Food and Agriculture Organization of the United Nations

7th Meeting of the International Network of Soil Information Institutions (INSII)

09-10-11 November 2021

Online meeting

GSOCseq v1.1

Guillermo Peralta & Isabel Luotto

INSII

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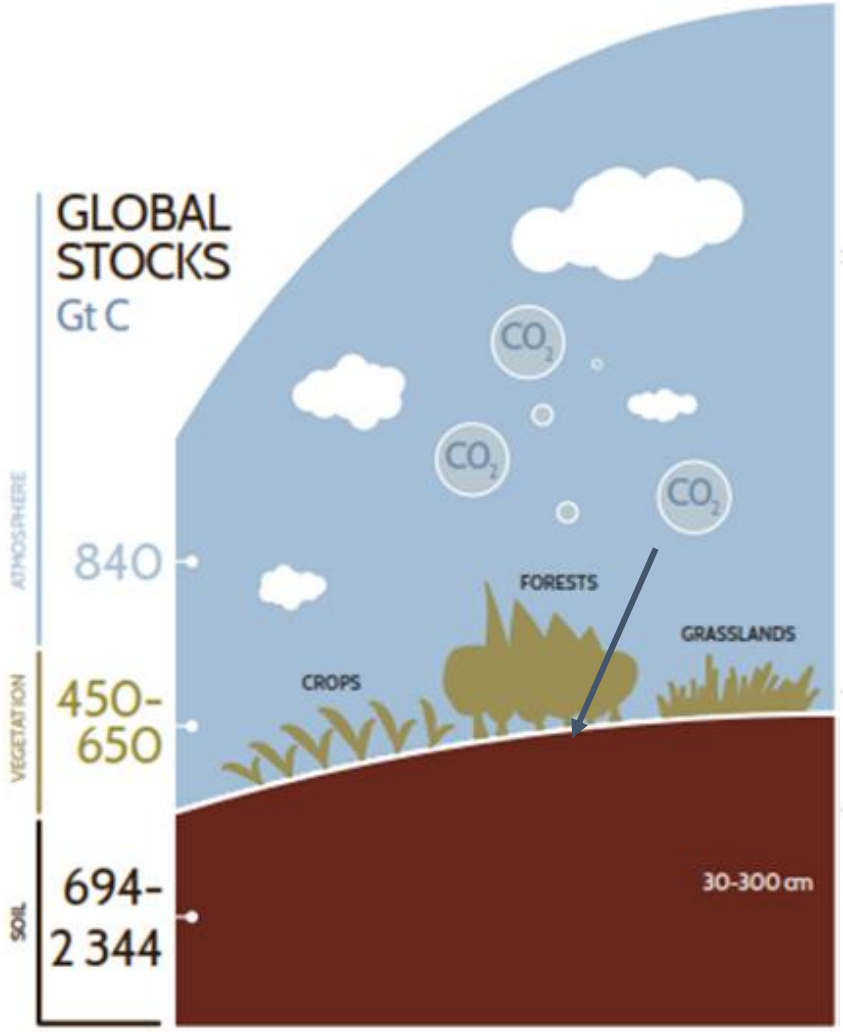
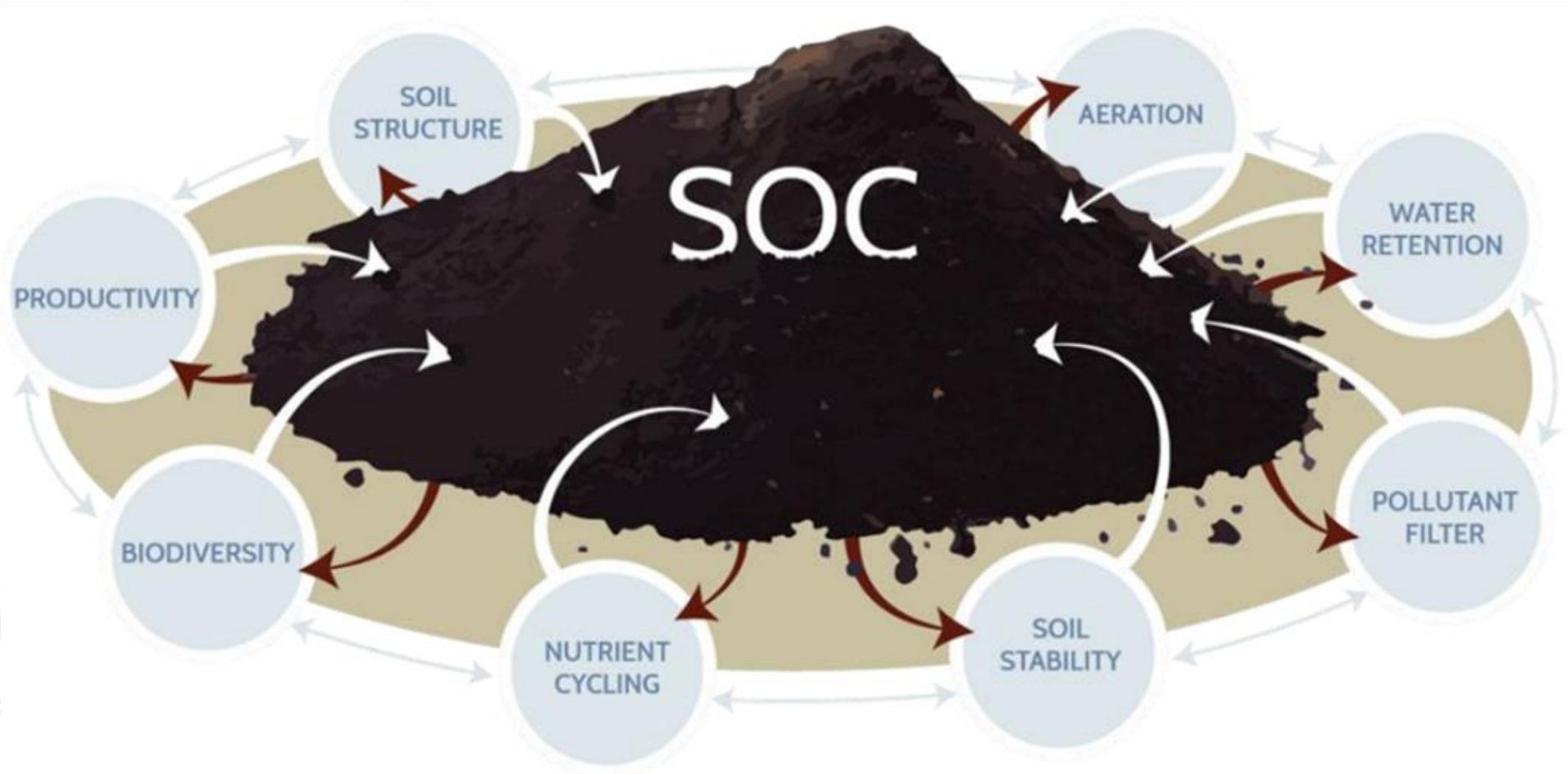
Soil organic carbon (SOC): Climate change



- **SOC** represents the **largest C pool** in terrestrial ecosystems
- Due to the magnitude, a small increase in SOC stocks can transform soils from greenhouse gas (GHG) **sources** to potential **sinks** (Paustian et al., 2016)
- **CO_2 sequestration** as SOC through sustainable soil management (SSM) practices has been outlined as one of the most cost-effective practices to mitigate GHG emissions (Smith et al, 2008; Lal et al., 2018; IPCC, 2019; Smith et al., 2020).

Soil organic carbon (SOC): Food security



Following FAO members request, Global Soil Partnership (GSP) started the GSOCseq initiative to:

Why **GSOC**seq?

1. **Set** attainable and evidence based **national targets for carbon sequestration**

2. **Identify areas** that have high SOC sequestration **for SSM projects**

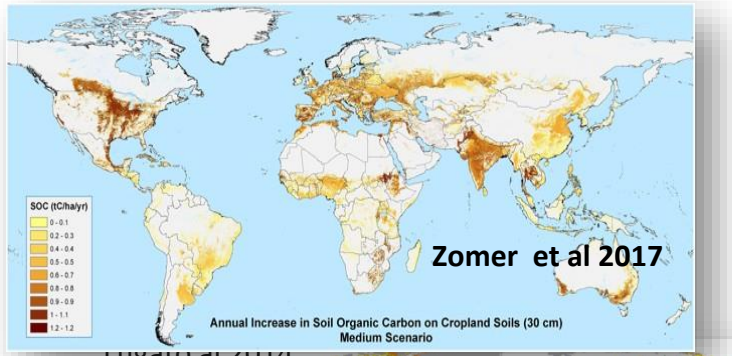
3. **Improve technical capacities** on sustainable soil management, soil data management, digital soil mapping and modelling



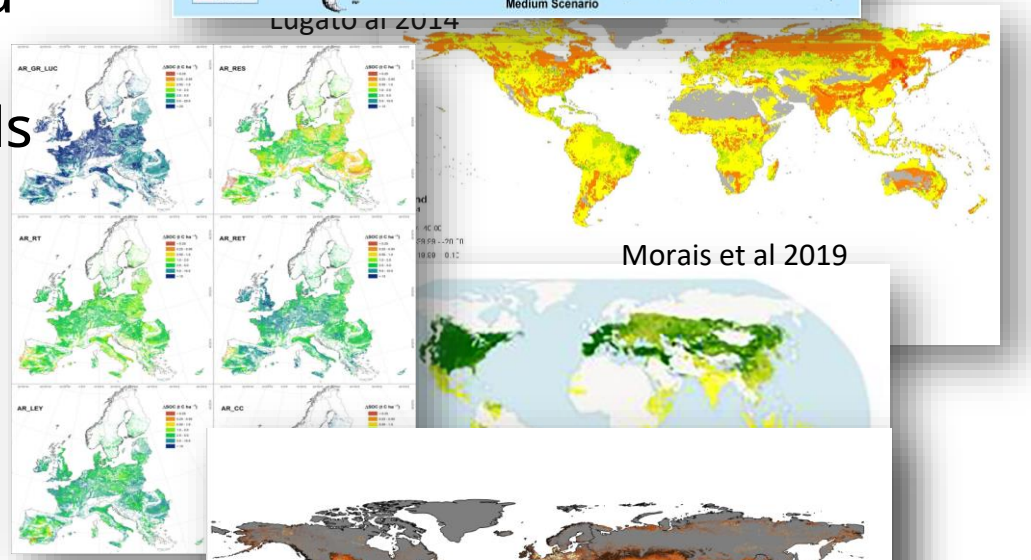



GSOCseq a Global Map based on country-driven (“bottom-up”) approach

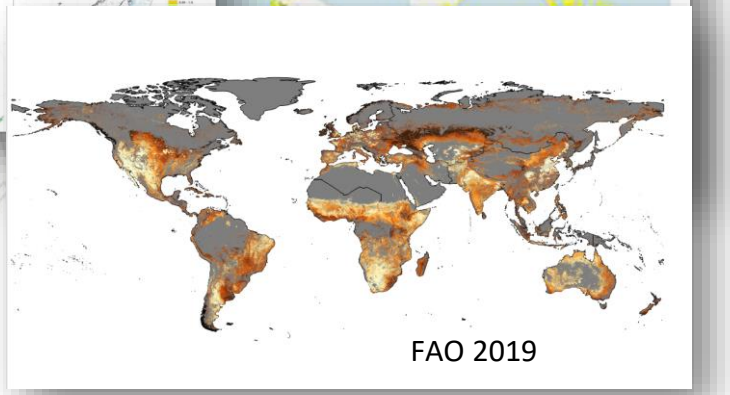
- **Local expertise**, best available local data and local knowledge
- **Interaction** from experts from different fields and institutions
- Constitutes a **“living product”** being continuously updated and **improved**
- **Tool** to encourage SSM practices



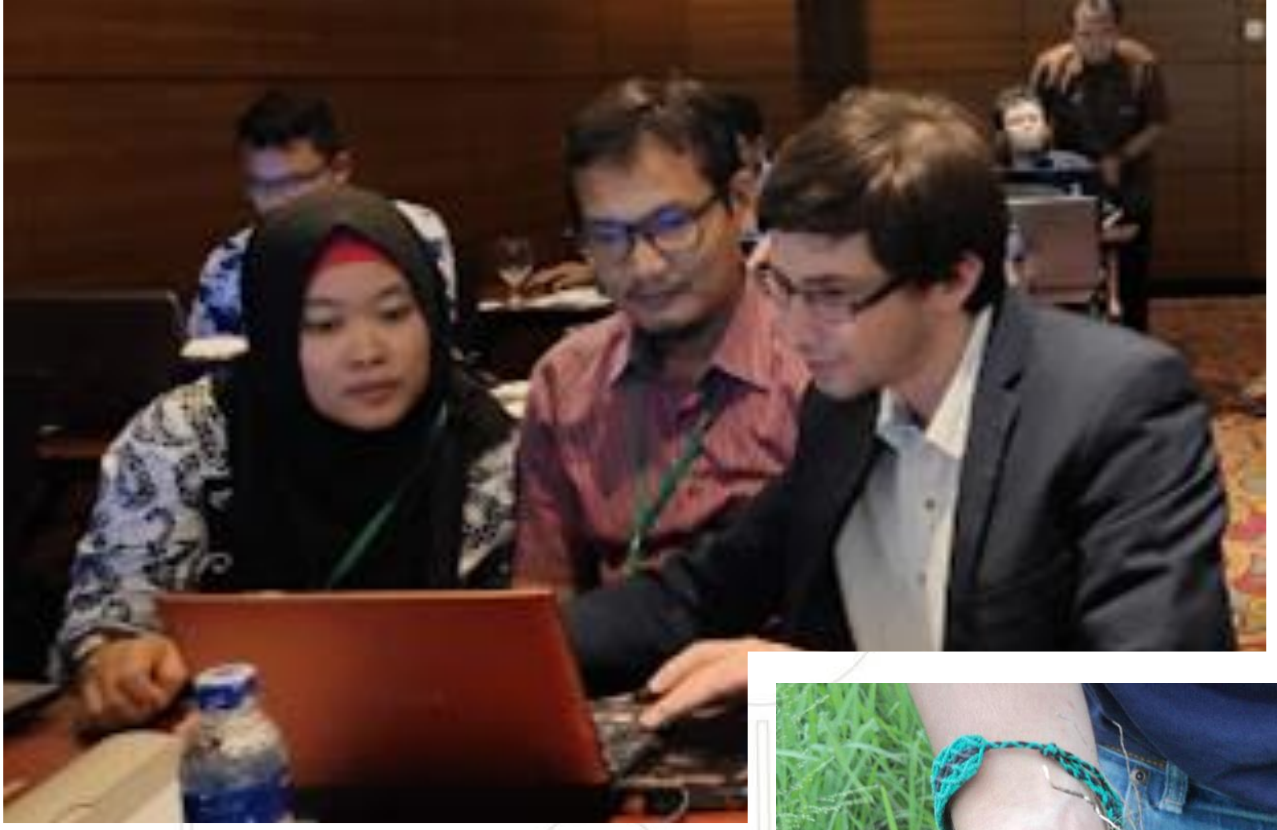
Lugato et al 2014



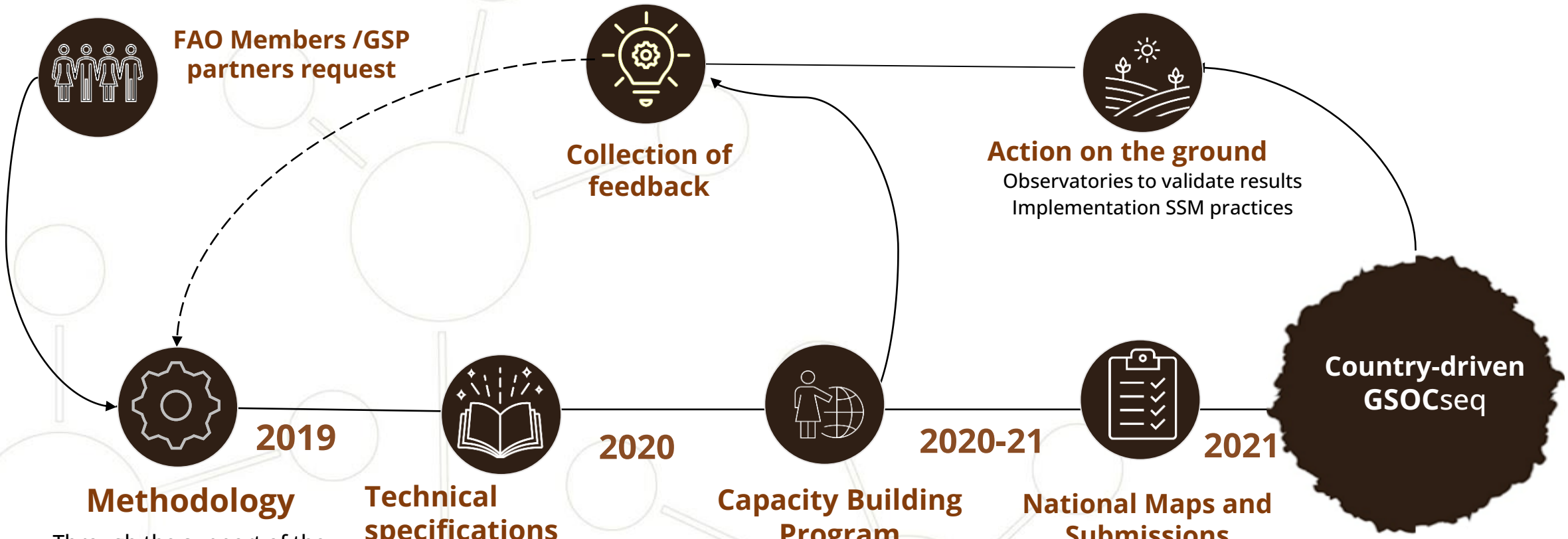
Morais et al 2019



FAO 2019



How is the GSOCseq process?



How?
Framework -Summary

- 20-year projections
- After the adoption of SSM that increase C inputs
- 0-30 cm Depth
- In current agricultural lands (Each country can model preferred land uses, restoration, etc.)

Why RothC as standard model?

- Standard method among countries (DayCent, Century, ICBM, YASSO,DAISY,AMG, CLM5, etc.)
- Fewer data requirements; data relatively simple to obtain;
- It has been applied across several ecosystems, climate conditions, soils and land use classes;
- Successfully applied at national, regional and global scales; e.g. Smith et al., (2005), Smith et al., (2007), Gottschalk et al., (2012), Wiesmeier et al., (2014), Farina et al., (2017), Mondini et al., (2018), Morais et al., (2019)
- It (or its modified/derived version) has been used to estimate carbon dioxide emissions and removals in different national GHG inventories as a Tier 3 approach; Smith et al., (2020): Australia (as part of the FullCam model, Japan (modified RothC), Switzerland, and UK (CARBINE, RothC).

RothC Data requirements

Climate

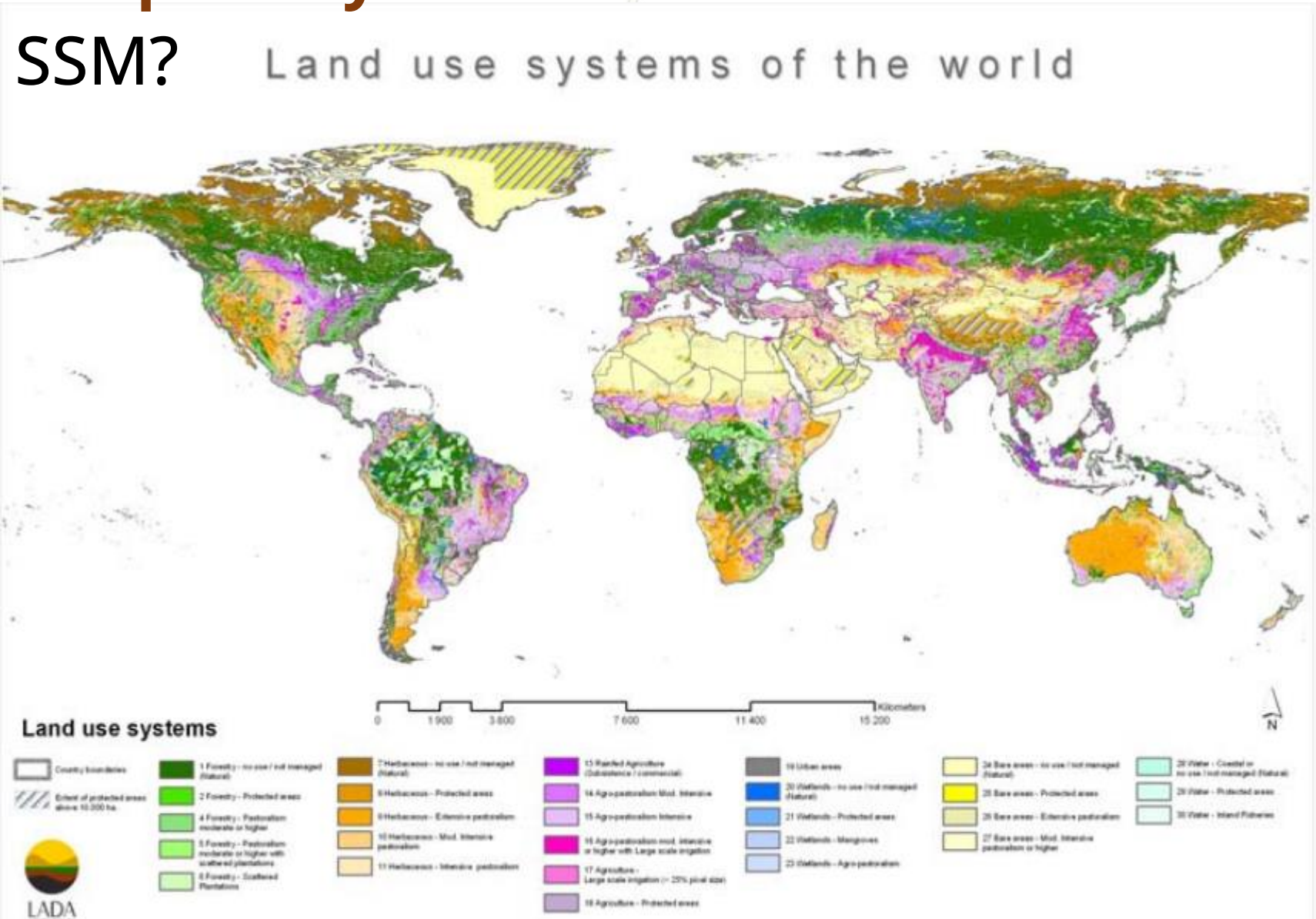
Soil

Management

Climate Data	Soil Data	Land Use- Management Data
1. Monthly rainfall (mm) 2. Average monthly mean air temperature (°C) 3. Monthly open pan evaporation (mm)/evapotranspiration (mm)	1. Total initial 0-30cm SOC stocks (t C ha^{-1}) 2. Initial C stocks of the different pools (t C ha^{-1}): DPM, RPM, BIO, HUM, IOM 3. Clay content (%) at simulation depth.	1. Monthly Soil cover (binary: bare vs. vegetated) 2. Monthly Carbon inputs from plant residues (aboveground + belowground), (t C ha^{-1}) 3. Monthly Carbon inputs from organic fertilizers and grazing animals' excretion (t C ha^{-1}) 4. DPM/RPM ratio, an estimate of the decomposability of the incoming plant material

How to harmonize and model thousands of different practices, often combined? ...Especially with limited data

SSM?



... First stage...

Practices that increase C inputs

3 scenarios:

+5 % increase Ci

+10 % increase Ci

+20 % increase Ci

Conservative ranges...may be high for other systems

based on Smith, 2004; Wiesmeier et al., 2016

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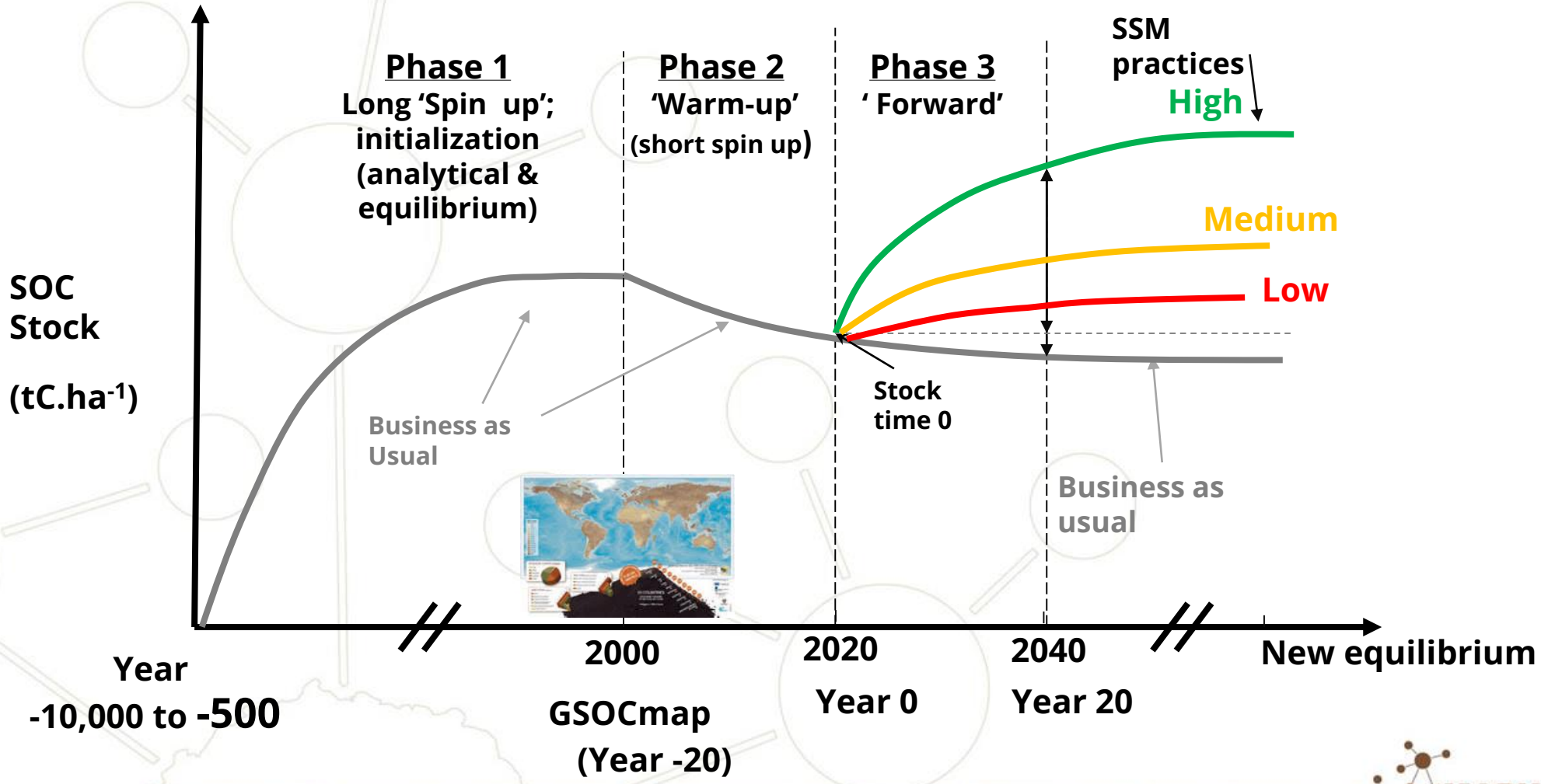
For each 1 x 1 km pixel:



Approach based on Smith et al. (2006; 2008); Gottschalk et al. (2012)

Uncertainty layers are estimated for each modeling unit and for each scenario:

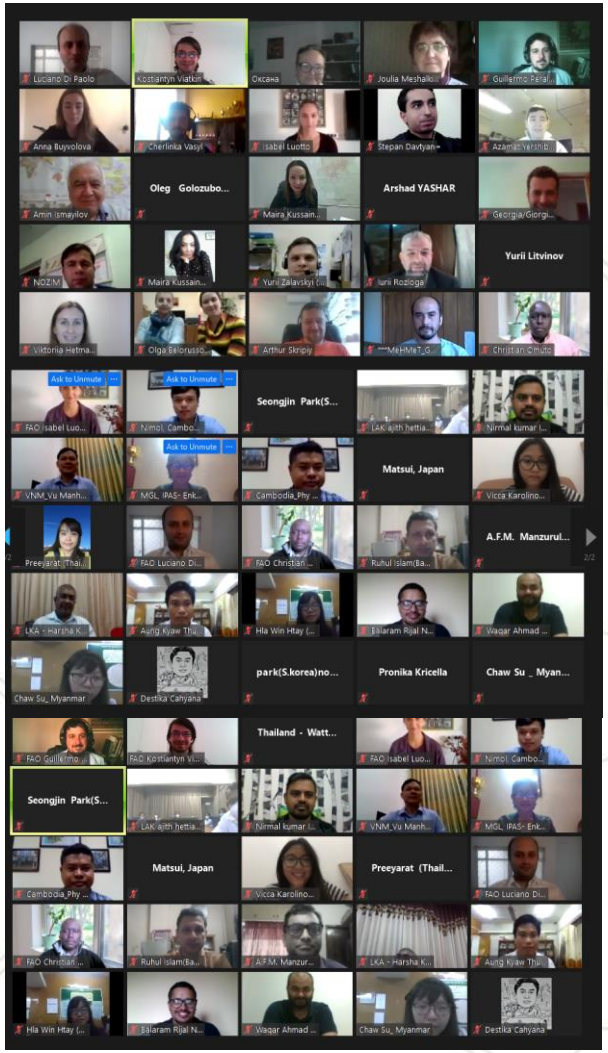
- They're based on the uncertainties of the input data considering minimum and maximum values (corresponding to the limits of a 95% confidence interval)
- A set of predefined input parameters, considered to have the greatest influence in RothC modeling results (initial SOC stocks, carbon inputs, and soil and climatic variables) was selected

Each national submission is going through Quality Assessment/Quality Check (QA/QC)

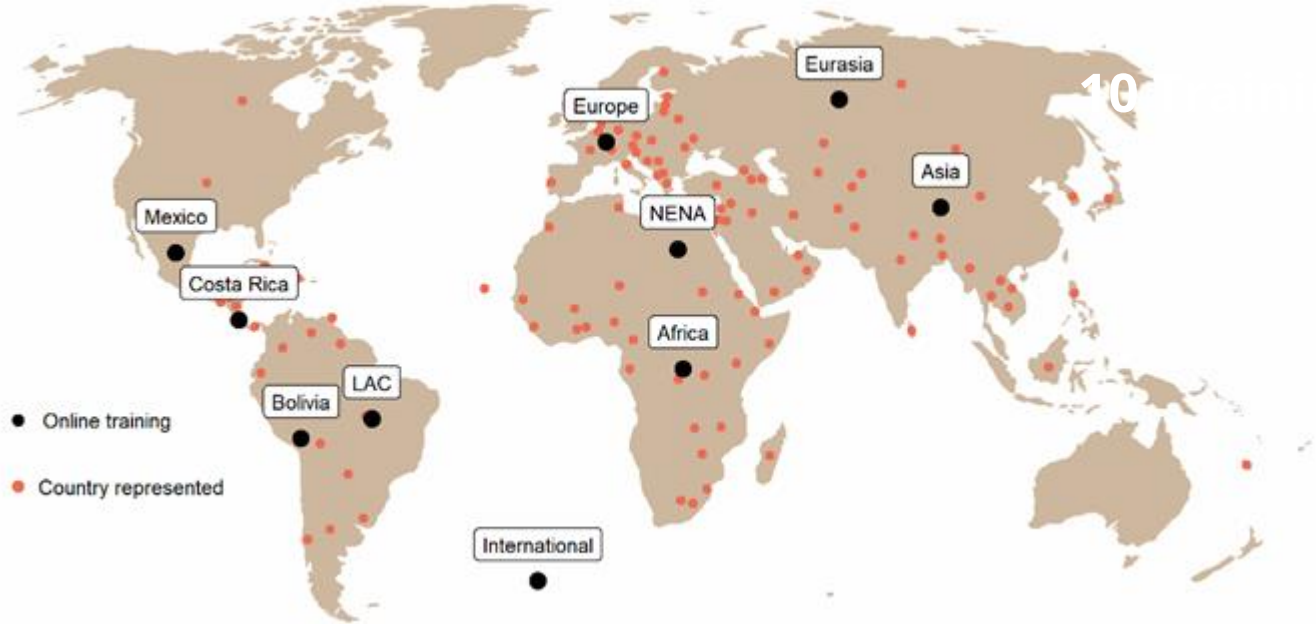
- The QA/QC protocol is available as an Annex on the Technical Manual: https://fao-gsp.github.io/GSOCseq/annex-ii-quality-assurance-and-quality-control.html

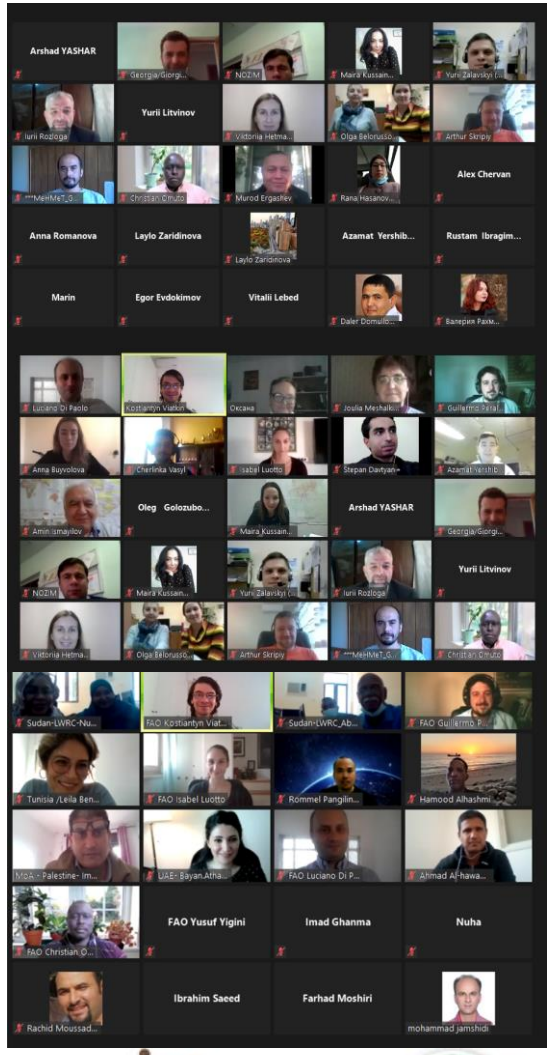
GSOCseq: National Submissions

Capacity development

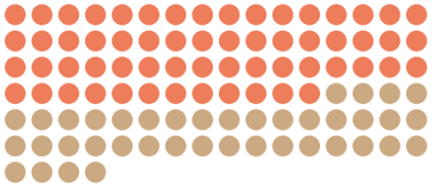


10 online trainings

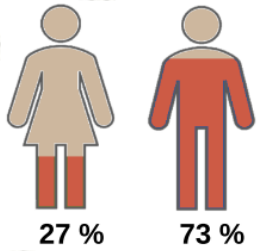




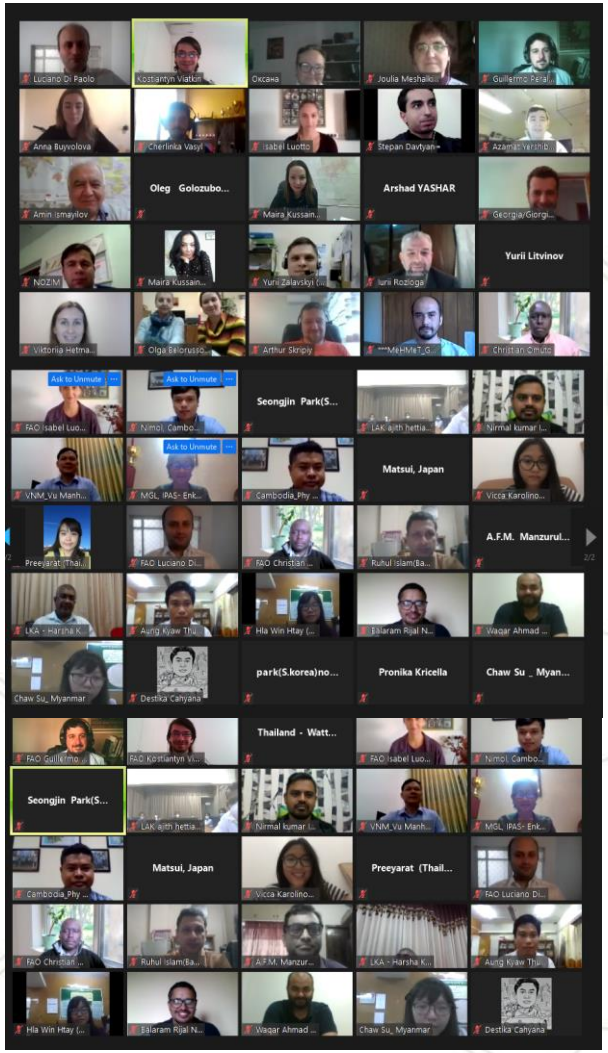
119 countries



433 participants

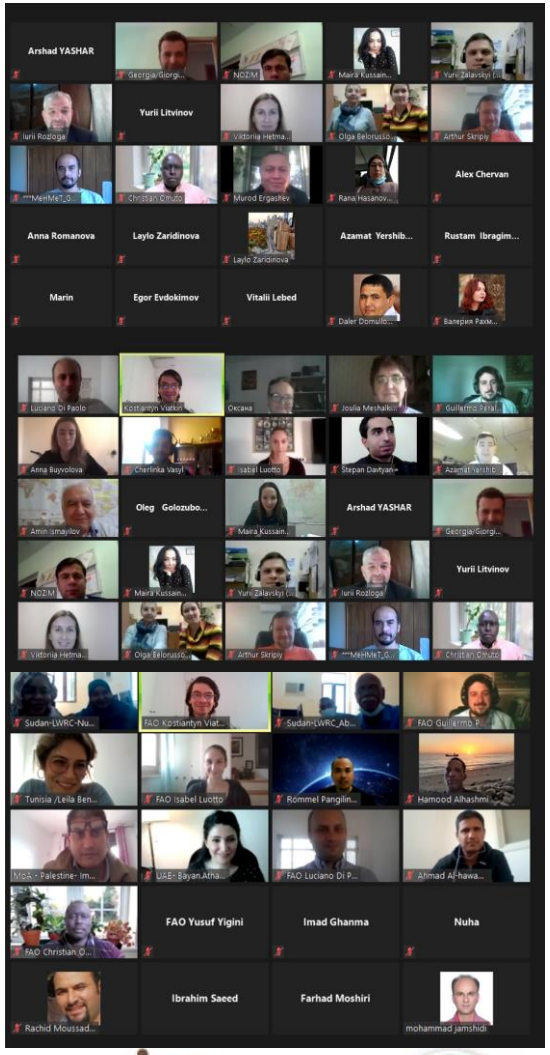


Contributions to date…



- **46 national submissions**
- **73 countries, map in progress** (temporarily filled using global layers)
- **69 no response;** no request to be blank; gap filled
- **9 countries blank**

Current version: 90% of the global agricultural area, being continuously updated



GSOCseq data platform

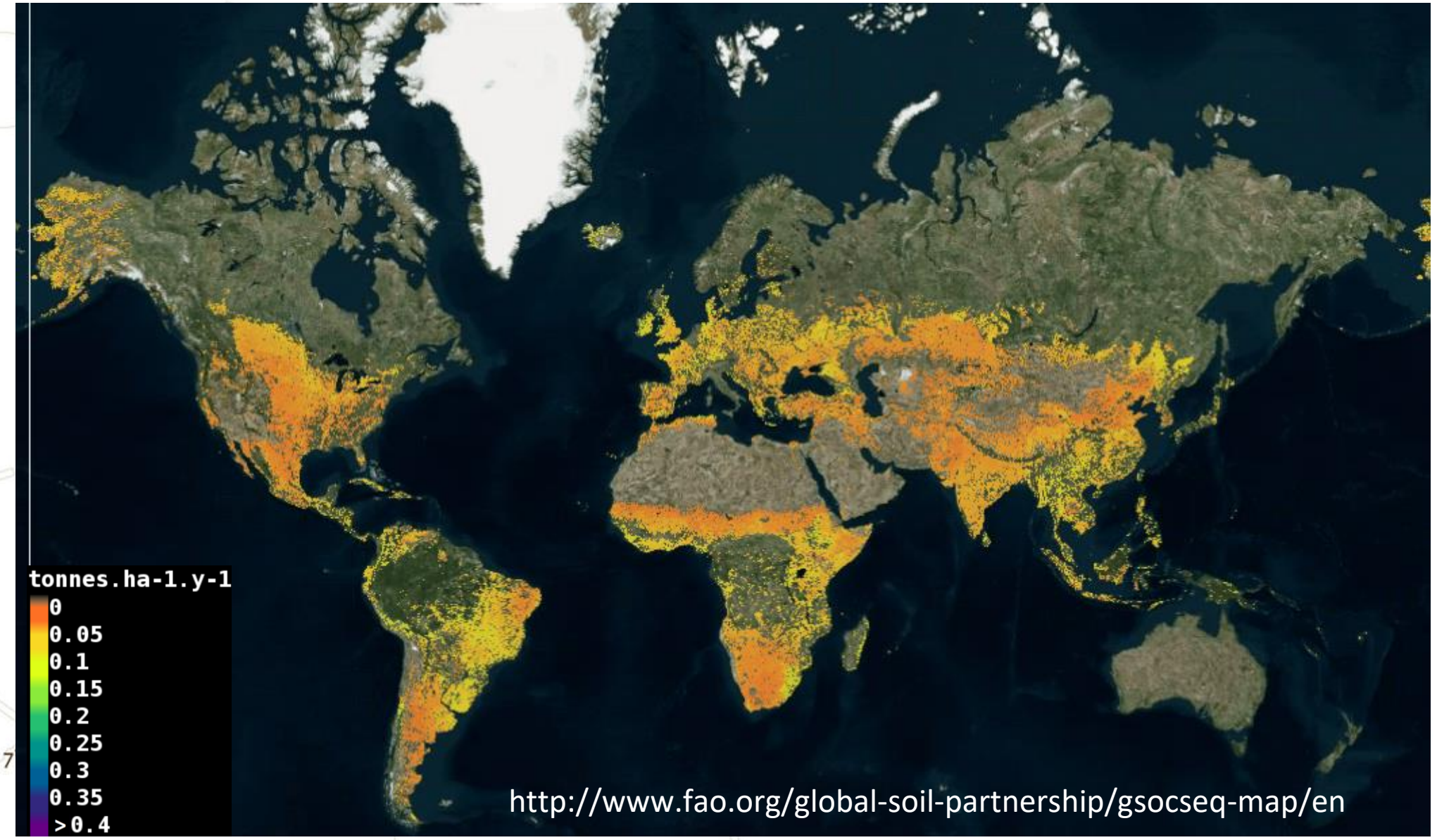
Relative sequestration rates tonnes.ha-1.y-1

SSM1 >> SSM3

GSOCseq v1.0.0

- SOC sequestration (tC/ha/yr) SSM 1-3
- Agricultural lands (croplands + grazing lands)
- 20-year period
- Depth: 0-30 cm
- 1 x 1 km resolution

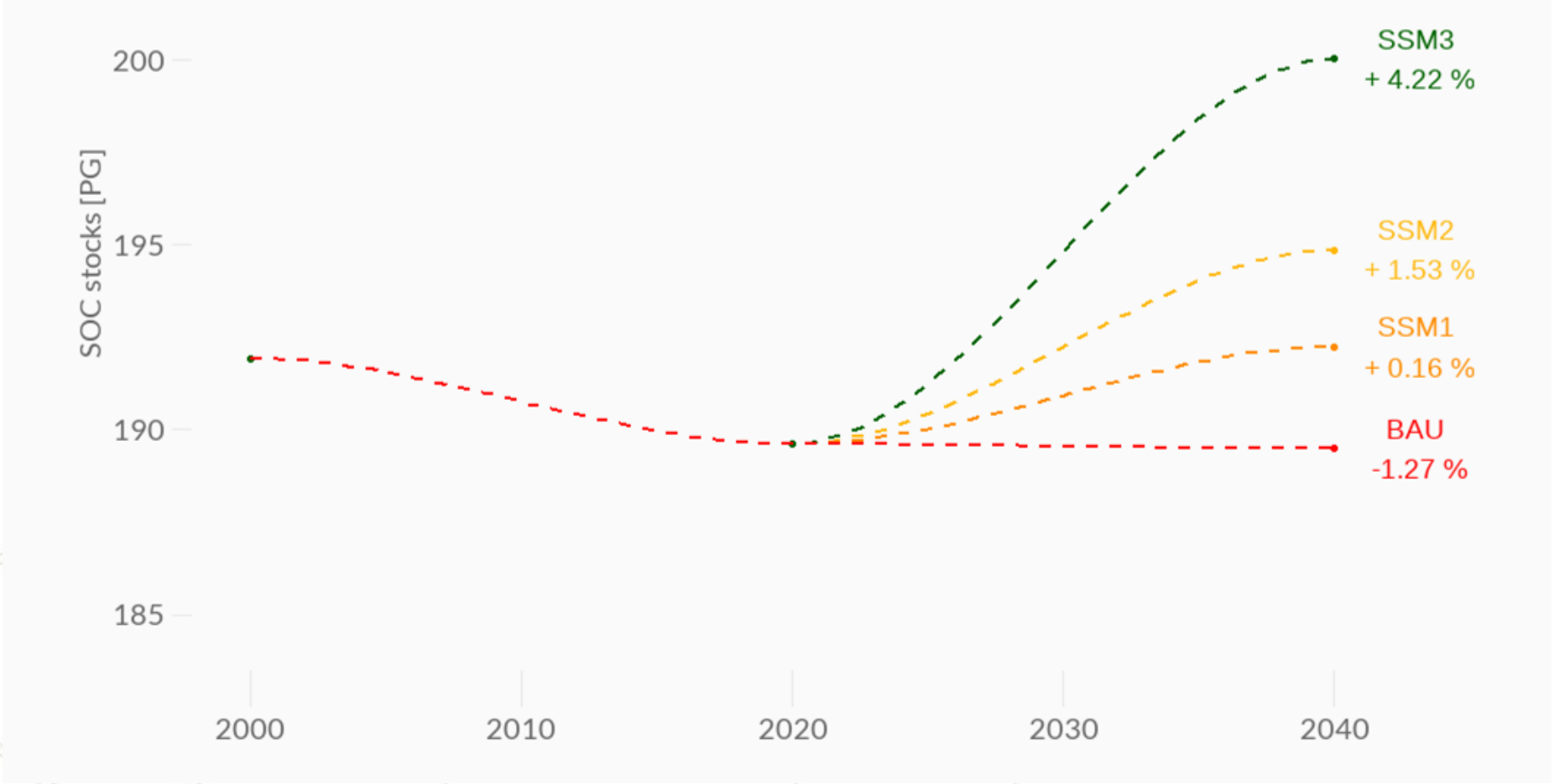
http://54.229.242.119/GloSIS/



GSOCseq v1.0.0 Uncertainties (%)

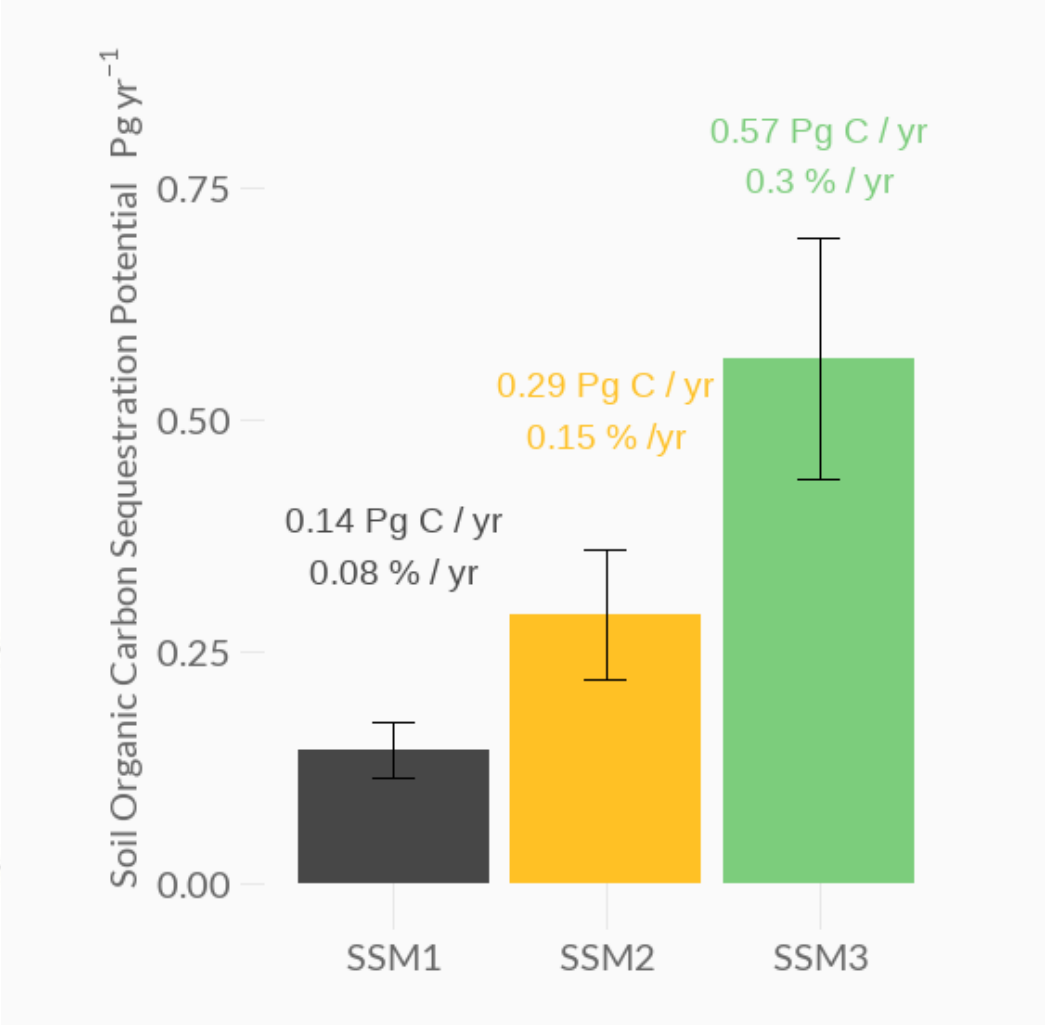
First results - Global SOC stocks*

***Excluding blank countries (GSOCseq v1.1)**



First results - Annual SOC sequestration*

*Excluding blank countries

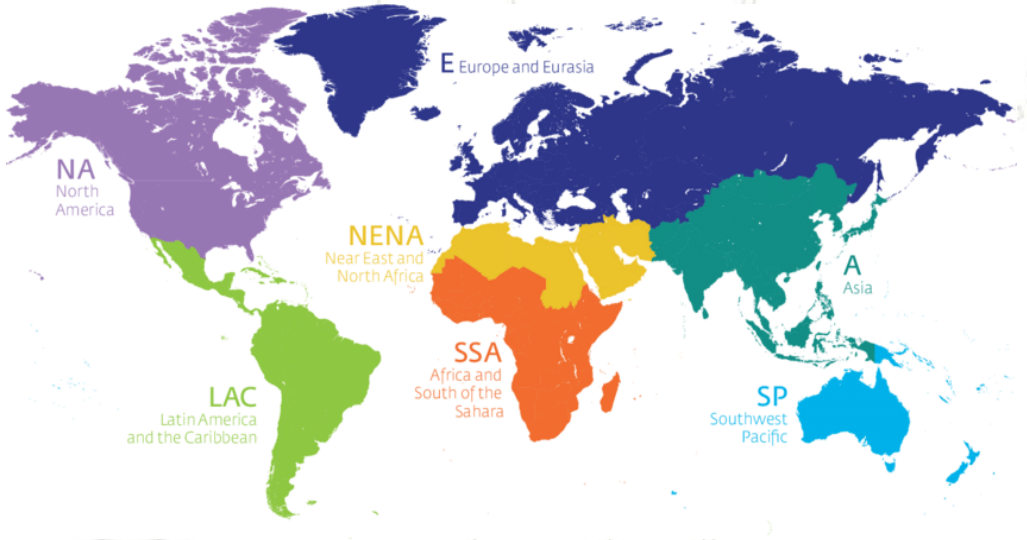


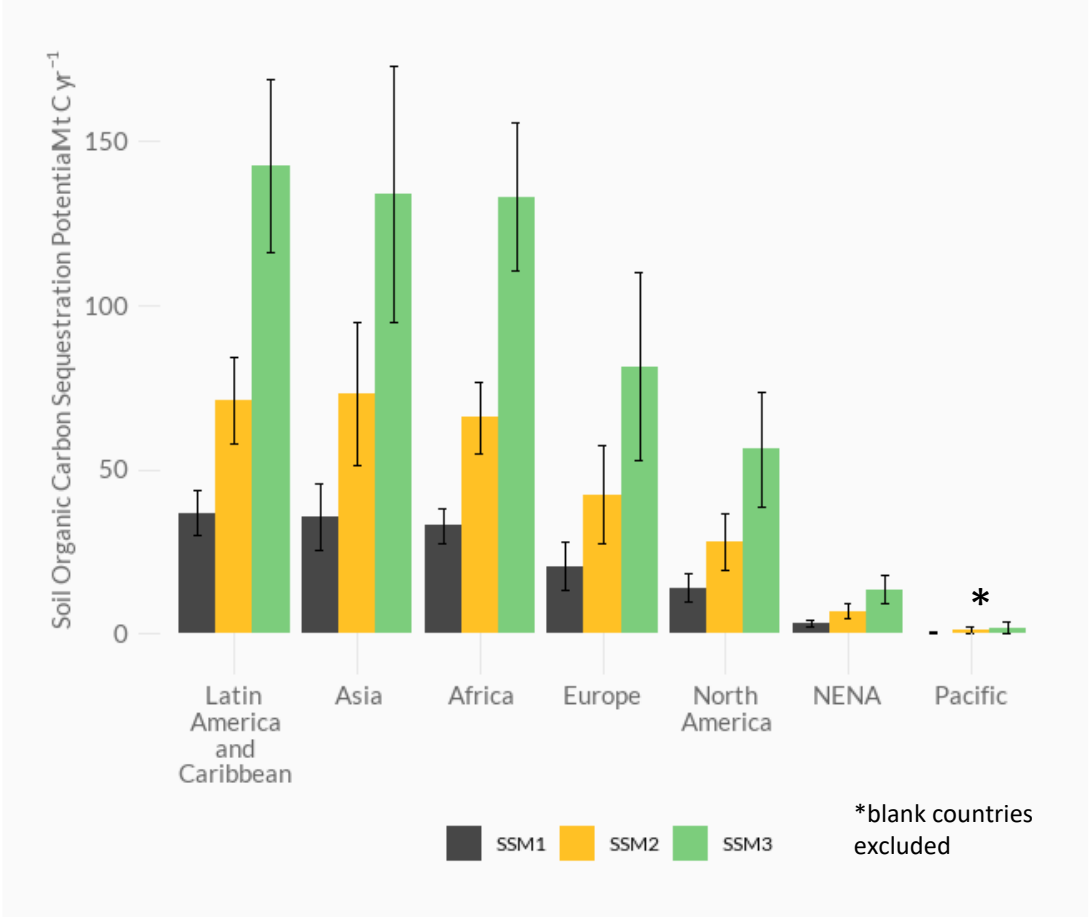
Previous estimates

Source	Seq.rate Pg C.year^{-1}
Paustian et al (2004)	**0.44 - 0.88**
Smith et al (2008)	**0.44 - 1.15**
Sommer and Bossio (2014) (croplands+grasslands)	**0.37 - 0.74**
Batjes et al (2019)	**0.32 - 1.01**
Lal et al (2018) (croplands+grasslands/shrublands)	**0.48 – 1.93**
Fuss et al (2018)	**0.54 – 1.36**

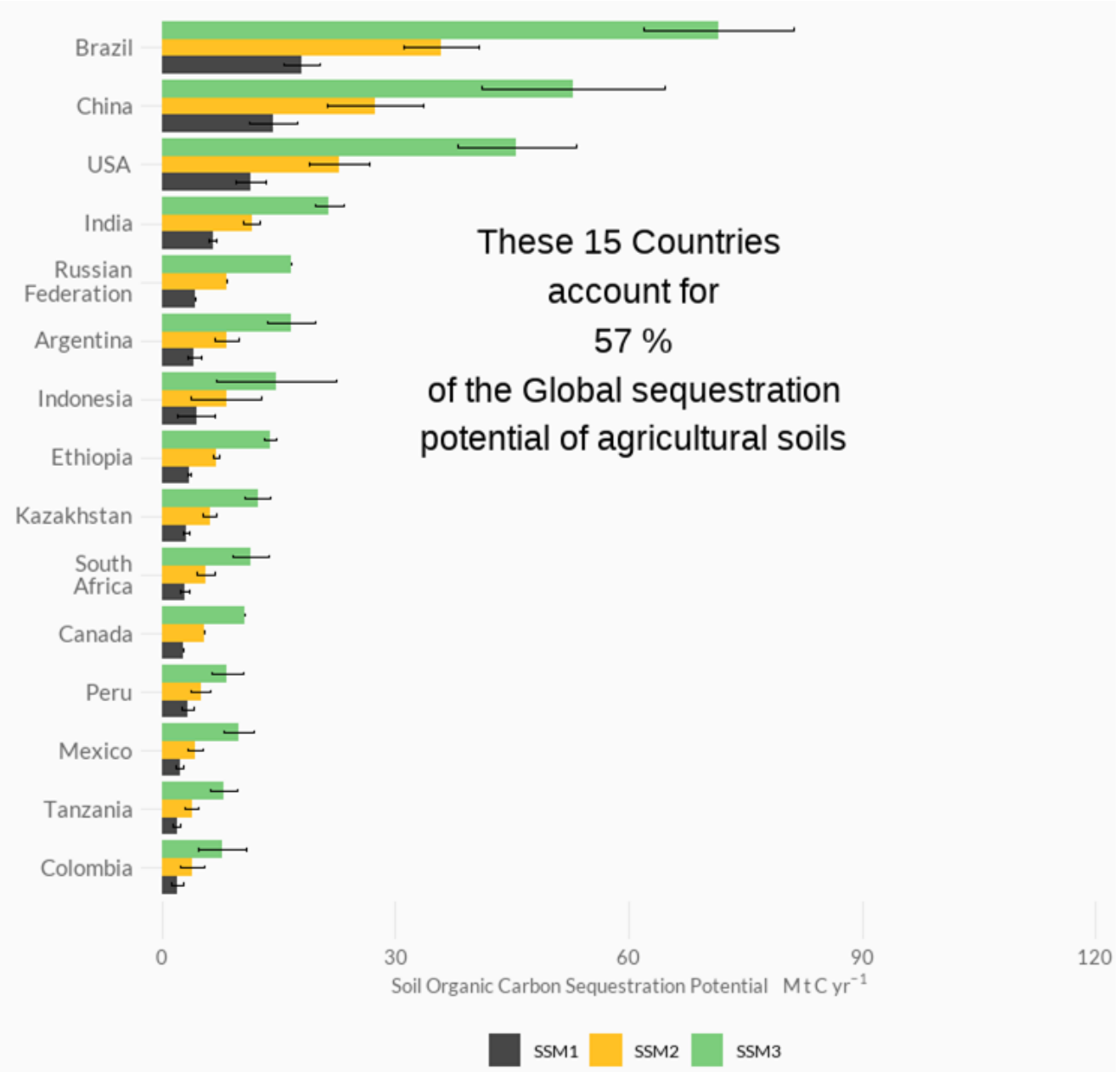
Potential uses - statistics

Which **climates**, **land uses**, **regions**, **countries** have greater SOC sequestration potential?





Potential uses - statistics

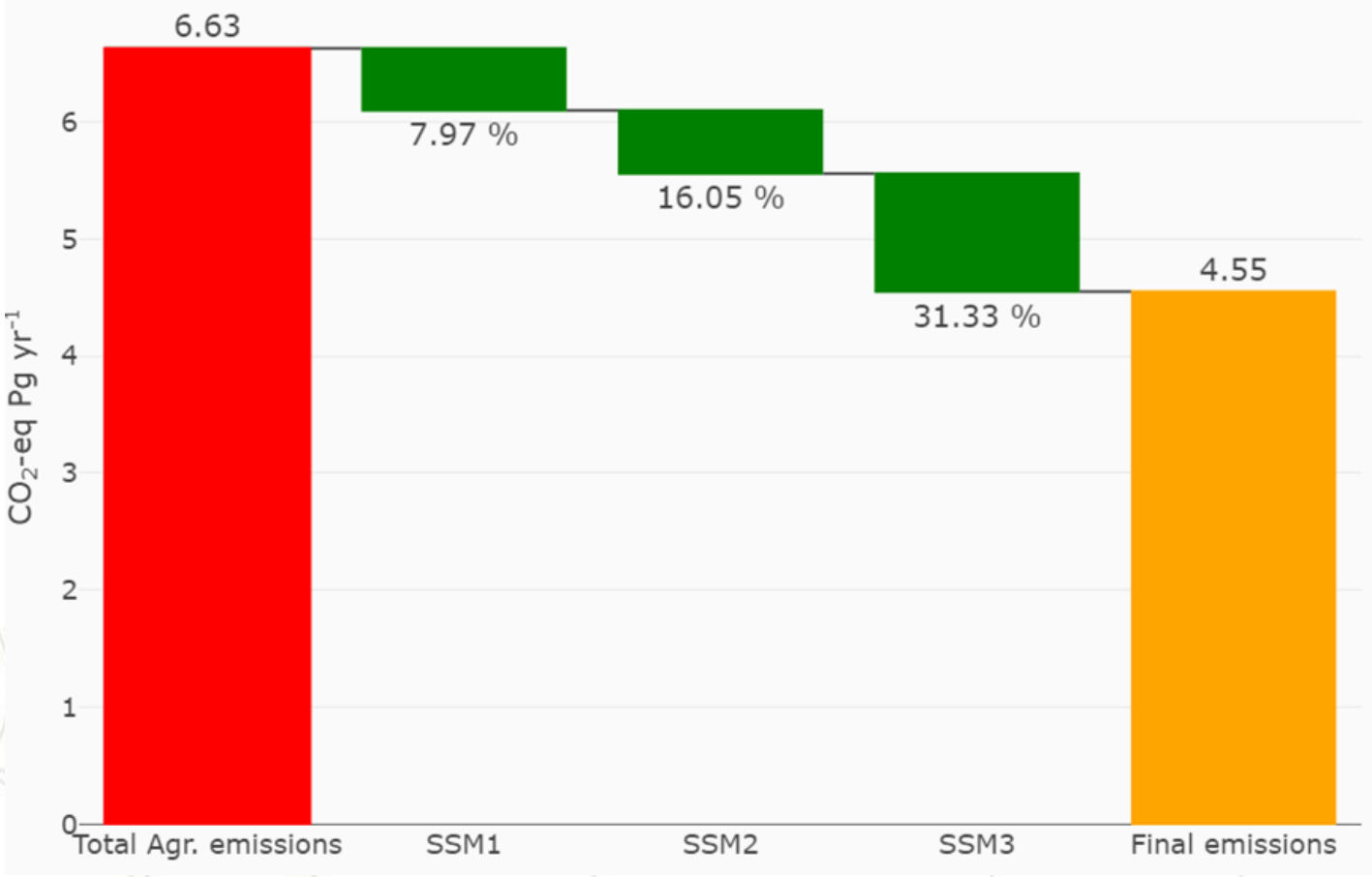


See Technical Report for details

Potential uses - Mitigation Potential*

***Excluding blank countries**

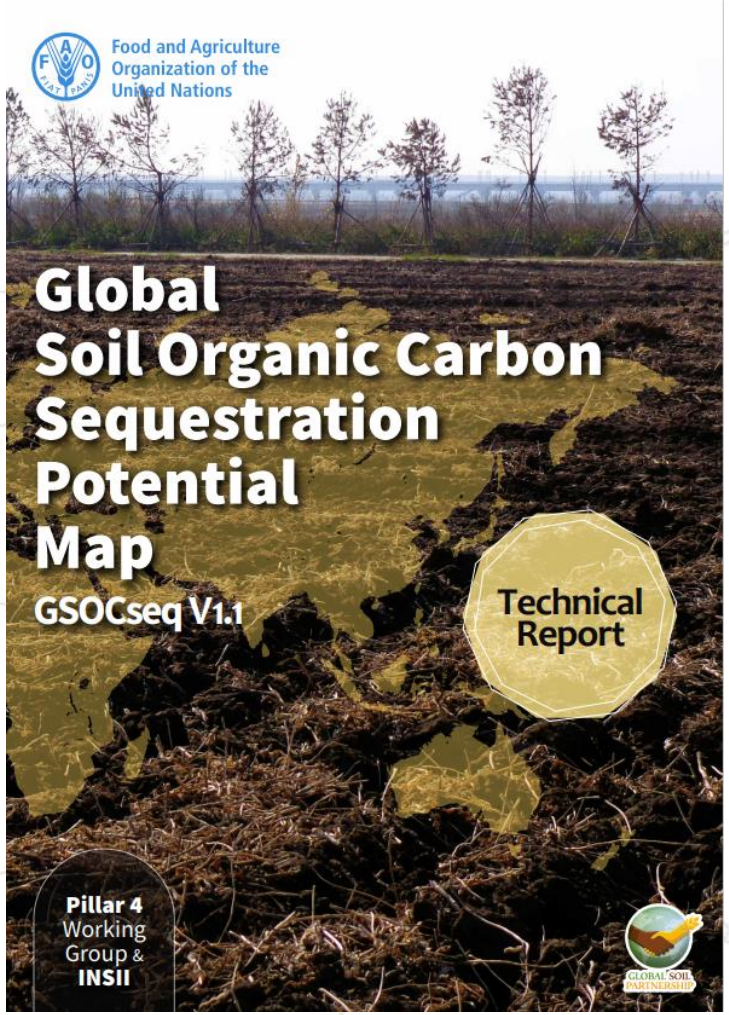
Agricultural soils play an important role in mitigating GHG emissions: yearly agricultural global emissions could be cut by 31 %



*Total Agricultural Emissions from FAOSTAT (2019)

Also work on other mitigation strategies:

GSOCseq v1.1 Technical Report



- A draft version of the GSOCseq v1.1 Technical Report is available for your comments and review
- Please download the pdf draft version of the GSOCseq Technical Report and the Review Sheet here: https://drive.google.com/drive/folders/1bHDSkV-eHa5ZQ8dwqUnDI1a7xRuMgRlk?usp=sharing
- Please send your review (filled review sheet) by 20/11/2021 to isabel.luotto@fao.org by email.

GSOCseq v1.1 Technical Report

Comments, suggestions are to be submitted offline using the provided review sheet

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(1)	(2)	(3)	(4)	(5)	(6)	(7)
Page no.	Line no.	Chapter or Annex (e.g. 3.2)	Paragraph/ figure/table/	Type of comment*	Comment (justification for change of technical aspects must be supported by either scientific literature or technical documents)	Proposed change (please provide alternative text)

** Please specify the type of comment in column five by using the following abbreviations: fo = formatting; ge=general; te=technical.*

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Limitations

- Models are simplifications of reality
- No universal models
- Erosion, Clay type? soil nutrients effects?
- pH? Bases?
- aridic soils? Sodic soils? Salt affected? Allophanic soils?
- red-ox potential; waterlogging, anaerobiosis; organic soils?
- micro and meso fauna effects?
- Soil structure? Soil compaction?
- Resolution
- Need to develop local scenarios for C inputs
- Include all sources of uncertainties
- Among others!!!!

… but we need an initial step…

Way forward

- **Periodical updates: GSOCmap and GSOCseq**
- Strengthen **communication** to involve more countries
- Organize additional trainings/workshops
- Strengthen **Expert Network (expand expert GSOCseq working group)**
- Strengthen **interaction** with other existing SOC modelling/mapping **programmes**
- Improve approach and GSOCseq versions:
  - **Country**-specific SSM **scenarios; disentangling C inputs and initial SOC; methods regarding data limitations**
  - Local scenarios/practices: **C input increments vs specific practices?**
  - **Climate Change** scenarios; harmonized data sources? Which scenarios?
  - Specific **conditions** (e.g. allophanic soils, salt affected soils)
  - SOC changes at **deeper layers**
  - **Finer resolutions**
  - **Incorporate structural uncertainties: Multi-model** approach? **Improve scripts** (computational time)
- **On the ground actions** on SOC sequestration

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10 Minute BREAK

"Torture the data, and it will confess to anything"

Ronald Coase, British Economist

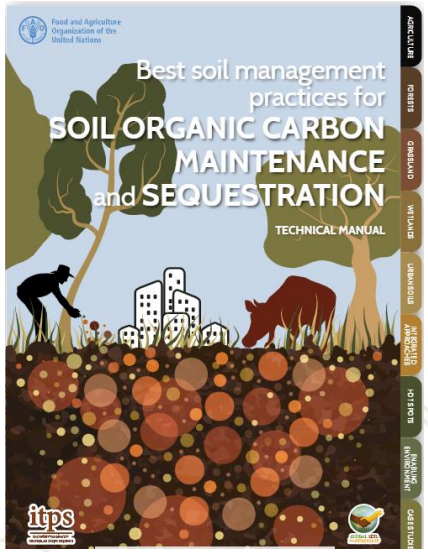
GSOCseq into action…

…a tool in ´Recarbonization´ - RECSOIL Projects

What is RECSOIL?

- RECSOIL is an innovative **initiative** with the aim to boost soil health through the maintenance and **enhancement of SOC stocks**.
- It constitutes a **mechanism** whereby **farmers** are encouraged to adopt **sustainable practices**
- The benefit of enhancing and maintaining SOC directly benefits farmers who will receive **technical support and financial incentives**

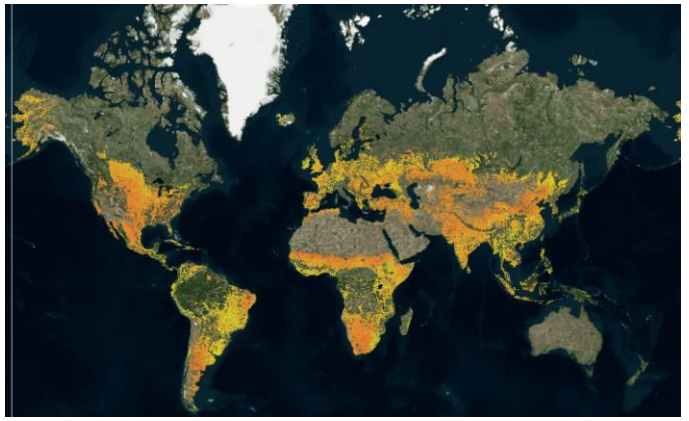
RECSOIL tools



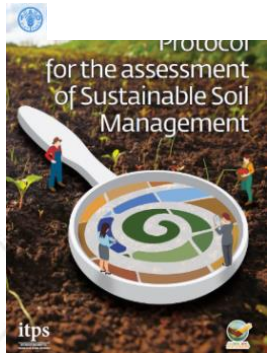
Technical manual: recommended practices

Network on black soils – special conservation areas

Enhances local capacities



GSOC and GSOCseq maps and their capacity development programs



SSM and GSOC MRV protocols

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

Standard Operating Procedures (SOPs)

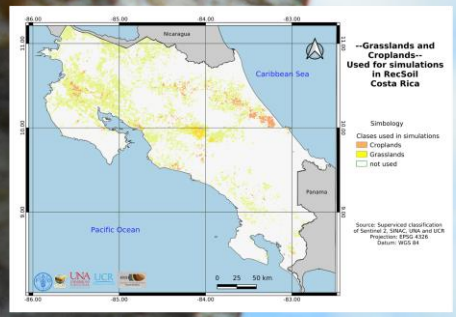
Harmonization of laboratory procedures

GSOCseq into action: RECSOIL projects

Countries have already started the process…

Identifying :

- the **main value chains**
- key **stakeholders/actors** at national level (government, extension services, institutions, academia, NGOs, consultants, etc)
- **farmer associations**: giving priority to small and medium agricultural production systems
- **risks** and **threats**
- potential **sustainable soil management practices** and associated **costs**
- **potential areas for RECSOIL projects + monitoring and validation sites - GSOCseq**



RECSOIL **Costa Rica**

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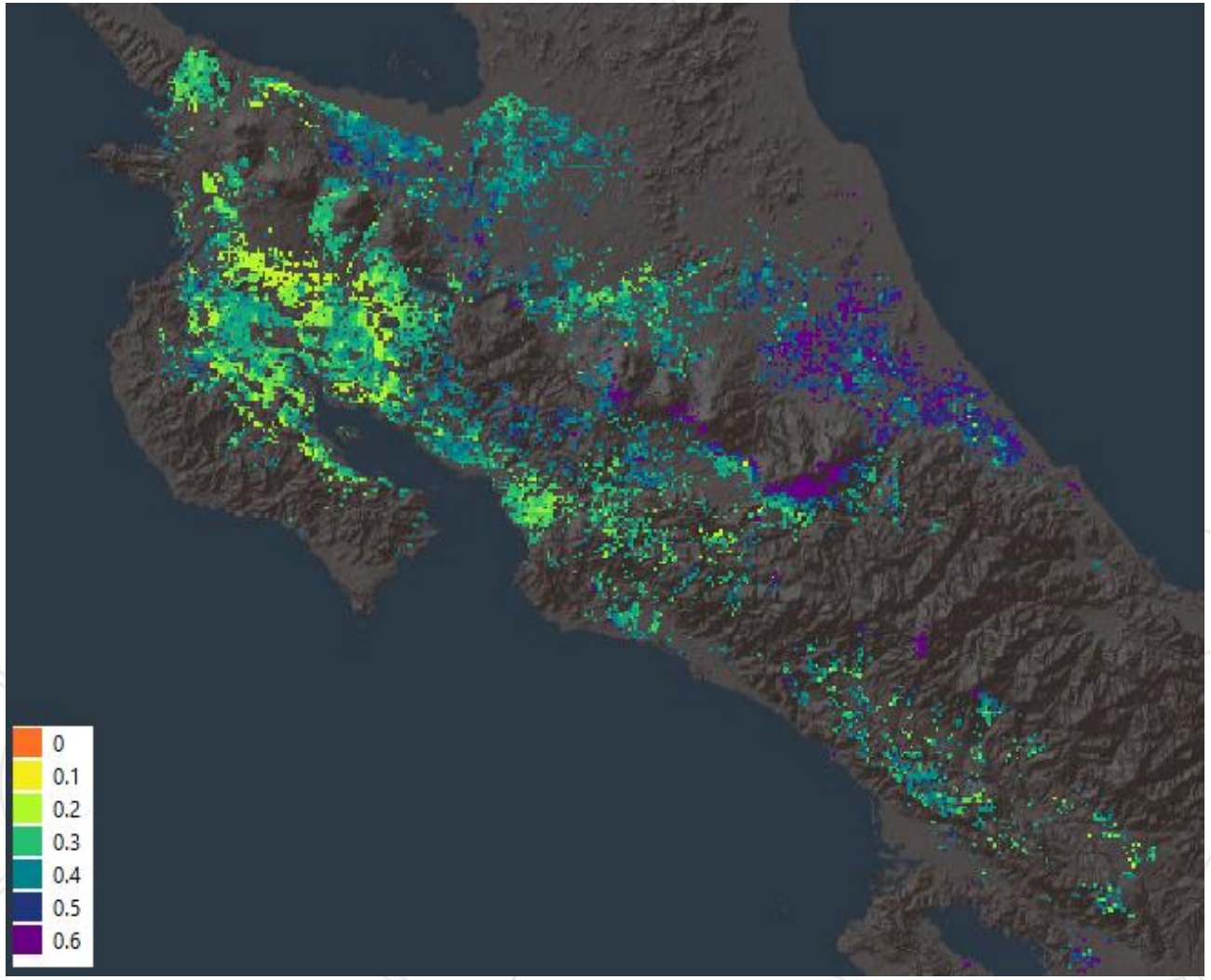
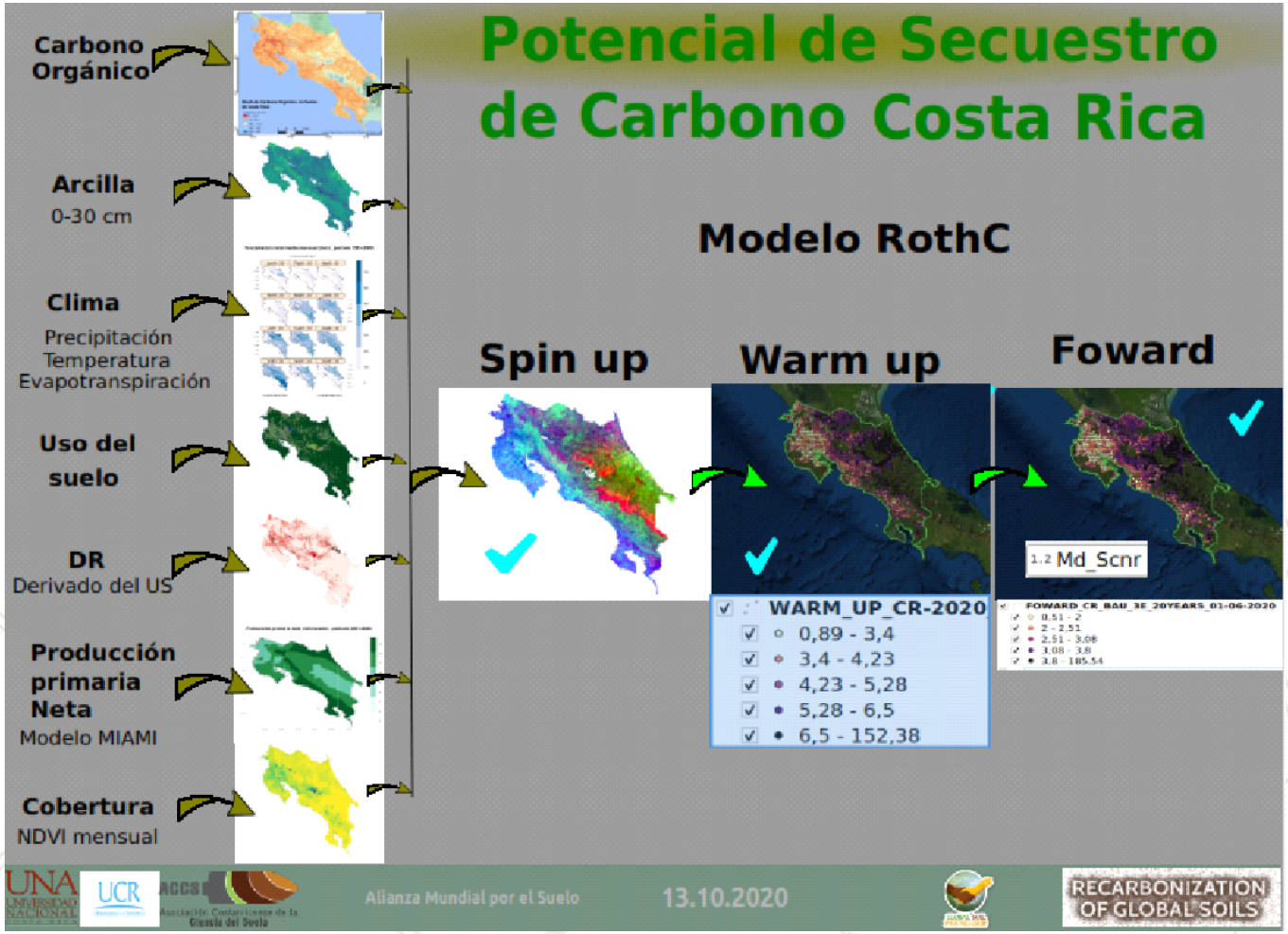
RECSOIL **Costa Rica**



	Relative sequestration		
	Low	Medium	High
	t C . ha^{-1}		
Croplands	0.10	0.19	**0.39**
Grasslands	0.08	0.17	**0.34**

		Relative sequestration		
	Area	Low	Medium	High
	Km^2	Mt C yr^{-1}		
Croplands	919	0.0092	0.0171	**0.0358**
Grasslands	9796	0.0784	0.1665	**0.3331**

RECSOIL **Costa Rica**

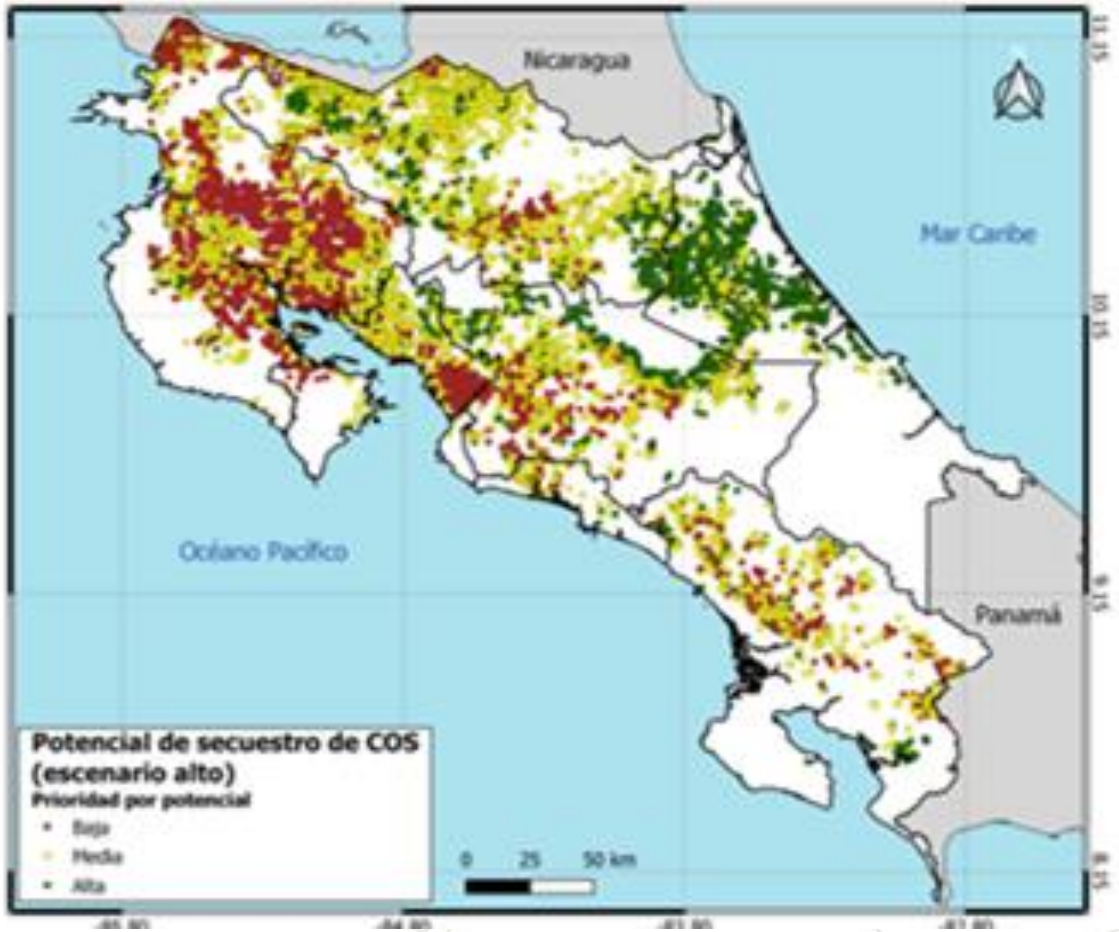


Improvements

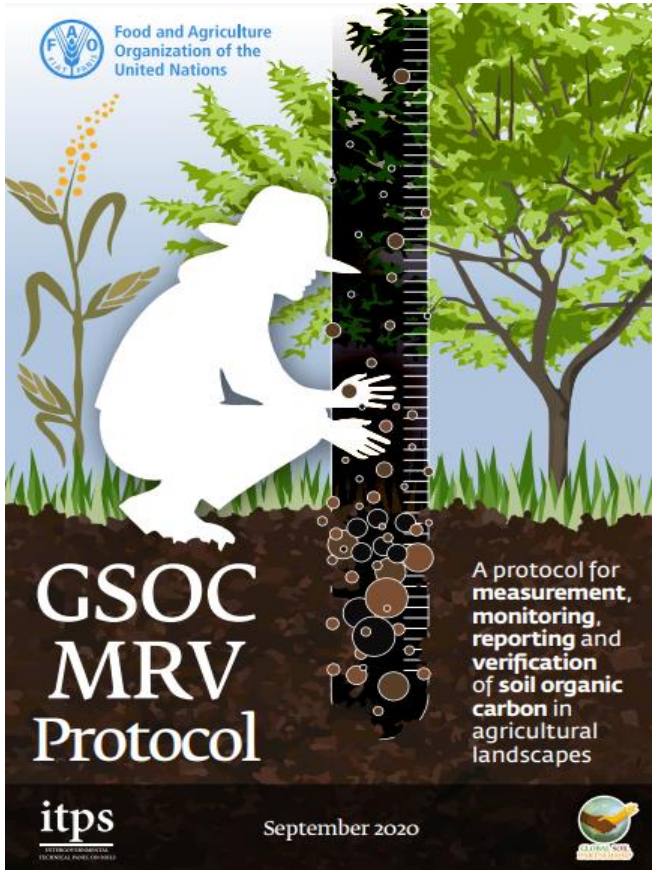
- Generated new input layers from local databases
- Resolution
- Local scenarios

RECSOIL **Costa Rica**

GSOCseq, Costa Rica



- Identify Regions with different Sequestration Potential
- Validation sites/observatories
- Potential Sites to establish selected SSM



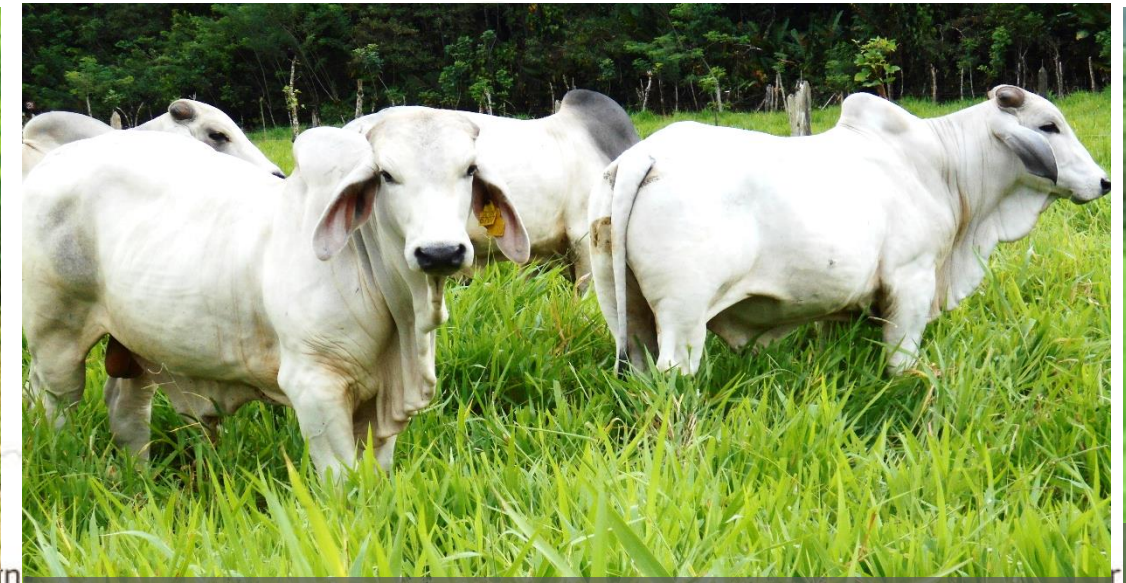
RECSOIL Costa Rica Grasslands

- Identified practices to tackle degradation threats and increase SOC stocks
- Costs ($)
- Examples:

Grazing management ("rational grazing" e. PRV)

"Living fences" - legumes

Using forage "bridges"/ "Banks" as supplements



Sowing Improved pastures

Nutrient management/ amendments in pastures

RECSOIL **Costa Rica Coffee**

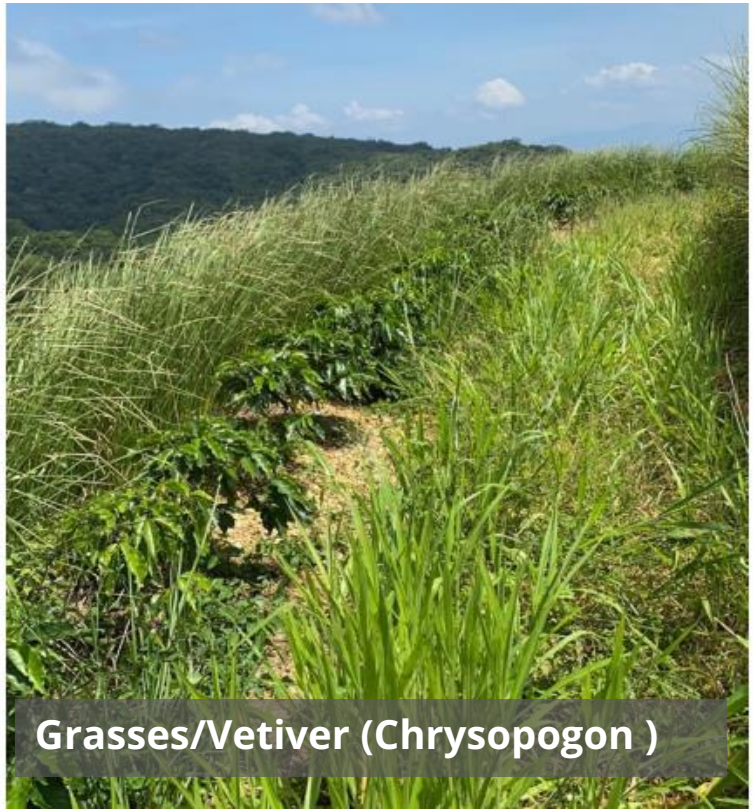
- Identified practices to tackle degradation threats and increase SOC stocks
- Costs ($)
- Examples:

Erosion control: curves, terracing, ditches

Organic amendments
Nutrient management/ inorganic amendments

Agroforestry (Shadow, Soil protection)

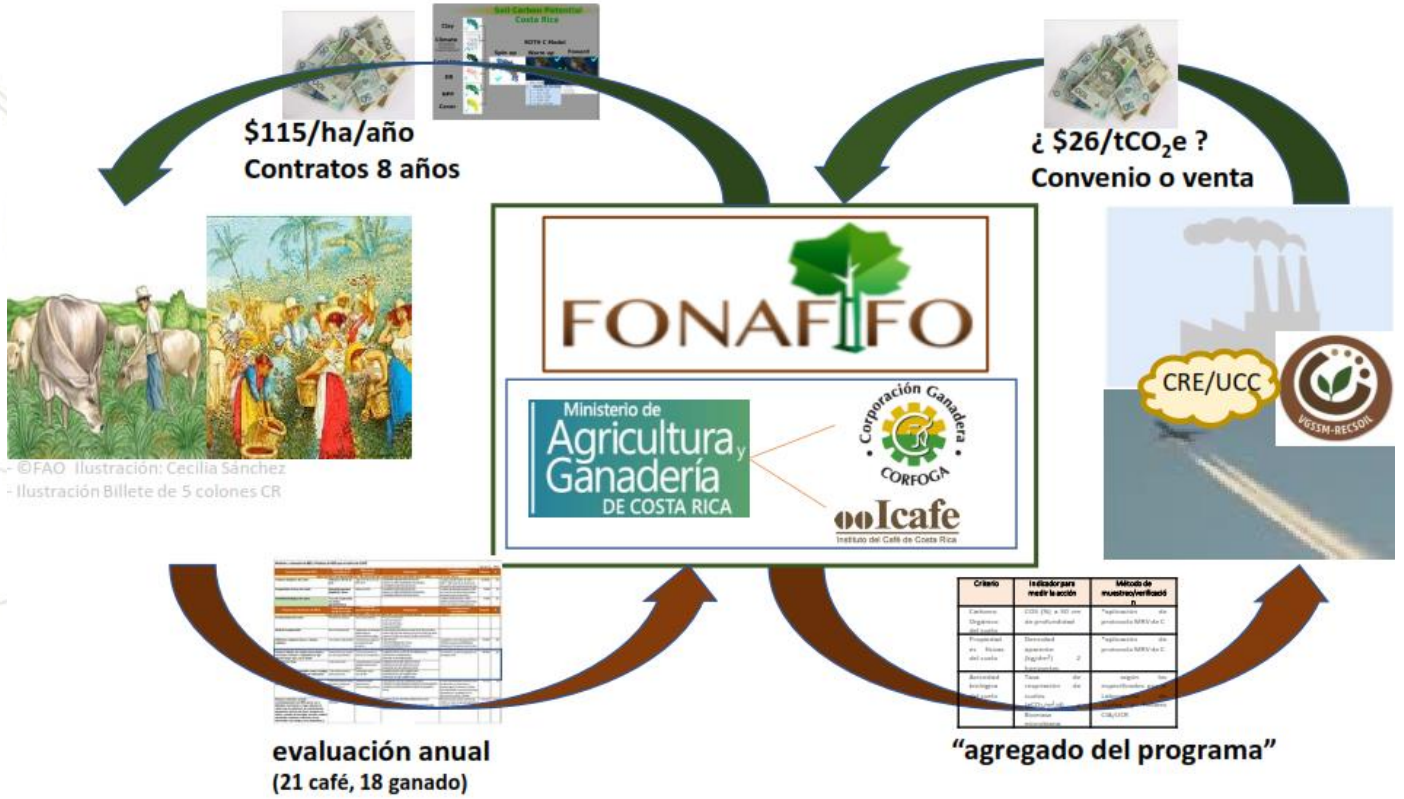
Green covers, cover crops



Grasses/Vetiver (Chrysopogon)

RECSOIL **Costa Rica**

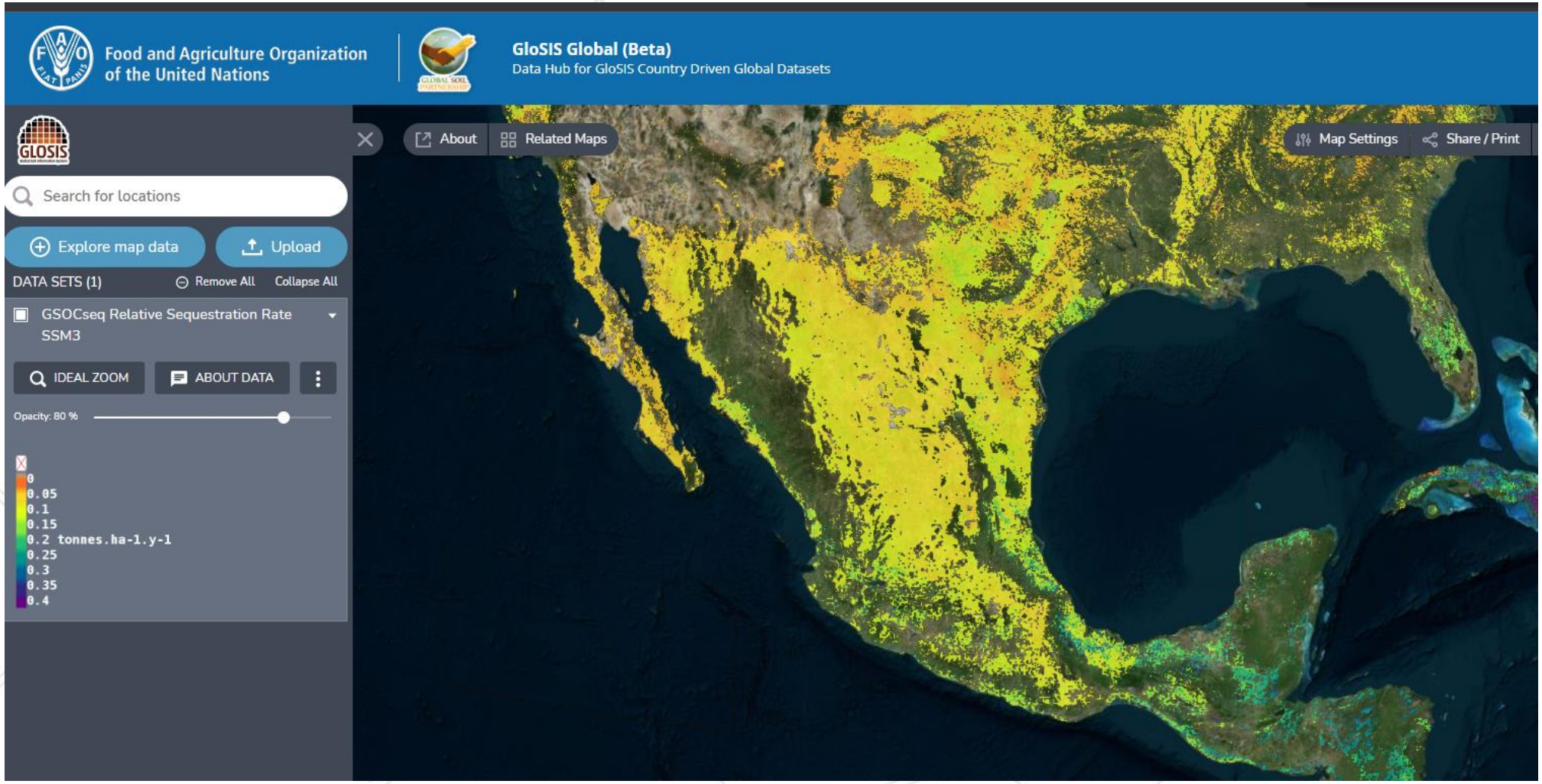
Implementation model and mechanisms



Source: RECSOIL Costa Rica report

RECSOIL **Mexico**

RECSOIL **Mexico**



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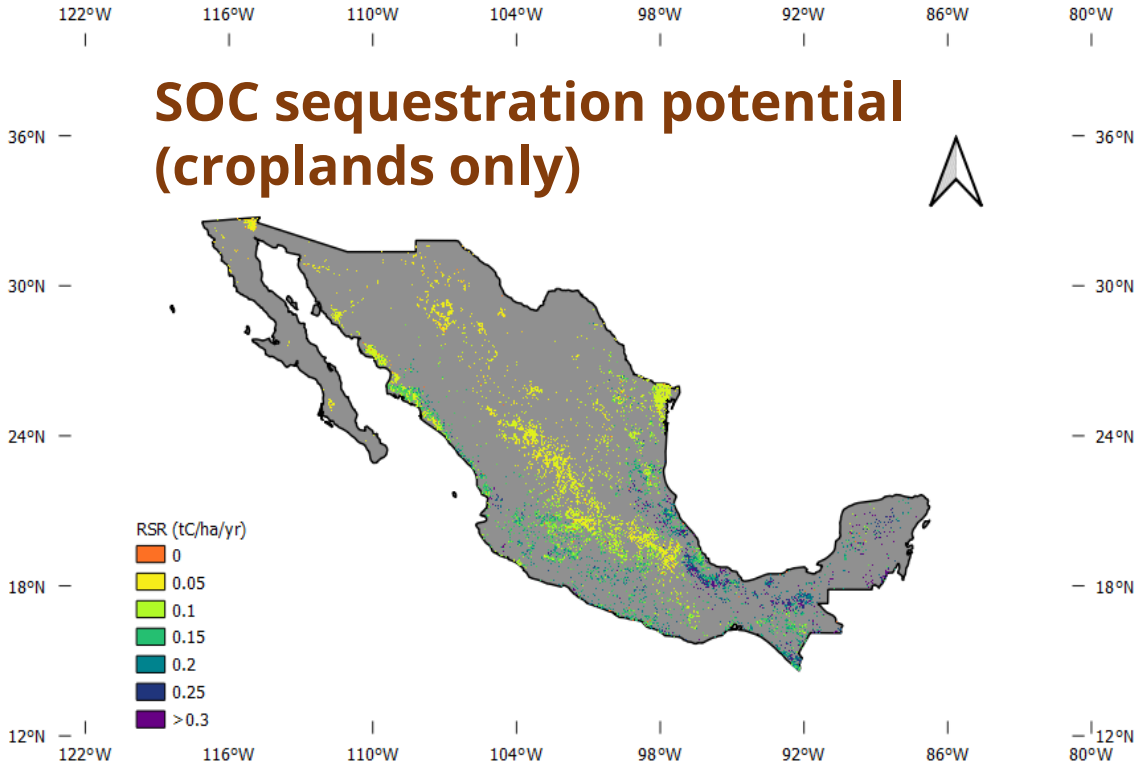
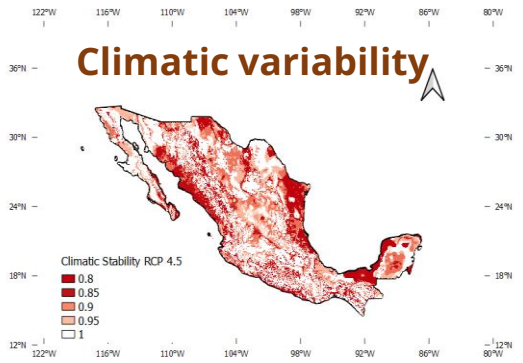
RECSOIL **Mexico**

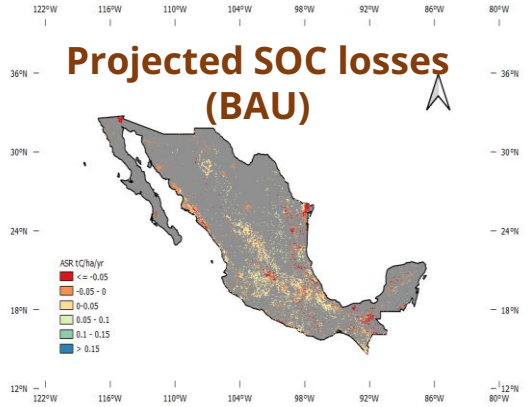
SOC sequestration potential (croplands only)



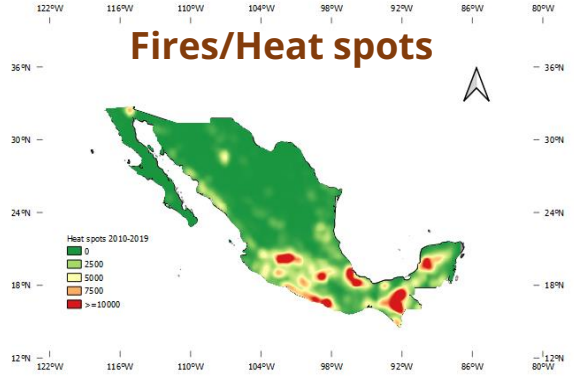
Climatic variability



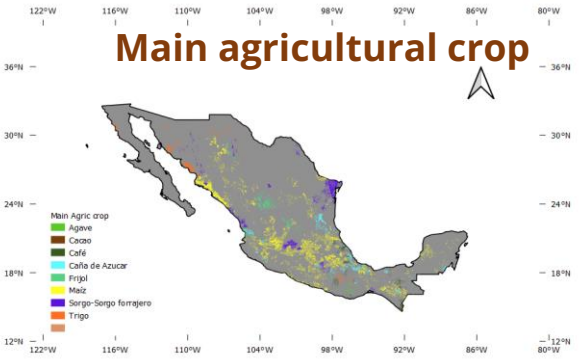
Projected SOC losses (BAU)



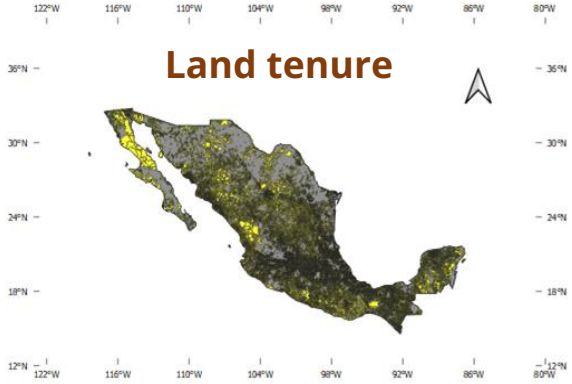
Fires/Heat spots



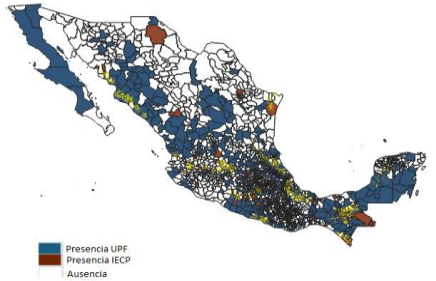
Main agricultural crop



Land tenure



Existing programmes



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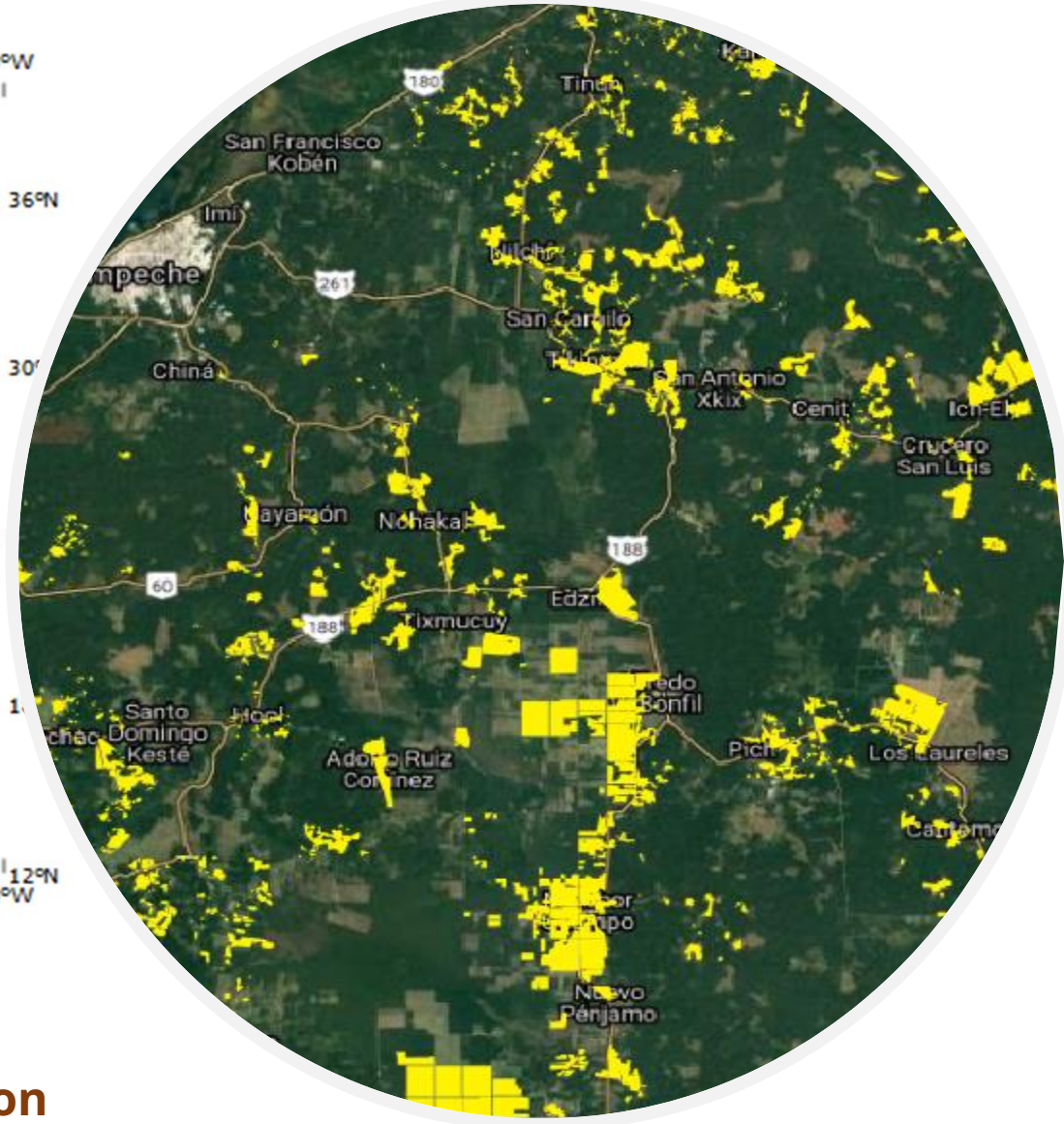
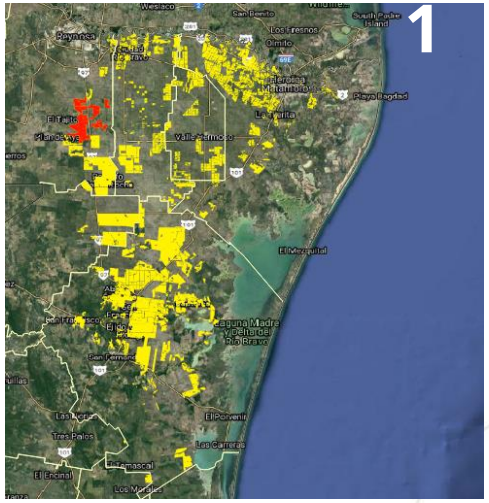


- High Risk – Low Seq Potential → CC adaptation strategies
- High Risk – High Seq Potential → CC adaptation + mitigation
- Low Risk – High Seq Potential → CC mitigation

Communal lands (tierras ejidales) - Target basins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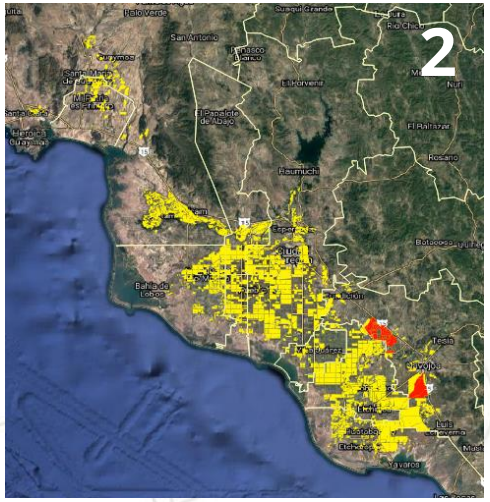
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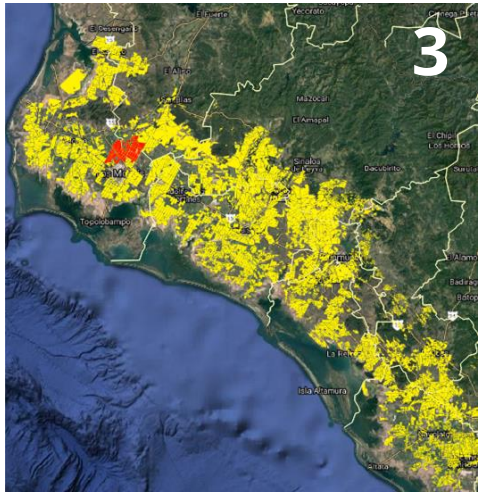
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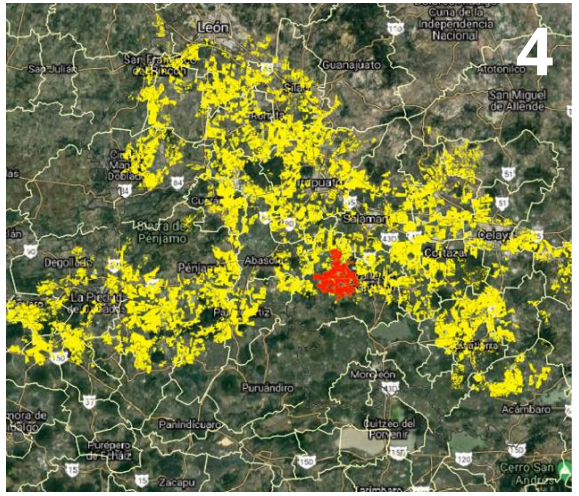
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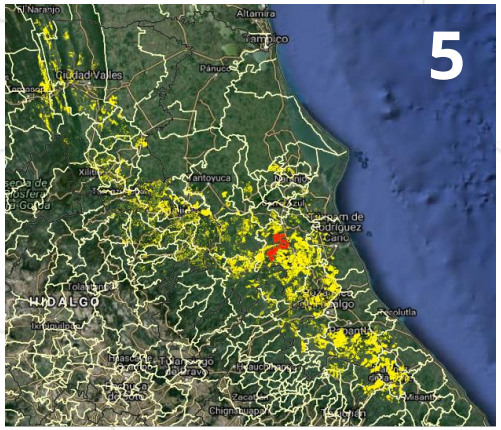
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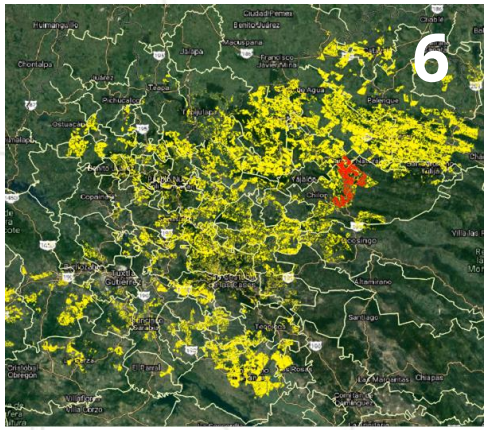
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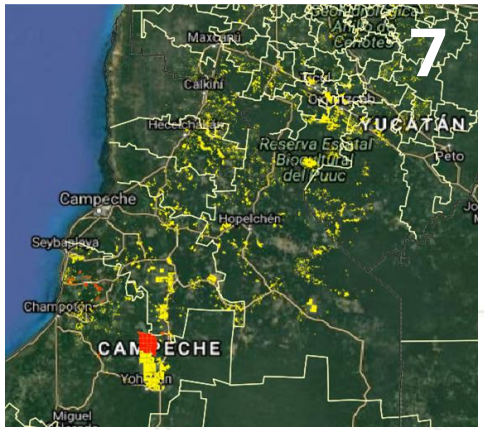
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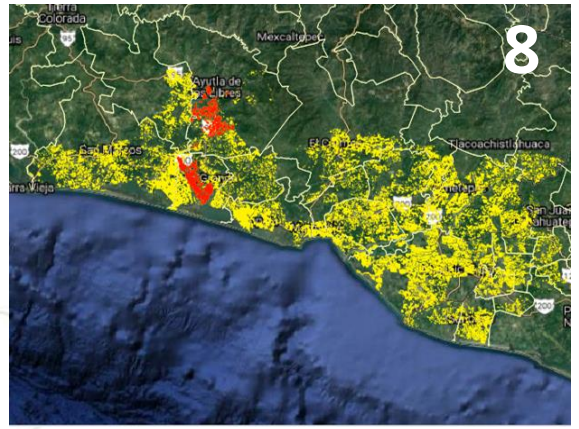
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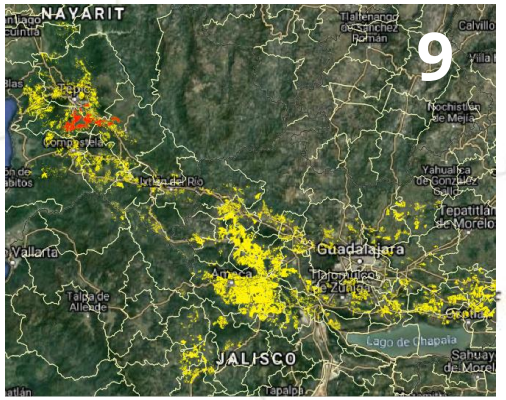
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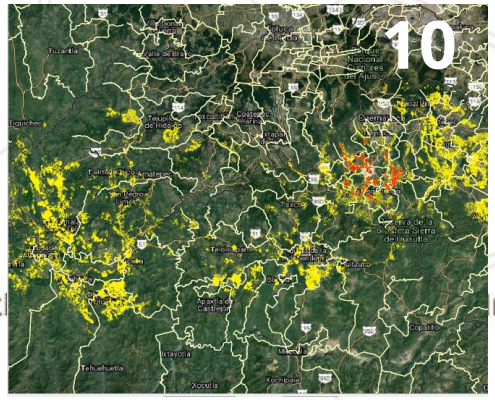
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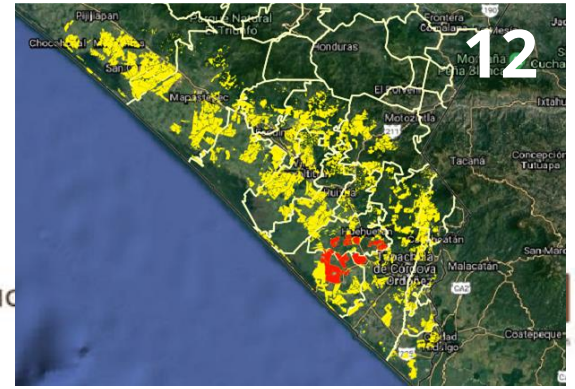
12

RECSOIL **Mexico**

id	code	Cluster	Strategy	Main crop	Existing program	State	Municipio	Selected area (ha)	Potential farmers
1	AR_BP	**Tamaulipas**	Adapt	Sorghum	NA	Tamaulipas	Reynosa	9,597	5,025
2	AR_BP	**Sonora**	Adapt	Wheat	PDR-2019-SON-EDO-284 - Trigo	Sonora	Navojoa	9,246	4,841
3	AR_BP	**Sinaloa**	Adapt	Maize	PDR-2019-SIN-CONAZA-032 –Bovino/Maíz	Sinaloa	Ahome	9,659	5,057
4	AR_BP	**Guanajuato**	Adapt	Maize	PDR-2019-GTO-FIRCO-359	Guanajuato	Valle de Santiago	9,721	5,090
5	AR_AP	**Veracruz_N**	Adapt+Mit	Maize	PDR-2019-VER-EDO-303	Veracruz	Álamo Tamapache	9,420	7,191
6	AR_AP	**Chiapas_C**	Adapt+Mit	Coffee	PDR-2019-CHIS-EDO-069	Chiapas	Chilón	9,688	5,072
7	AR_AP	**Campeche**	Adapt+Mit	Maize	PDR-2019-CAM-EDO-054	Campeche	Champotón	9,636	5,045
8	AR_AP	**Guerrero**	Adapt+Mit	Maize	PDR-2019-GRO-EDO-147; PDR-2019-GRO-EDO-140	Guerrero	Ayutla de los Libres	9,794	5,128
9	BR_AP	**Nayarit_Jal**	Mit	Maize	NA	Nayarit	Xalisco	9,649	5,052
10	BR_AP	**Morelos**	Mit	Maize	PDR-2019-MOR-FIRCO-374	Morelos	Miacatlán	9,509	4,979
11	BR_AP	**Veracruz_S**	Mit	Maize	PDR-2019-VER-EDO-316	Veracruz	José Azueta	9,501	7,253
12	BR_AP	**Chiapas_S**	Mit	Coffee	NA	Chiapas	Huehuetan	9,518	3,966
								114,938 ha	**63,697**

Identification of ~64,000 beneficiaries (smallholders) of recarbonization, mitigation and adaptation projects (International funds)

From source ...to sink

Thank you for your attention

Special thanks to

- University of Aberdeen; Thünen-Institut
- 4p1000 SC, CIRCASA, UNCCD
- National SOCseq teams and all experts contributing to the process

Food and Agriculture Organization of the United Nations

7th Meeting of the International Network of Soil Information Institutions (INSII)

09-10-11 November 2021

Online meeting

DISCUSSION

"Errors using inadequate data are much less than those using no data at all"

Charles Babbage, English Polymath

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GLOBAL SOIL PARTNERSHIP