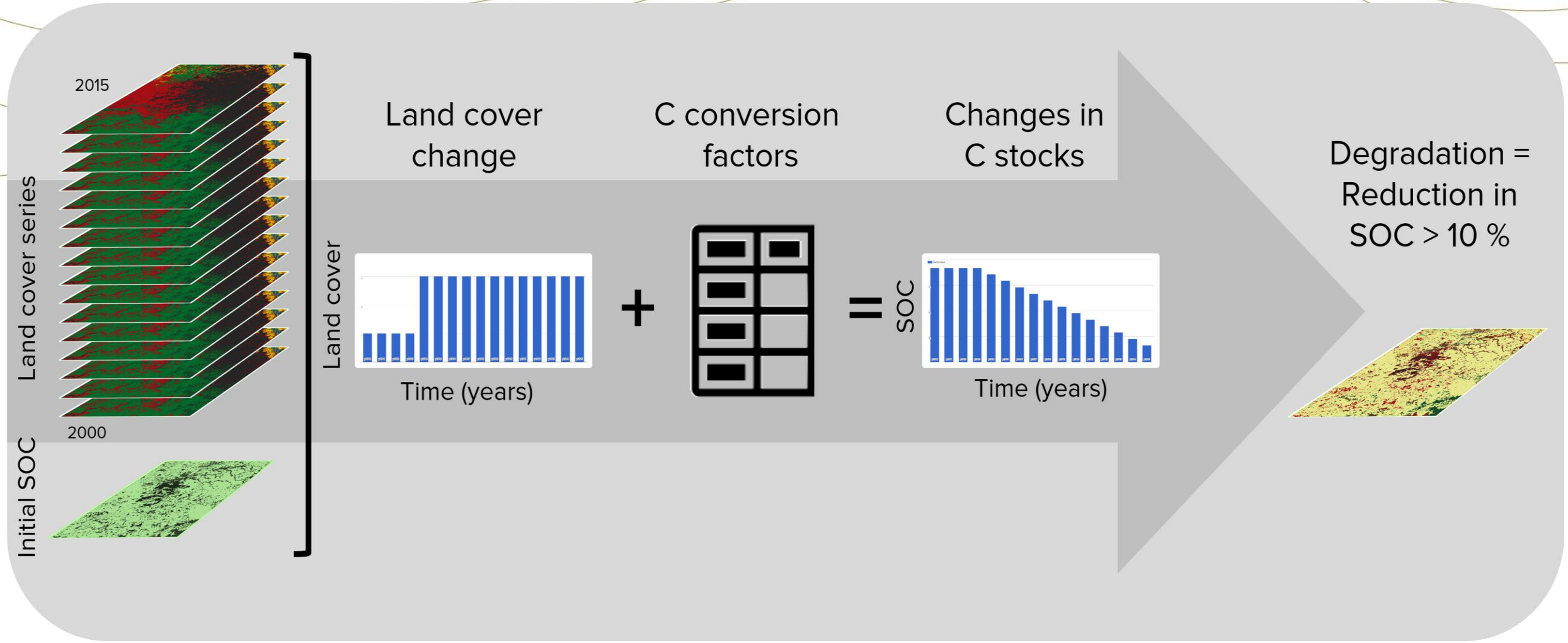
Method combining land cover and conversion factors in TRENDS.EARTH



Land-use based calculations of SOC changes disregard management

Greater accuracy can be achieved in LDN monitoring using RECSOIL tools

RECSOIL tools

Core indicators

Enabling environment activities

GLOSIS
Global Soil Information System

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

SLM practices and restoration

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Part 2 – RECSOIL phases

Implementation steps of the

RECSOIL GREEN PATH

PHASE I

Identification of priority countries to implement RECSOIL

Based on country expression of interest and hotspot analysis using the GSOCseq map

PHASE II

Preparation, agreement and launch

- Identify and select project stakeholders including government representatives, technical support, soil labs, and farmers' associations
- Identification of target regions and SSM practices
- Agree on initial project plan and budget

PHASE III

Technical training and capacity building

- Farmers (Global Soil Doctors Programme)
- Soil laboratories (through GLOSOLAN)
- National technical support (through GSP Secretariat)

PHASE IV

Definition of project areas, practices and monitoring plan

- Refine and finalize exact project areas through further land eligibility analysis
- Gathering of spatial, management and socioeconomic data of the project area - Metadata
- Stratification of the project area
- Definition of the sampling design and density
- Selection of additional indicators

PHASE V

Baseline assessment

- Baseline assessment through application of the SSM protocol

PHASE VI

Implementation, monitoring and communication

- Implementation of SSM practices
- Annual monitoring
- Mid-term reporting

PHASE VII

Final analysis and closure

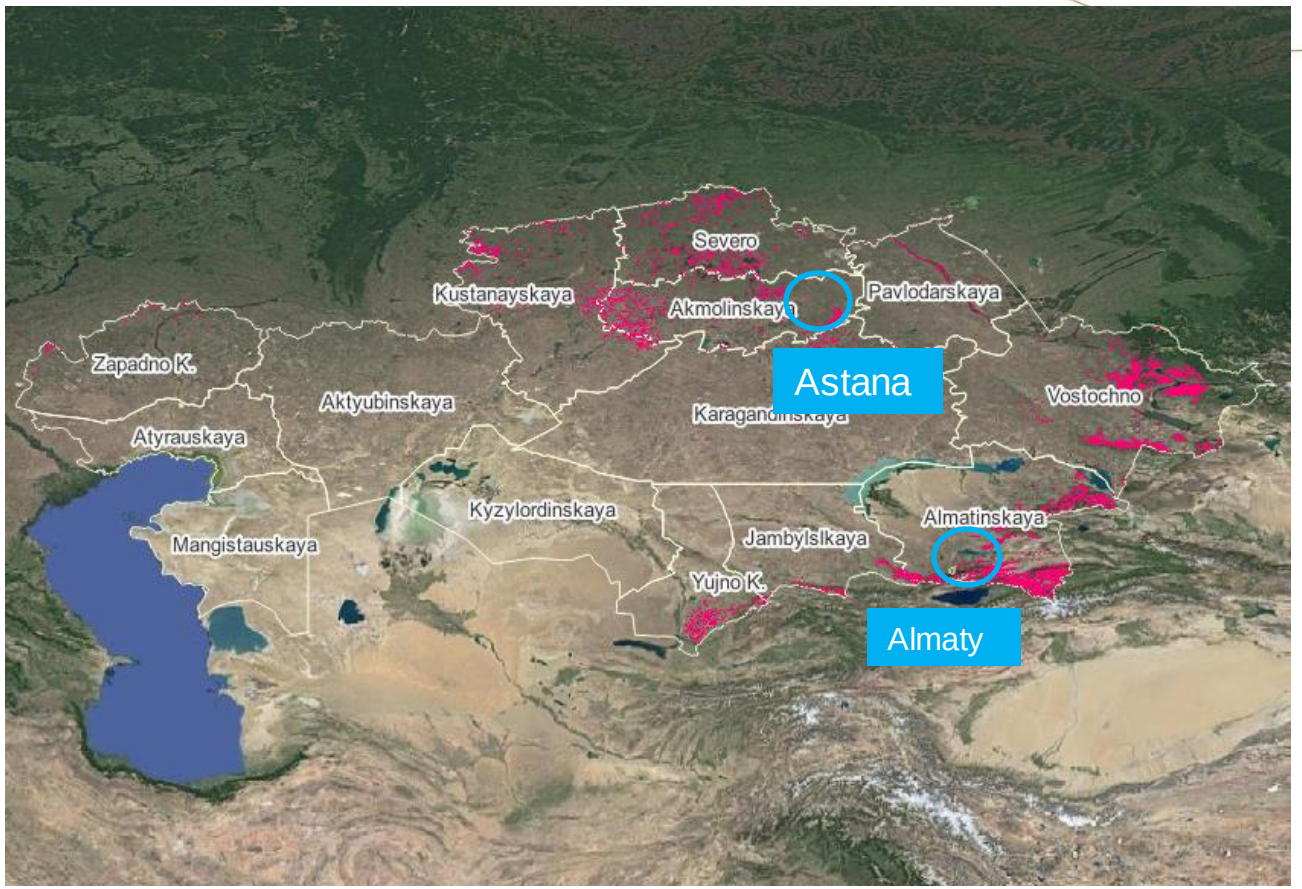
- Final assessment of SOC changes, GHG emissions and soil health status (4 years after the implementation of SSM practices)
- Final project reporting
- Continuity planning

Phase I

Selection of countries and hotspot analysis

1. We identify the best countries using GSOCseq.
2. We also examine the country's commitment to soil health and GHG emissions reduction, as well as its readiness.
3. We combine different layers to identify "hot spots" for RECSOIL implementation in the country.

E.g. 1) Areas with high Sequestration and high convergence of issues



Phase II

RECSOIL

STAKEHOLDERS AND RESPONSIBILITIES

GSP SECRETARIAT

- Project Supervision
- Project co-creation
- Technical support
- Following up the scaling up of RECSOIL

FAO NATIONAL OFFICE

- Project Supervision II
- Project co-creation
- Identification of stakeholders
- Lateral agreements documentation

NATIONAL TECHNICAL SUPPORT

- Project Coordinator
- Decision-making
- Financial administration
- Project co-creation
- Soil sampling campaigns
- Data curator (data collection & QC)
- Data analysis and Reporting
- Technical and extension services
- Coordination of capacity building and KE

GOVERNMENTAL REPRESENTATIVE

- Project Manager
- Project co-creation
- Identification of stakeholders
- Sustainability
- Co-financing
- Project reporting supervision

SOIL LABORATORY/IES

- Project partner
- Soil lab analysis
- Lab quality assurance
- Lab results upload to the RECSOIL database
- Support data result interpretation

FARMER'S ASSOCIATION

- Project members
- Project co-creation
- Farmer's engagement
- Support to decision-making
- Material purchase
- Supervision of field operations

COMMUNITY LEADERS

'SOIL DOCTORS' & FARMERS

Phase II

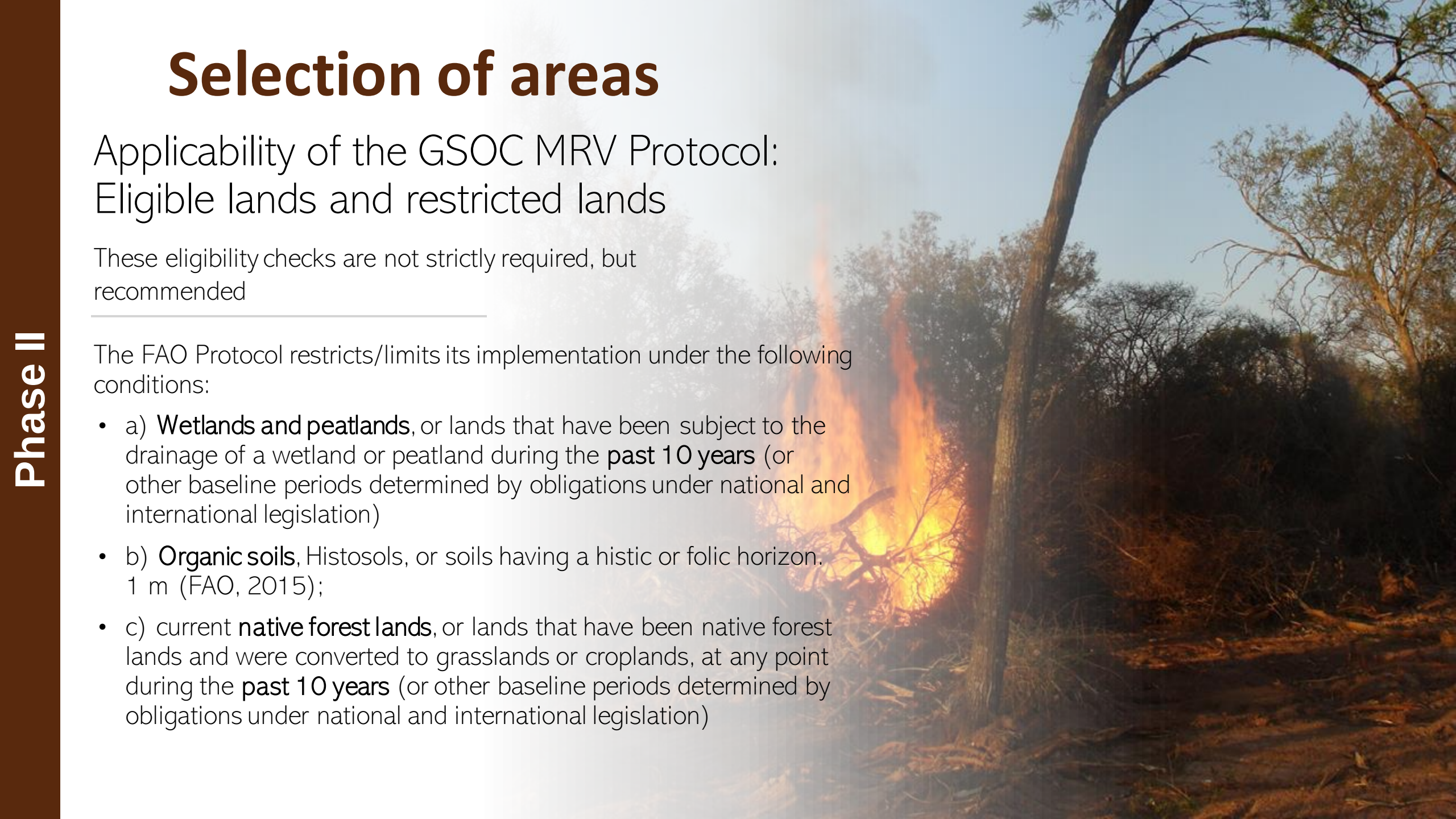
Selection of areas

Applicability of the GSOC MRV Protocol: Eligible lands and restricted lands

These eligibility checks are not strictly required, but recommended

The FAO Protocol restricts/limits its implementation under the following conditions:

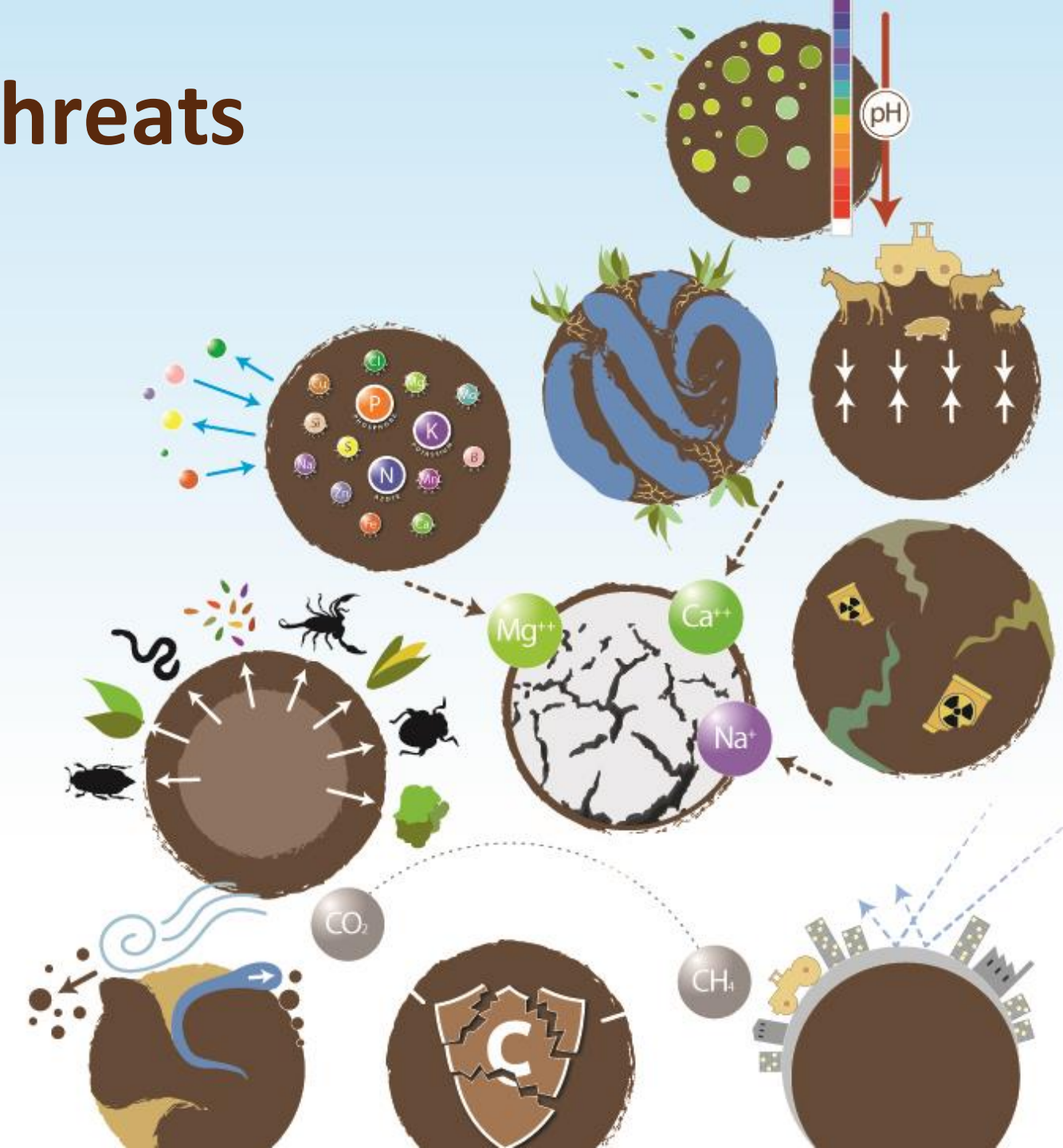
- a) **Wetlands and peatlands**, or lands that have been subject to the drainage of a wetland or peatland during the **past 10 years** (or other baseline periods determined by obligations under national and international legislation)
- b) **Organic soils**, Histosols, or soils having a histic or folic horizon. 1 m (FAO, 2015);
- c) current **native forest lands**, or lands that have been native forest lands and were converted to grasslands or croplands, at any point during the **past 10 years** (or other baseline periods determined by obligations under national and international legislation)



Phase II

Identification of soil threats

- During the introductory meetings, **soil threats** affecting the project area are identified.
- **Practices** that could be adopted to **sequester carbon** and **minimize these threats** are also identified.
- Identification of practices and soil threats is a joint process and government, farmers, technician, researchers and other stakeholders participate in the process.



Phase III

Soil Doctors Programme – trainings for farmers

GSP

- ✓ Offers certified training for trainers
- ✓ Provides posters and scientific support
- ✓ Supports trainings for soil doctors
- ✓ Provides soil education kits

PROMOTERS

- ✓ Support training of trainers
- ✓ Adapt educational material to the local context
- ✓ Provide feedback on educational material
- ✓ Provide training for soil doctors in the field

611 Trainers and 1 407 Soil Doctors certified in 14 countries 7 517 farmers reached (estimated)

The involvement of extension agencies is essential!

Soil Doctors
GLOBAL PROGRAMME
GLOBAL SOIL PARTNERSHIP

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Soil Doctors Programme – Education materials

What is soil?

What is soil organic matter?

How to enhance SOM?

\+

What is soil pH?

OR

What is soil biodiversity?

5 Posters

- Texture
- SOM-Colour
- Aggregate stability
- Soil structure
- Mottles
- Earthworms and macroinvertebrates
- Roots

Soil Doctors
GLOBAL PROGRAMME
GLOBAL SOIL PARTNERSHIP

7 Field exercises

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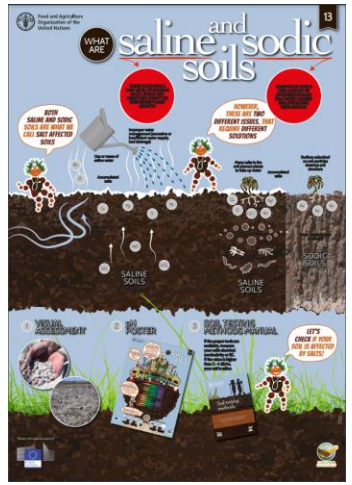
Soil Doctors Programme – soil threats

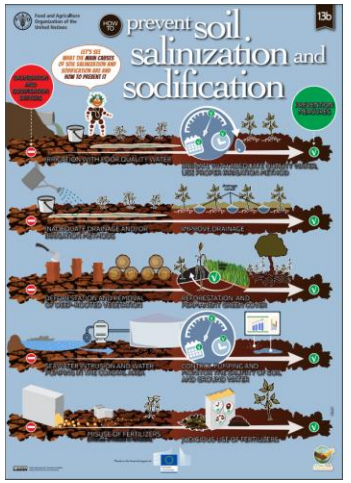
Develop generic material on soil threats to be used around the Globe

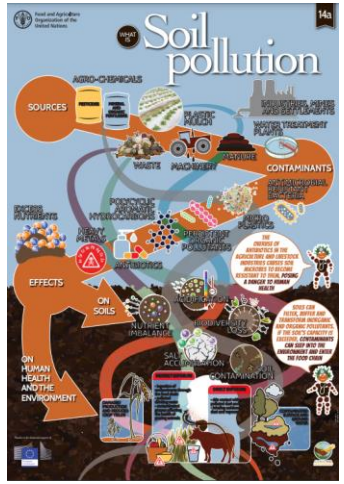
1. Adjust exisiting posters to local conditions
2. Develop field exercises on specific soil threats
3. Work with farmers and local stakeholders to better communicate and disseminate SSM

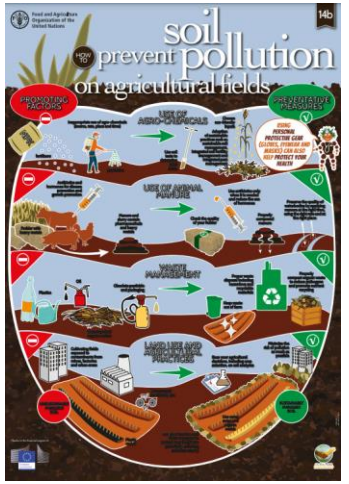
What is?



Prevention







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Phase III

Trainings for field technicians

- Stratification in homogeneous units and definition of sampling scheme (online);
- Use of Google Earth Engine (online);
- Data collection and management (online);
- SSM and GSOC-MRV protocols (online);
- Sample collection and visual soil assessment (on the field);
- Data analysis – soil health and greenhouse gas emissions estimates (EX-ACT).

Phase III

Trainings for lab technicians

- Use of harmonized lab procedures – standard operating procedures (SOPs);
- Quality control procedures;
- Safety and security in the lab.

The methods to quantify SOC already harmonized by GLOSOLAN are the following:

SOP Walkley-Black method – titration and colorimetric method (**EN** | **ES** | **RU**)

Soil organic carbon – Tyurin spectrophotometric method (**EN** | **RU**)

Training video: Walkley and Black - **titration** and **colorimetric** method

Training video: **Tyurin spectrophotometric method**

Soil Organic Carbon methods : Sustainability of methods

Method	Risk for human health related to the use of chemicals and the overall implementation of procedure by staff	Environmental risk (waste disposal)	Level of technology required	Average duration of the analysis	Global mediar price of the analysis (for the customers
Walkley & Black	High	High	Low	Up to one working day	6 USD
Tyurin	High	High	Low	Up to one working day	7.6 USD

Published by Google Sheets – Report Abuse – Updated automatically every 5 minutes

Matrix to assess risk in the laboratory You can download this file and fill it according to your laboratory's situation, in order to evaluate the risk and take the adequate actions. Plese consult the instruction available on the GLOSOLAN website on how to fill the matrix and the table to evaluate the results obtained,	**Consequences to People**		Minor impact on skills	Minor impact on capability	Unavailability of core skills (affecting services)	Unavailability of critical skills or personnel	Prolonged unavailability of critical skills /people
			Minor injury or first aid treatment	Injury requiring treatment by medical practitioner	Major injury/ hospitalization	Single death and or multiple major injuries	Multiple deaths
Quantitative Likelihood	Multiply the two numbers and report the result in the table, where the axes of the two numbers intersect		***Severity***				
			Insignificant 1	**Negligible 2**	**Moderate 3**	**Extensive 4**	**Significant 5**
Has occurred on an annual basis in this organization or given the current situation, it is predicted that this will occur	***Likelihood***	**Almost certain 5**					
Has occurred in the last few years in this organization or recently in other similar organizations or, given recent circumstances it is predicted to occur in the near future		**Likely 4**					
Has occurred at least once in the history of this organization or is considered to have 5% chance of occurring in the near future		**Possible 3**					
Has never occurred in this organization but has occurred infrequently in other similar organizations or is considered to have 1% chance of occurring in the next few years		**Unlikely 2**					
Is possible but has not occurred to date in this organization or in any similar organization, and is considered to have much less than 1% chance of occurring in the next few years		**Rare 1**					

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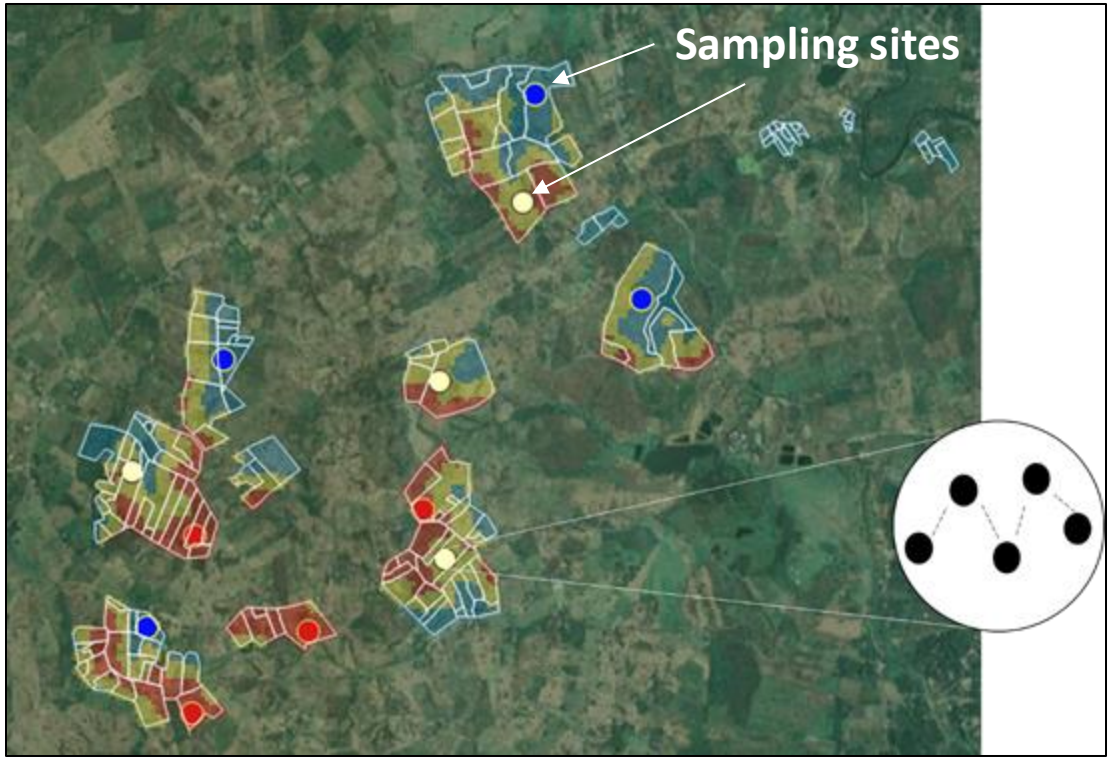
Trainings for lab technicians

Phase III

1. Refine stratification;
2. Define sampling strategy;
3. Collect Project metadata;
4. Define additional indicators.



Specific land use (indicate the area)

Land Use

Category	Type	Area (ha)
Class 1 : Agriculture	Annual crops	
	Seeded pastures (in rotation with crops; mixed)	
	Hay production	
	Silage production / other reserved feed	
	Forrage crops	
	Agroforestry	
	Agro-silvopasture	
	Bare fallow	
	Green fallow / cover crops	
	Dry rice/ mountain (highlands)	
	Plantations – perennial crops	
	Fruit	

Category	Type	Area (ha)
Class 2 : Grassland	Permanent established pasture	
	Natural prairies (permanent)	
	Shrubs	
	Forested grassland (Wooded)	
	Savanna	
	Silvo-pasture	
Class 3: Forestry	Commercial forestry	
	Forest conservation	
	Native forest (conservation)	
	Native forest (harvested)	
Class 4 : Wetlands	Wetlands and peatlands (unused)	
	Wetlands and peatlands (harvests) (Use :	
Class 5 Other	Abandoned/degraded land	
	Multipurpose	
	Other (construction, etc.)	

Specific observations :

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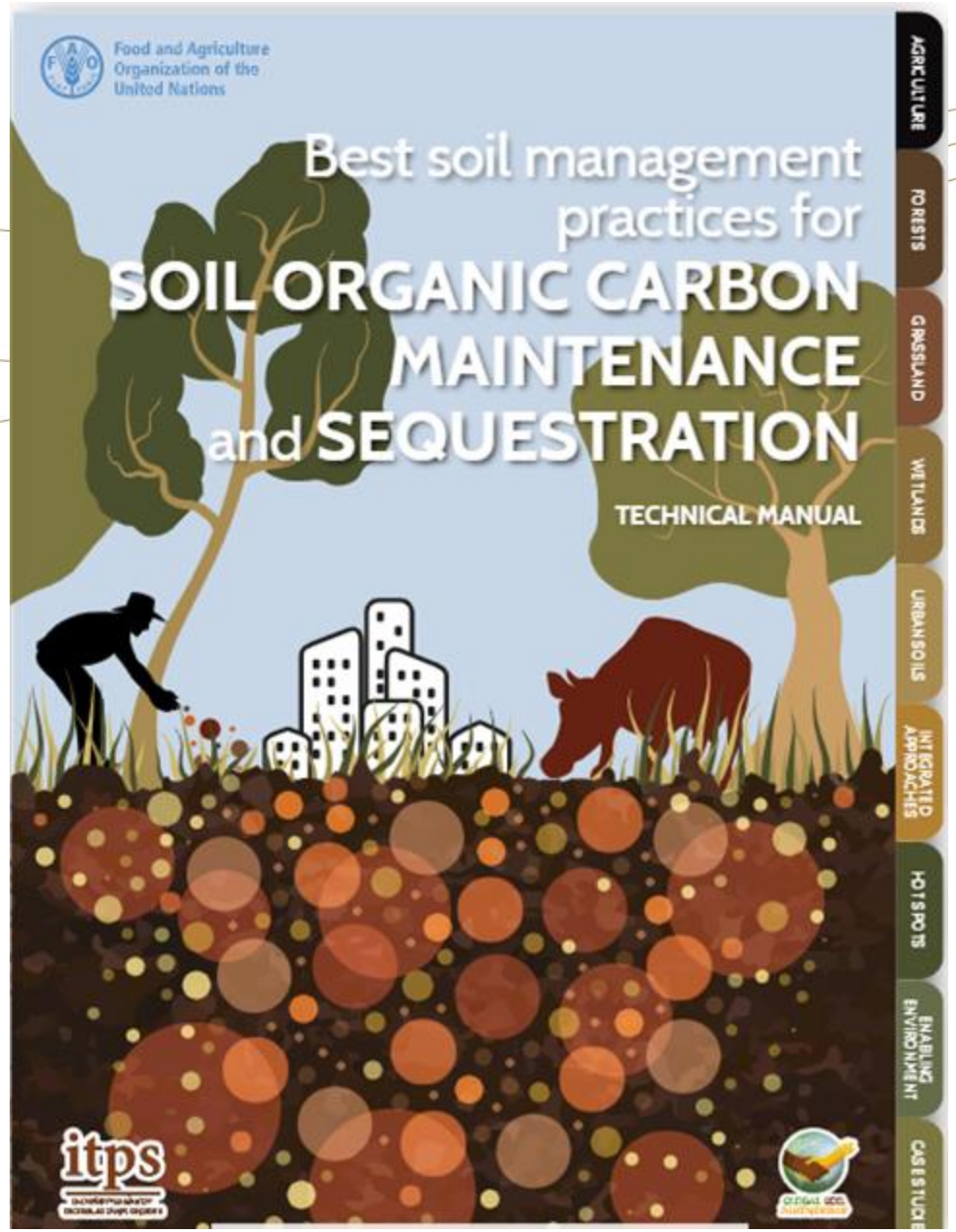
Phase IV



https://www.fao.org/documents/card/en/c/cb6606en/

Selection of sustainable soil management practices

1. Knowledge of local experts, extension agents, soil scientist, farmers, and agronomists
2. Technical Manual: Recommended Practices

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- Practices to maintain or increase SOC, improve soil Health
- Costs ($)
- Labour burden

Grazing management ("rational grazing" e. PRV)

"living fences" - legumes

Forage bridges

Sowing improved pastures

Nutrients and amendments management

Erosion control: curves, terraces, etc

Organic and inorganic amendments

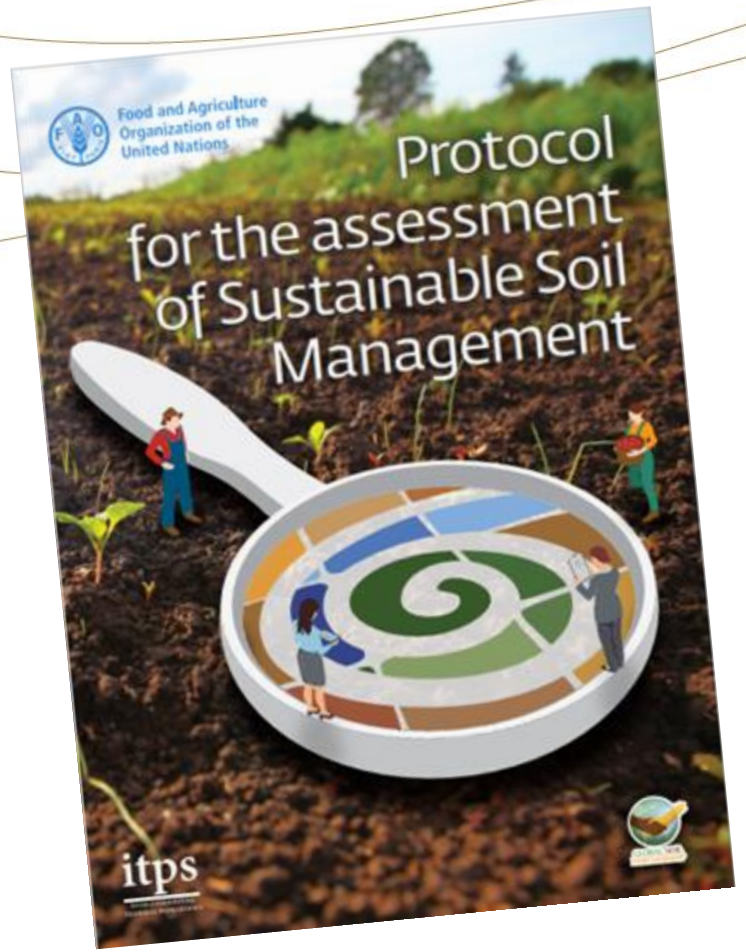
Agroforestry systems (shade, soil protection)

Green manure, cover crops

Grass/Vetiver(Chrysopogon)

Phase IV

SSM Protocol



- ✓ Provides **key indicators (common to all RECSOIL projects)** and a set of **additional** indicators
- ✓ Provides the tools to assess **soil health** and **monitor the impact of management practices** on soil properties (physical, chemical and biological indicators)

Phase IV

SSM Protocol - 4 Key indicators

Soil productivity 	Agricultural productivity or biomass in dry matter (t ha^{-1} $year^{-1}$)
Soil organic carbon 	Organic carbon (%)
Soil physical properties 	Bulk density (kg dm^{-3}) In some cases, bulk density can be complemented by available water capacity, or other relevant soil physical properties *(See additional indicators)*
Soil biological activity 	Soil respiration rate (gCO_2 m^{-2} d^{-1}) Ideally combined with at least one other biological indicator *(See soil biological activity p. 4 and 5)*

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Phase IV

Additional indicators for monitoring

Soil Nutrients
(P, N, K, etc)

Soil salinity
(EC- Electrical conductivity)

Acidity – Alkalinity
pH

Available water capacity
(FC-PWP)

Water infiltration

Soil penetration resistance

Erosion
(USLE, erosión pins, Gerlacht boxes, etc)

Biological activity
(Enzimatic activity, microbial biomass, etc.)

Soil Biodiversity
(e.g. pitfall traps, etc)

Soil pollution
(concentration, trace elements, pesticides, etc)

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Key indicators sampling and monitoring

Phase V-VII

What to measure?

- Total SOC (%)
- Bulk density (t /m3)
- Particulate Organic Carbon (POC, optional)

→ C stocks (t C /ha)

- Soil respiration (+ other biological parameters
- Soil productivity (per hectare)

+

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Phase V-VII

Key indicators sampling and monitoring

Depth?

- Minimum:
  - 0 -30 cm (for SOC, chemical and physical parameters)
  - 0 – 10 cm (for biological parameters)
- Recommended: 0-10 cm + 10-30 cm
- Adaptations (to use chemical sampling data)

  E.g. 0-20 cm + 20-40 cm (+40-60 cm)

Frequency?

- Baseline (time= 0) Mandatory
- 2 years (optional)
- 4 years (mandatory)

Promoting s

Soil health monitoring

Phase V-VII

VSA -Visual Soil Assessment

(quali – quantititative) (Based on Shepherd 2008 – FAO)

FIGURE 1: Visual scoring (VS) of soil structure and consistence under cropping

GOOD CONDITION VS = 2
Good distribution of friable finer aggregates with no significant clodding

MODERATE CONDITION VS = 1
Soil contains significant proportions of both coarse firm clods and friable, fine aggregates

POOR CONDITION VS = 0
Soil dominated by extremely coarse, very firm clods with very few finer aggregates

Measured every year – based on the results SSM practices may be adapted

VSA of indicators such as:

Soil structure

Porosity

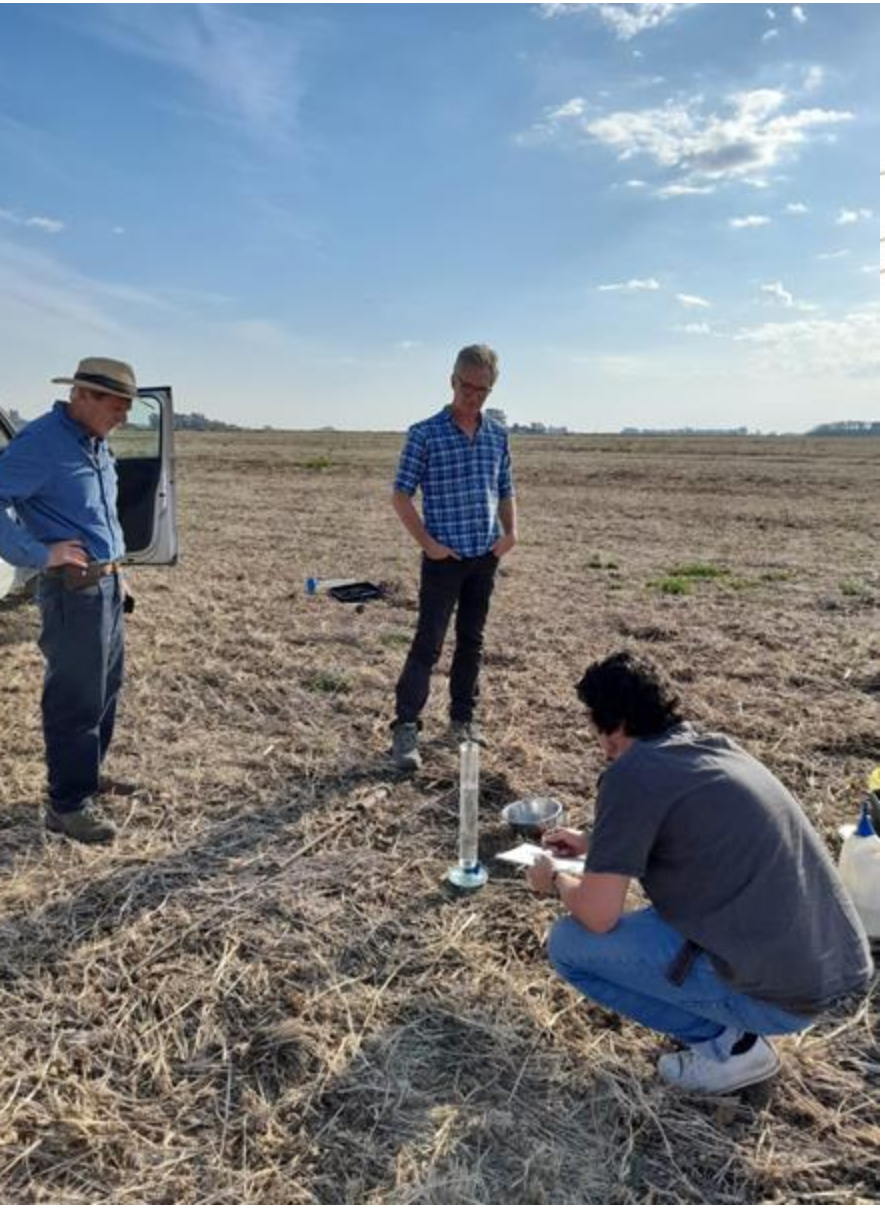
Color and mottles

Growth of roots, etc

Poor condition

Moderate condition

Good condition



E.g. Soil Health assessment no-till Argentina

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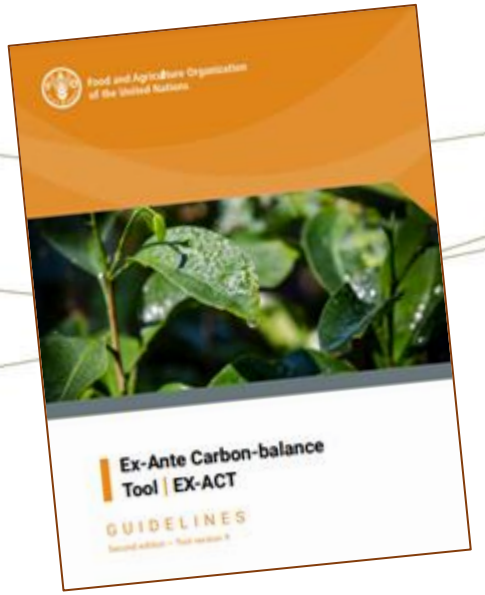
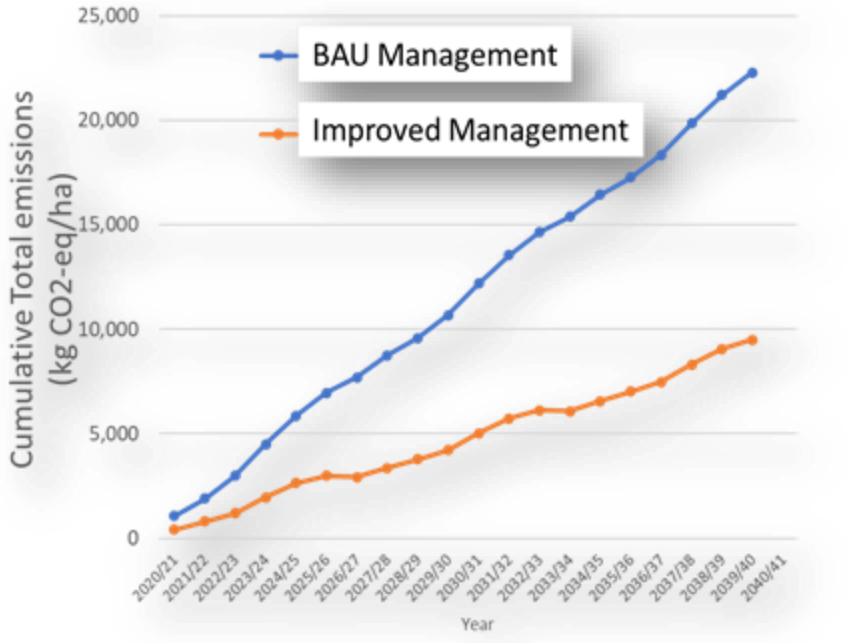
Phase V-VII

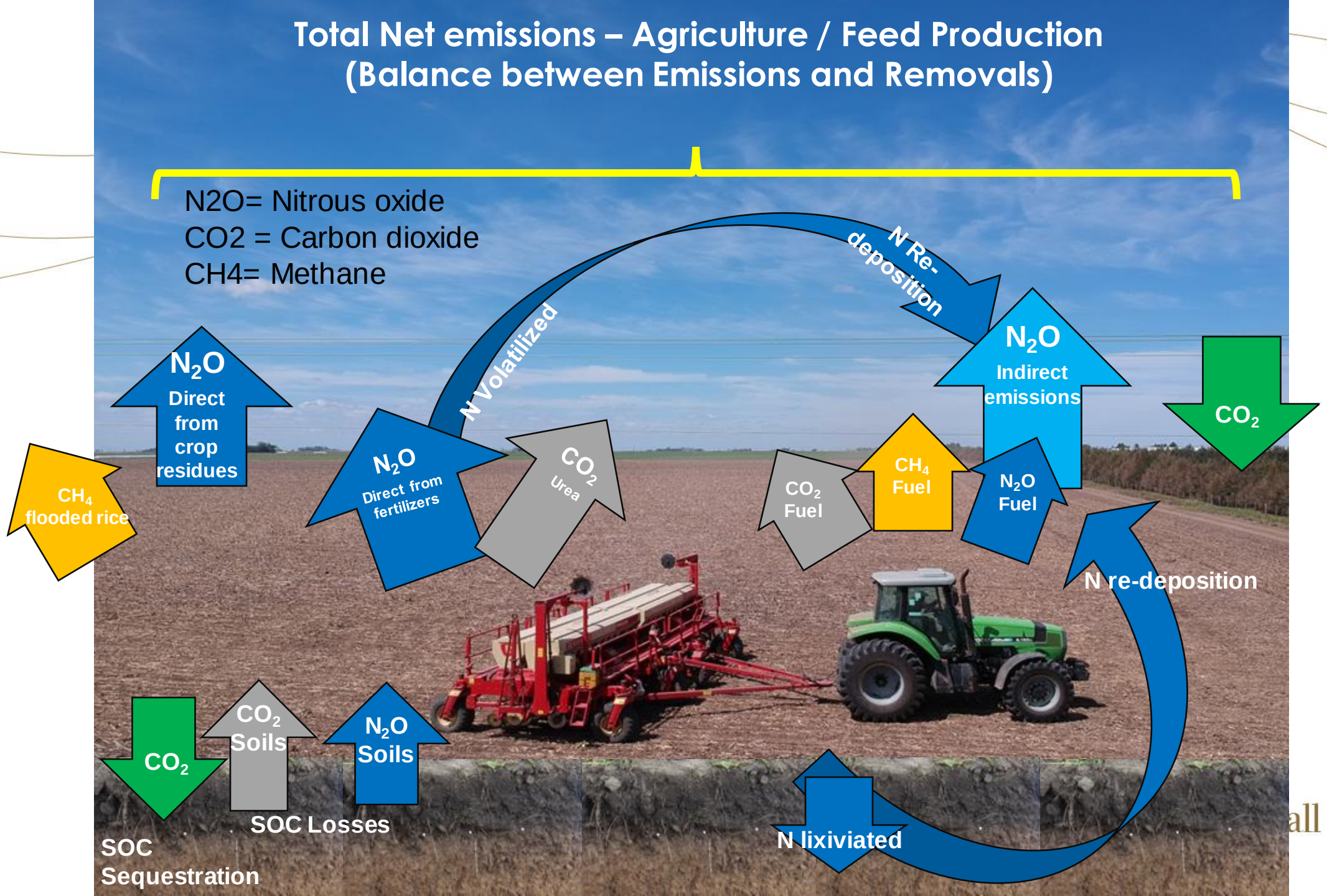
Estimation of GHG emissions





- Basic estimate of the project's GHG emissions (IPCC 2019) (using EX-ACT or another peer reviewed tool)
- Done at the baseline and at the end of the Project
- Other tools allow to monitor on annual basis

Total Net emissions – Agriculture / Feed Production (Balance between Emissions and Removals)



all

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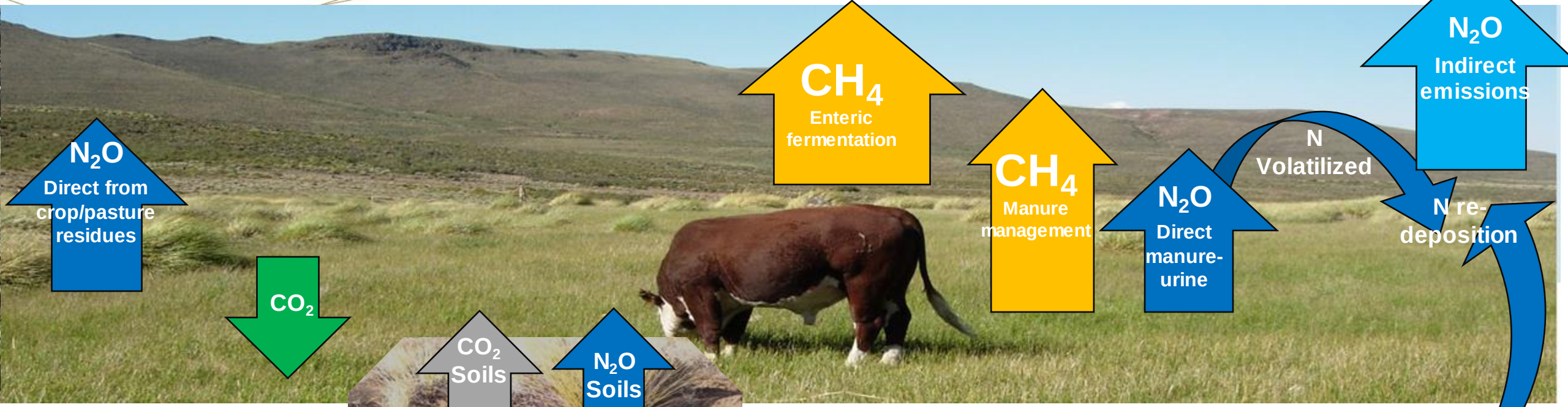
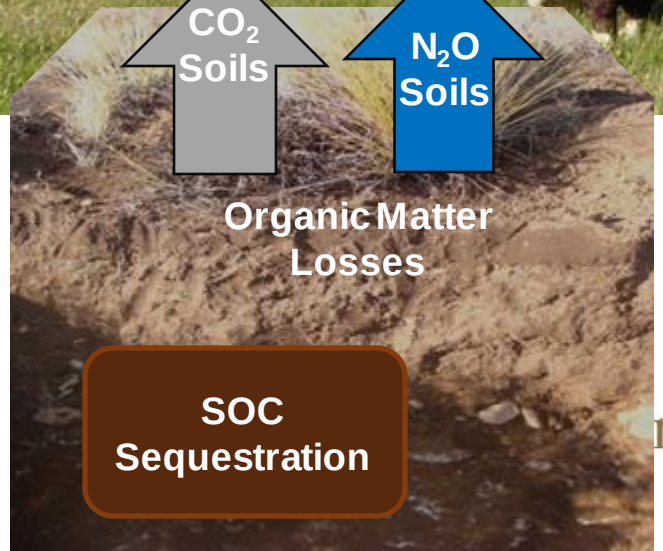
Total Net emissions – Livestock
(Balance between Emissions and Removals)





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Phase VI

Adoption of SSM practices

Cover Crops
Hairy Vetch +no till– Pergamino Argentina

Perennials in anual crop rotations

Improved Crop rotation and intercropping

use of organic amendments*

such as animal manure, plant residues, compost, digestates, biochar

Judicious fertilizer and inorganic amendments use*

methods, rates, timing, source

Biofertilizers, such as mycorrhiza, phosphate solubilizing bacteria, bio-inoculants and bioinducers;

Soil water conservation practices - terracing

Prevent or alleviate soil compaction

Grazing management to promote soil cover

Silvopastoral; agroforestry

Restoring abandoned croplands

Conservation tillage/ reduced /No till

Adoption of SSM practices

Phase VI

- Focus on SSM practices for soil pollution mitigation and remediation
- **Ecosystem-based solutions for soil remediation -** use micro and macroorganisms and plants
  - ➢ Bioremediation
  - ➢ Phytoremediation
  - ➢ Vermiremediation

Code	Code LU	Land Use	Code type	Type of practices	Code P	Practices
1.5.1	1	Croplands	5	Chemical and mineral additions	1	Mineral fertilization (macro, secondary and micronutrients)
1.5.2	1	Croplands	5	Chemical and mineral additions	2	Fertigation
1.5.3	1	Croplands	5	Chemical and mineral additions	3	Enhanced efficiency fertilizers
1.5.4	1	Croplands	5	Chemical and mineral additions	4	Improved application method (incorporated, fractionned, site specific)
1.5.5	1	Croplands	5	Chemical and mineral additions	5	Mineral (Ca) amendments to sequester soil inorganic carbon
1.5.6	1	Croplands	5	Chemical and mineral additions	6	Use of emissions inhibitors (nitrification, urease)
1.6.1	1	Croplands	6	Addition of other living organism	1	Biofertilizers application
1.6.2	1	Croplands	6	Addition of other living organism	2	Bioles or organic liquid fertilizers
1.6.3	1	Croplands	6	Addition of other living organism	3	Use of emissions inhibitors (nitrification, urease)
1.6.4	1	Croplands	6	Addition of other living organism	4	Bioinoculants
1.6.5	1	Croplands	6	Addition of other living organism	5	Biostimulants and phytohormones
1.6.6	1	Croplands	6	Addition of other living organism	6	Bioremediation and bioaugmentation
1.6.7	1	Croplands	6	Addition of other living organism	7	Earthworm inoculation
1.6.8	1	Croplands	6	Addition of other living organism	8	Hyperaccumulators
1.6.9	1	Croplands	6	Addition of other living organism	9	Use of biocontrol organisms
1.6.10	1	Croplands	6	Addition of other living organism	10	Use of oxalogenic plants to sequester soil inorganic carbon
1.6.11	1	Croplands	6	Addition of other living organism	11	Pollinators
1.6.12	1	Croplands	6	Addition of other living organism	12	Use of adapted crops (crop suitability)
1.7.1	1	Croplands	7	Genetic engineered crops	1	Genetic engineered salt- tolerant crops
1.7.1	1	Croplands	7	Chemical amendments	1	Liming and calcium amendments
1.8.2	1	Croplands	8	Chemical amendments	2	Biochar
1.8.4	1	Croplands	8	Chemical amendments	4	Gypsum on sodic soils

Phytoremediation

Site Name	Plant species	Contaminant
Guadiamar river area, (Aznalcollar mine, Spain)	Various	Pb, Cu, Zn, Cd, Ti, Sb, As
BTEX-contaminated groundwater (Genk, Belgium)	*Populus x canadensis* (poplar)	BTEX
Eka Chemicals site (Bohus, Sweden)	Various	Chlorinated organics, mercury
Former municipal gaswork site (Holte, Denmark)	Poplar and willow	Cyanide, BTEX, PAHs, oil
Pesticides storage (Niedwiady, Poland)	Poplars	Pesticides

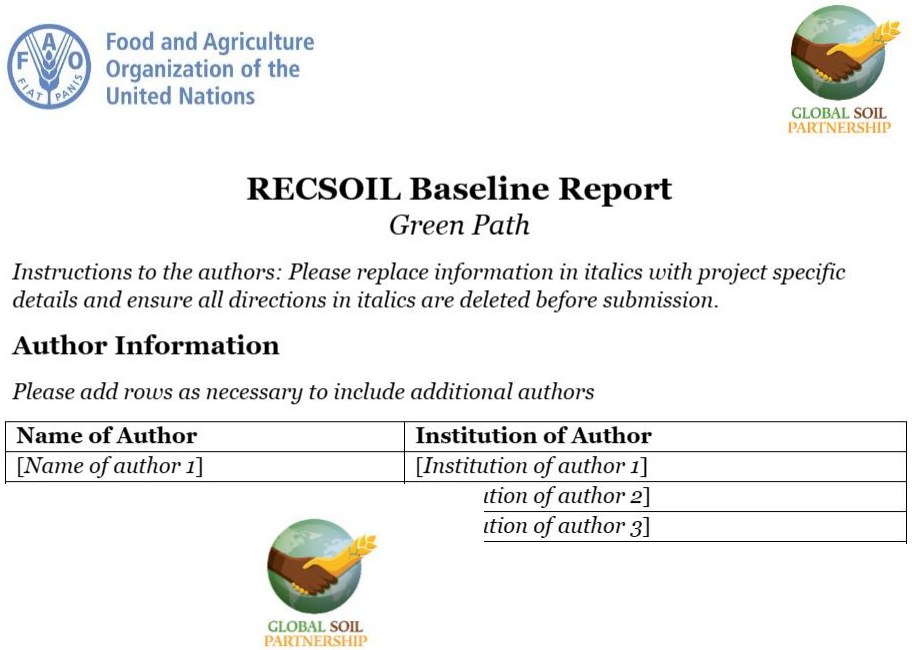
Schwitzguébel et al. 2002. J. Soil & Sediments. DOI: 10.1007/BF02987877

Reporting

Phase V-VII

Standardized reporting templates and feedback workshops for:

- Baseline assessment
- Annual Report
- Final report
- Continuity Planning



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RECSOIL Baseline Report

Green Path

Instructions to the authors: Please replace information in italics with project specific details and ensure all directions in italics are deleted before submission.

Author Information

Please add rows as necessary to include additional authors

Name of Author	Institution of Author
[*Name of author 1*]	[*Institution of author 1*]
	ıtion of author 2]
	ıtion of author 3]

Food and Agriculture Organization of the United Nations

GLOBAL SOIL PARTNERSHIP

RECSOIL Midterm Report

Green Path

Date of Report: *[DD Mon, YYYY]*

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Author Information

Please add rows as necessary to include additional authors

Name of Author	Institution of Author
[*Name of author 1*]	[*Institution of author 1*]
[*Name of author 2*]	[*Institution of author 2*]
[*Name of author 3*]	[*Institution of author 3*]

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Thank you!

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