Soil carbon: key to address vulnerabilities of agriculture to climate change and food security issues

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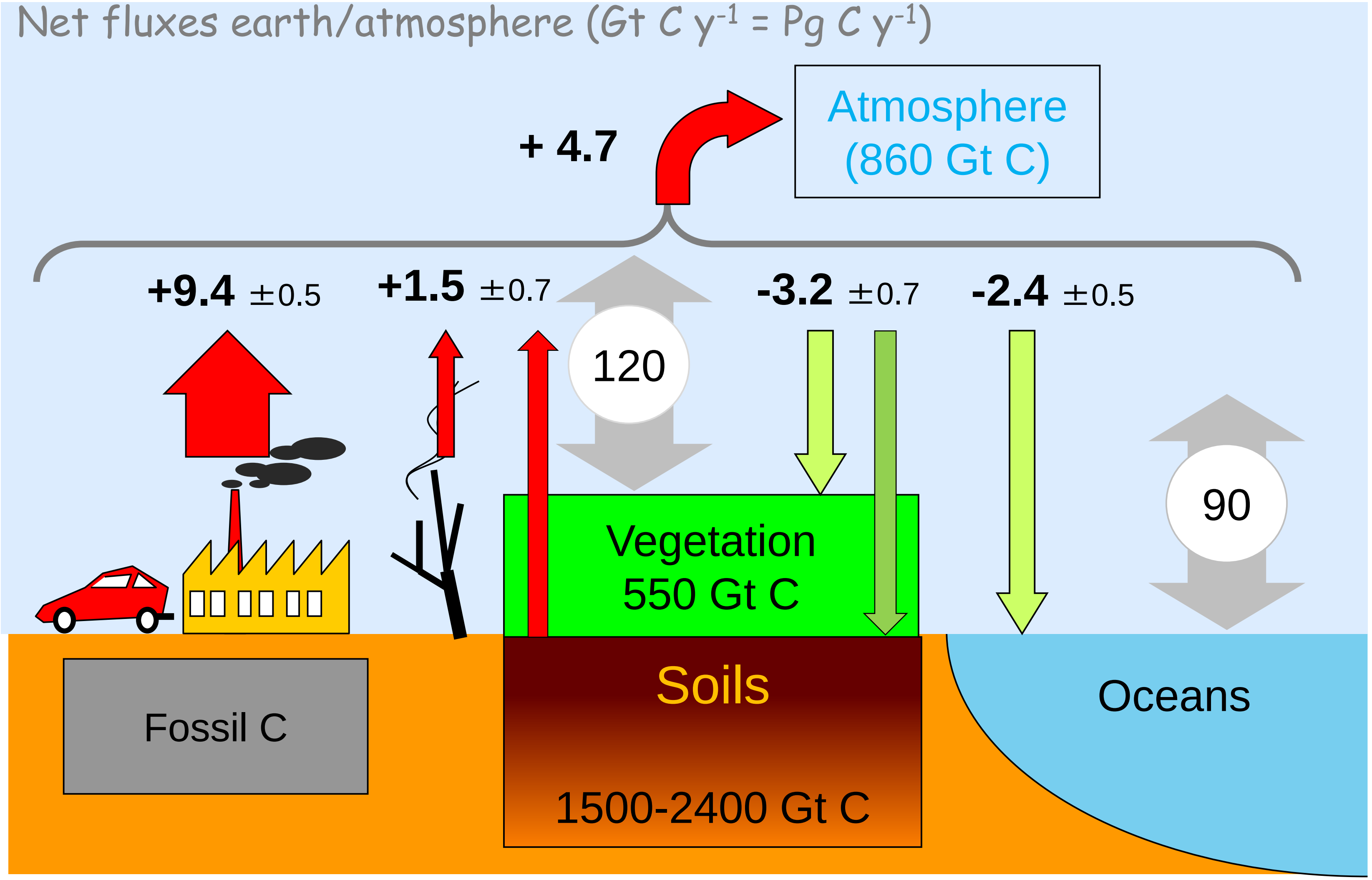
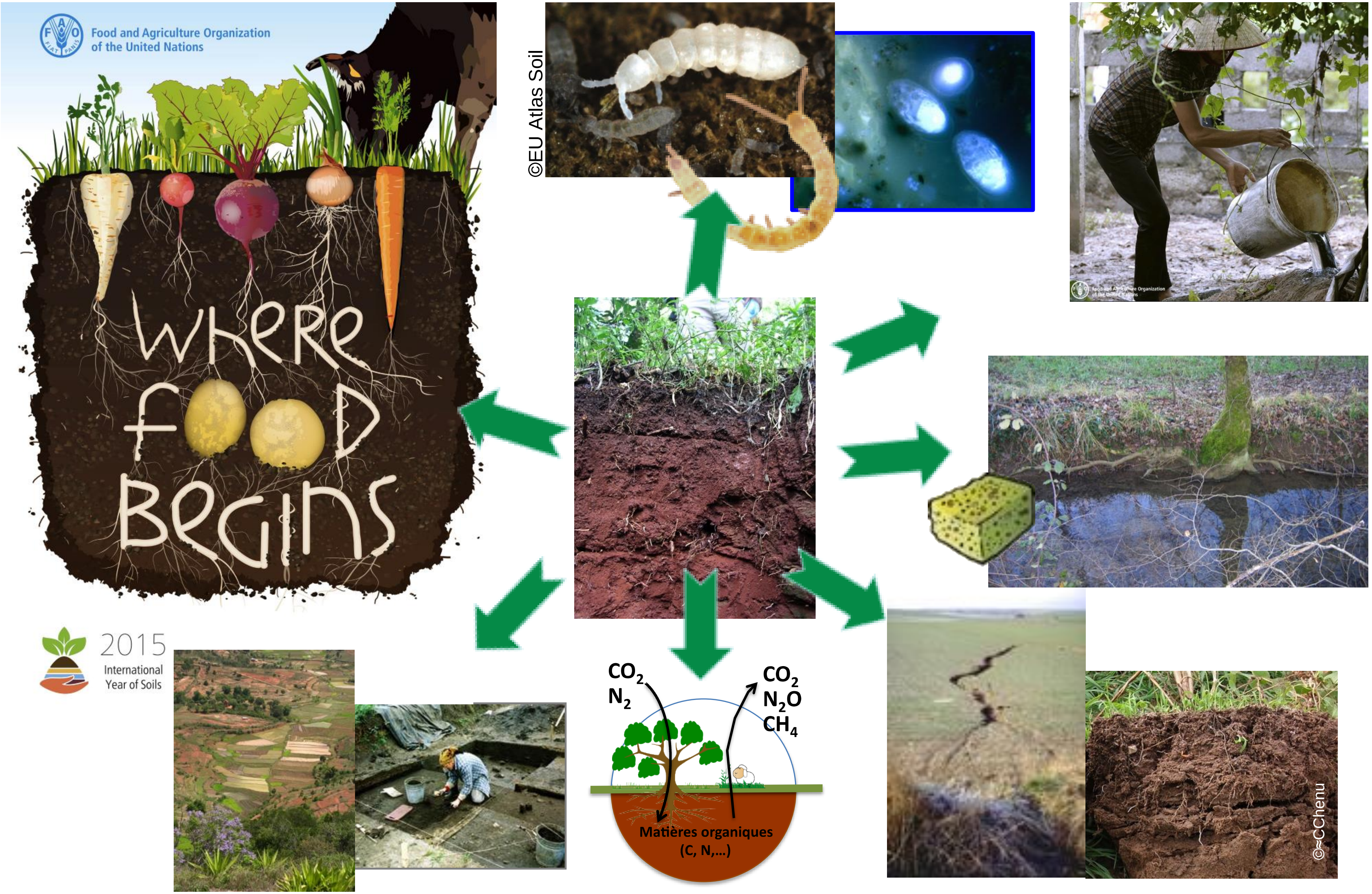
Why soil carbon?

Soil carbon pool is big



Graph adapted from Balesdent 1996
Values means 2008-2017 : Le Quéré et al. 2018

Soils provide ecosystem services



Soil *organic matter* provide ecosystem services

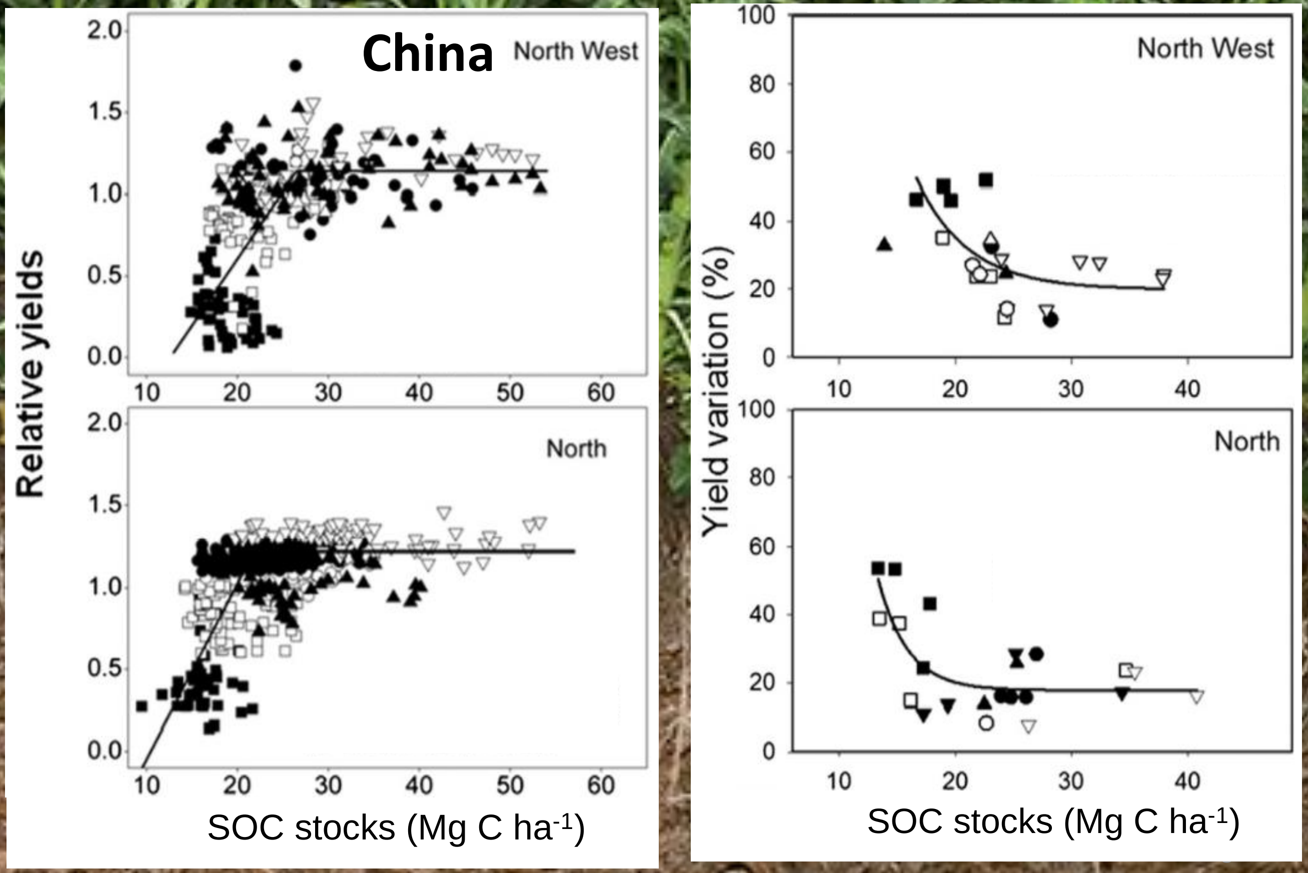
Soil *organic matter* provide ecosystem services

good soil structure
water infiltration and retention
aeration
provision of nutrients
beneficial organisms

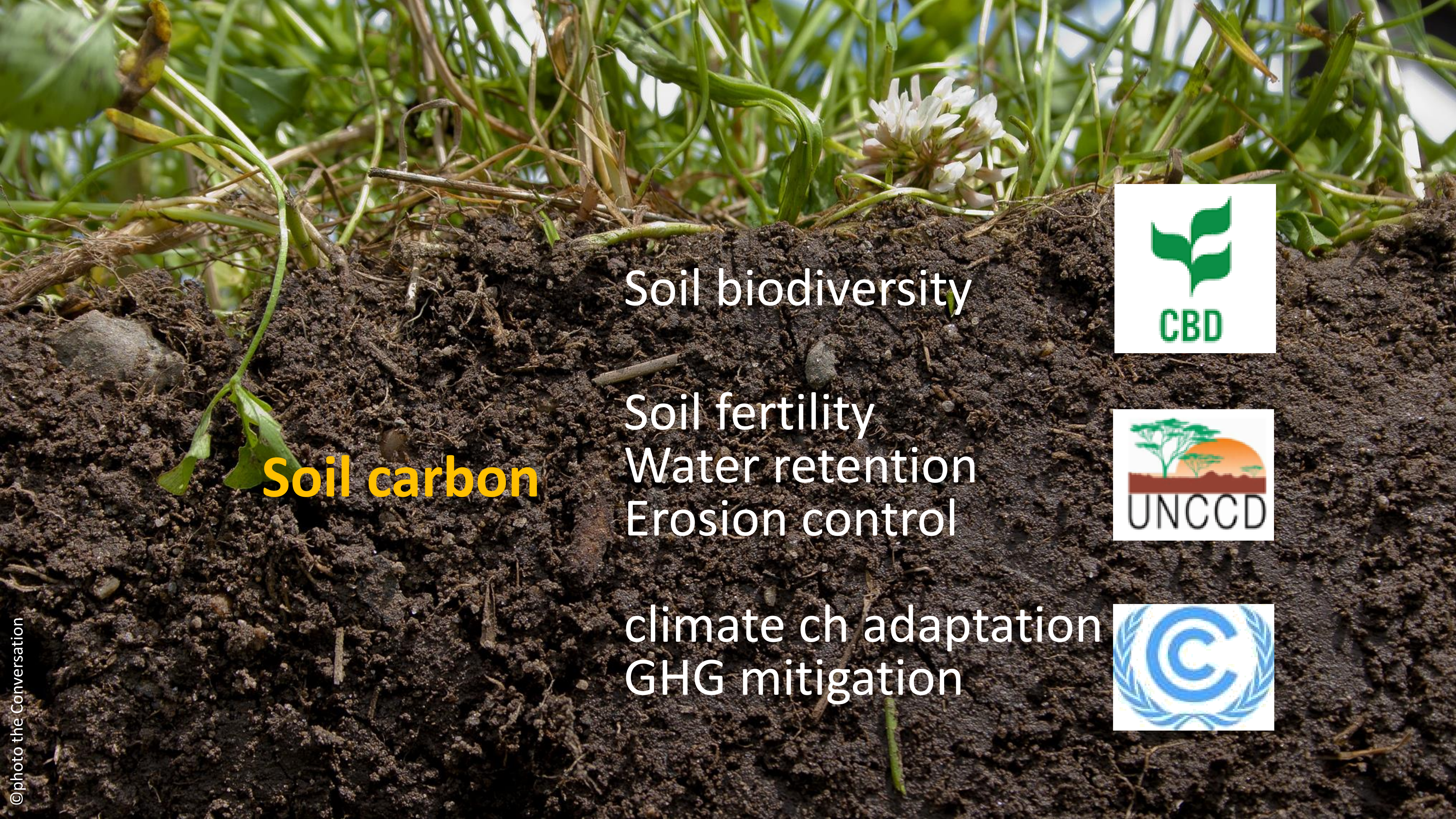
→ Soil fertility - Soil health

Food security

Adaptation to climate change



Zhang et al. 2016


Soil carbon
Soil biodiversity
CBD
Soil fertility
Water retention
Erosion control
UNCCD
climate ch adaptation
GHG mitigation
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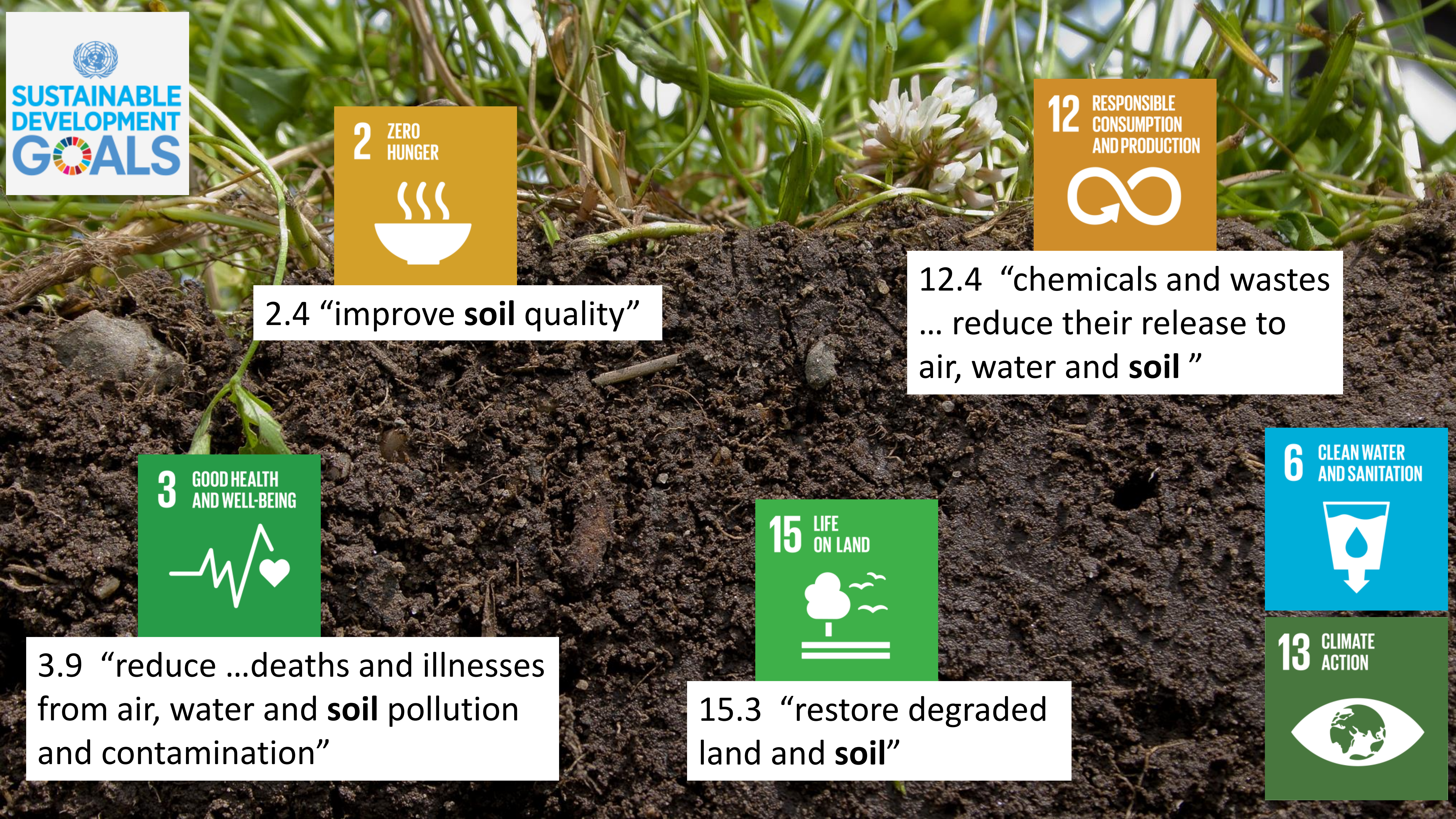


2.4 “improve **soil** quality”

12.4 “chemicals and wastes … reduce their release to air, water and **soil** ”

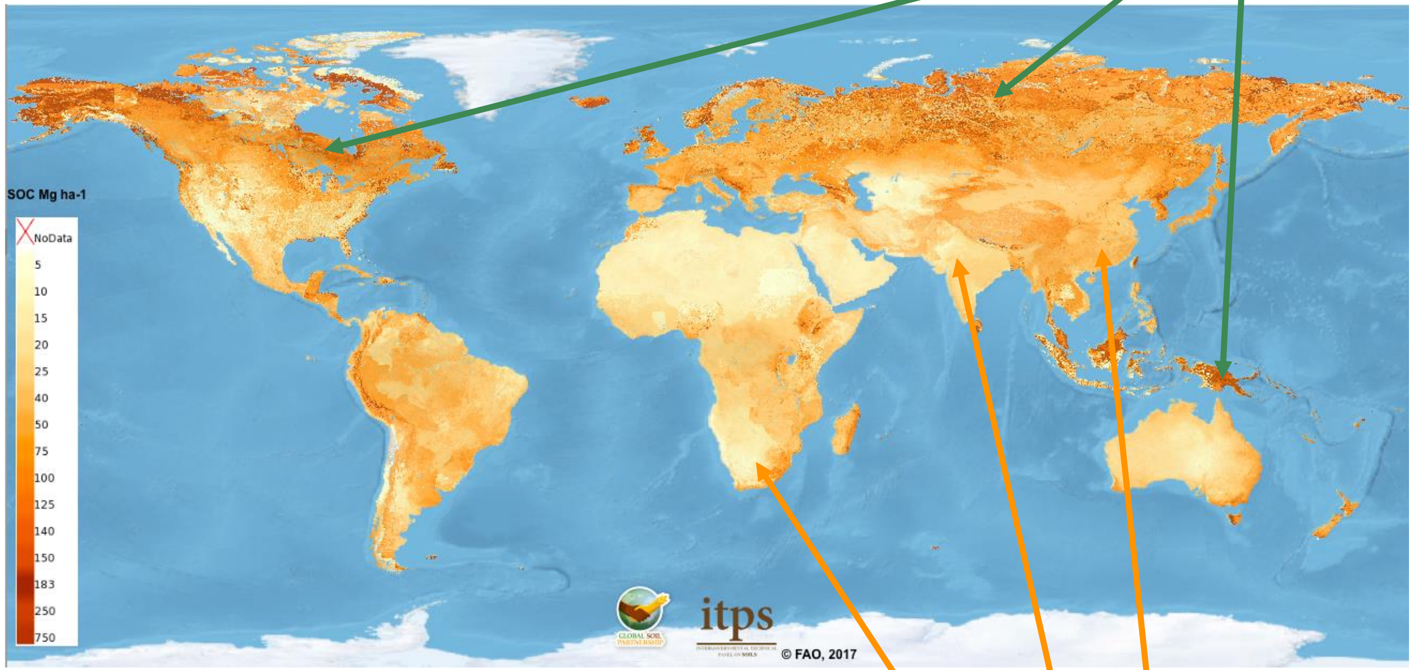
3.9 “reduce …deaths and illnesses from air, water and **soil** pollution and contamination”

15.3 “restore degraded land and **soil**”

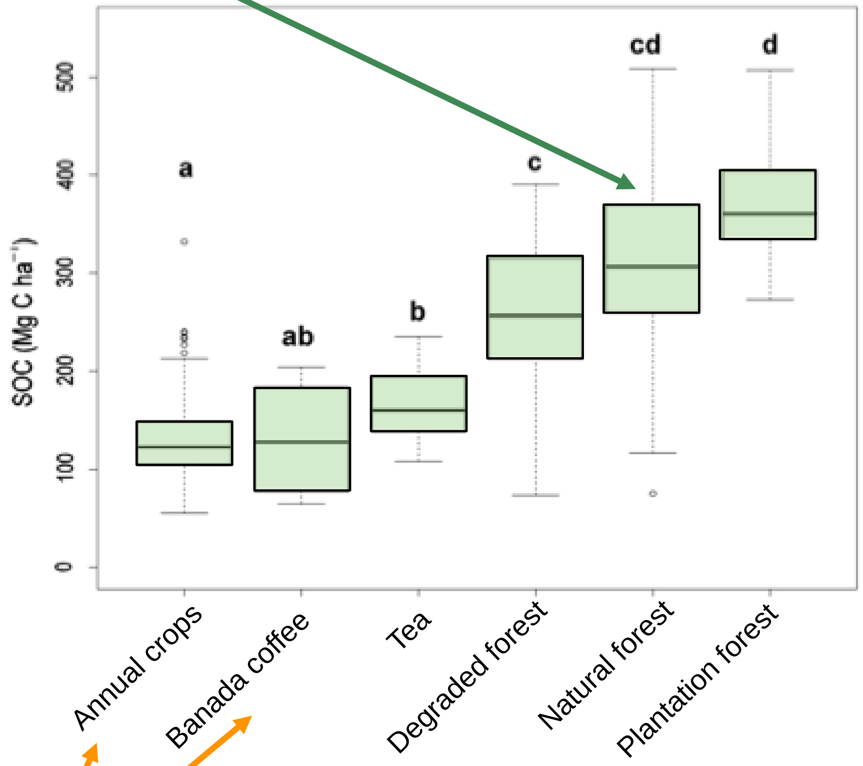
Objectives

Protect existing SOC stocks

FAO, GSP, dec 2017 Global soil carbon map



Rwanda, *Wasige et al. 2014*



Increase SOC stocks

Maintain and increase soil carbon: how and how much?

Carbon cycle at the local scale

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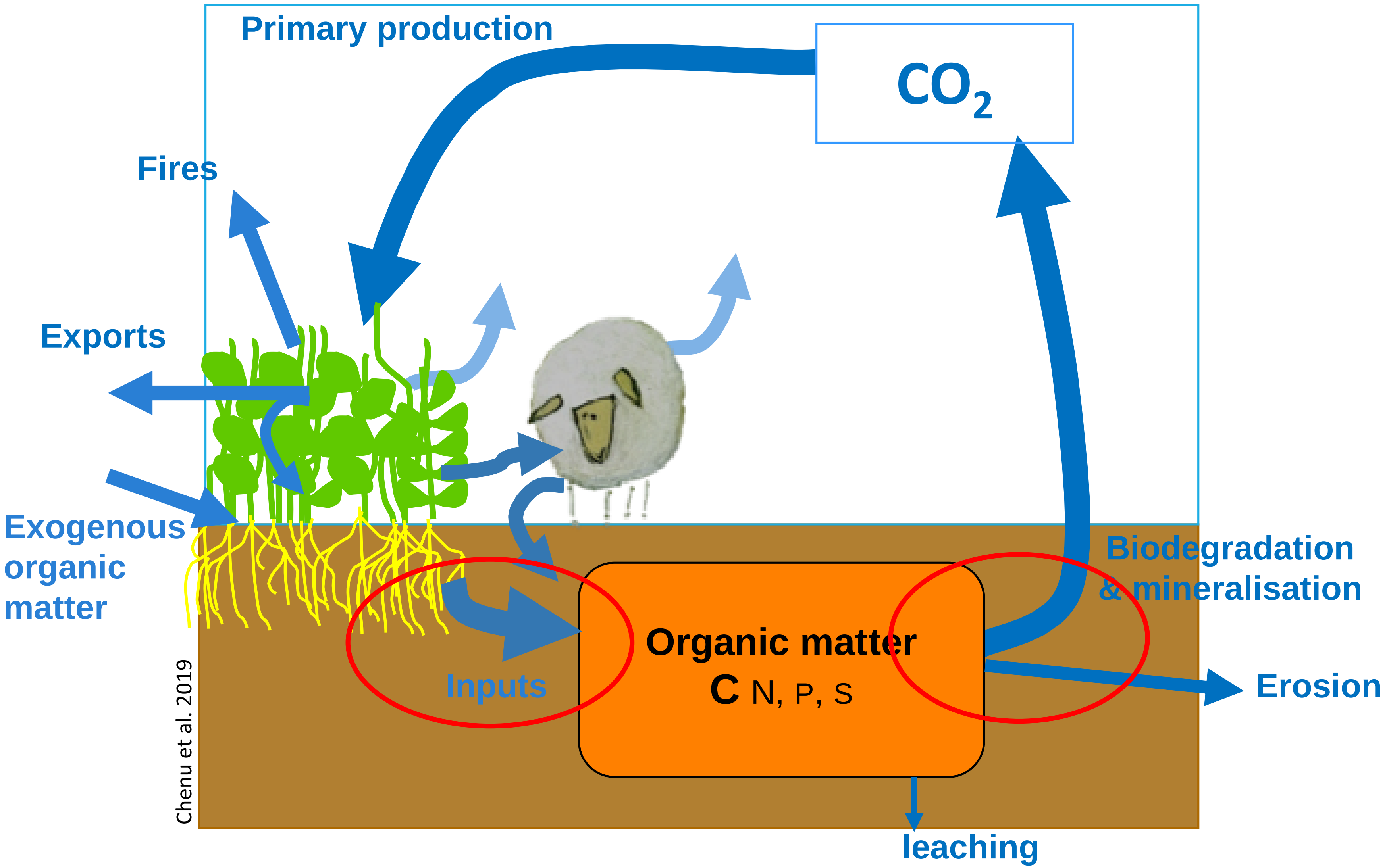
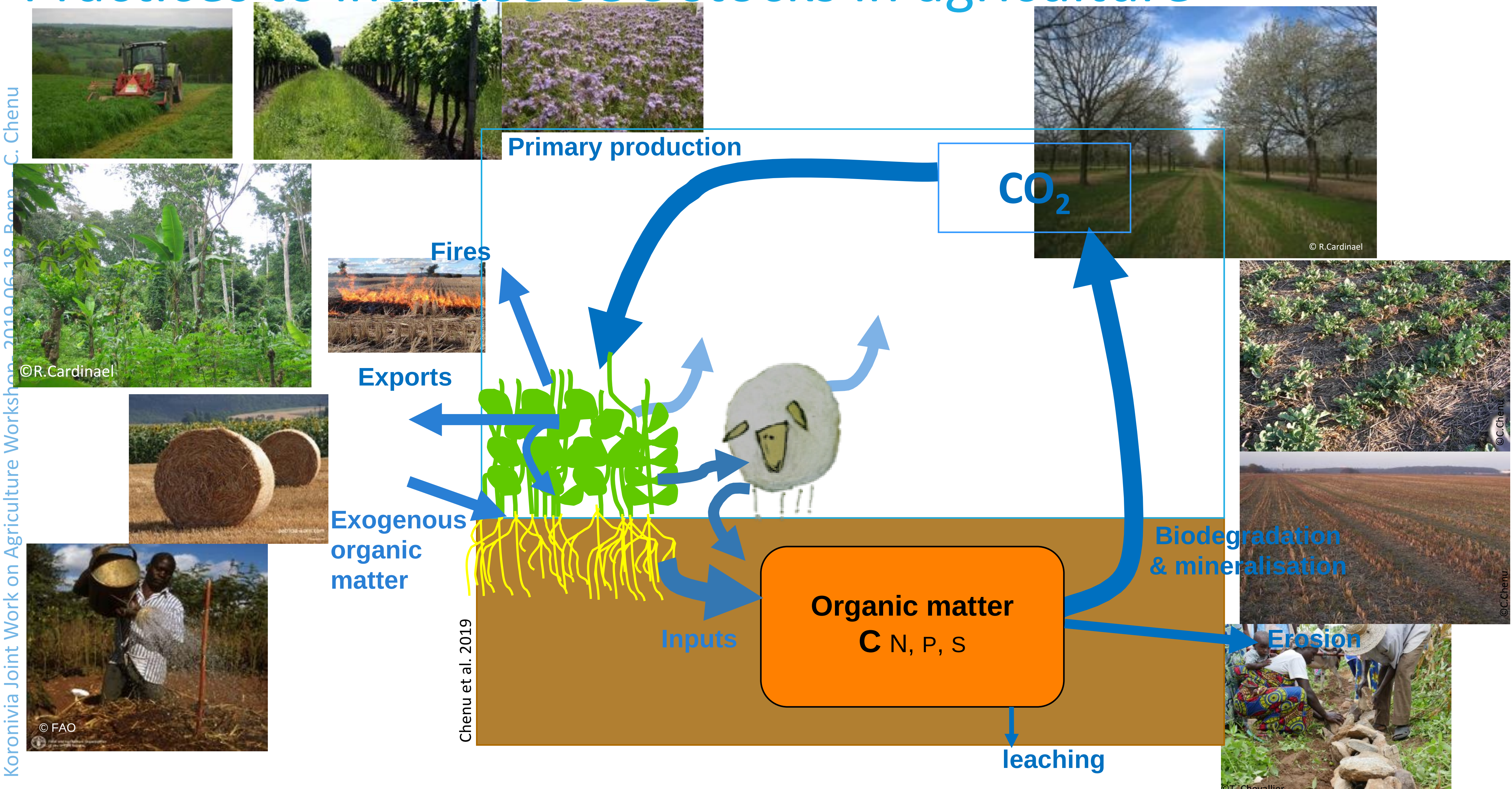
Storage

Sequestration



Practices to increase SOC stocks in agriculture



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Practices to increase SOC stocks in agriculture

Meta-analyses *Fujisaki et al. (2018) for tropical soils (duration 7 to 22 years)*

Management practices	n	SOC changes Mg C ha^{-1} yr^{-1}
Organic inputs	16	0.45 ± 0.14
Mineral fertilization	37	0.24 ± 0.06
Mineral + organic inputs	38	0.34 ± 0.04
Rotation	12	0.83 ± 0.17
Reduced tillage	47	0.32 ± 0.06
Reduced tillage + inputs	64	0.56 ± 0.08
Mean		**0.41 ± (**


Environ. Res. Lett. 13 (2018) 124020 https://doi.org/10.1088/1748-9326/aaeb5f

Environmental Research Letters

LETTER

Revisiting IPCC Tier 1 coefficients for soil organic and biomass carbon storage in agroforestry systems

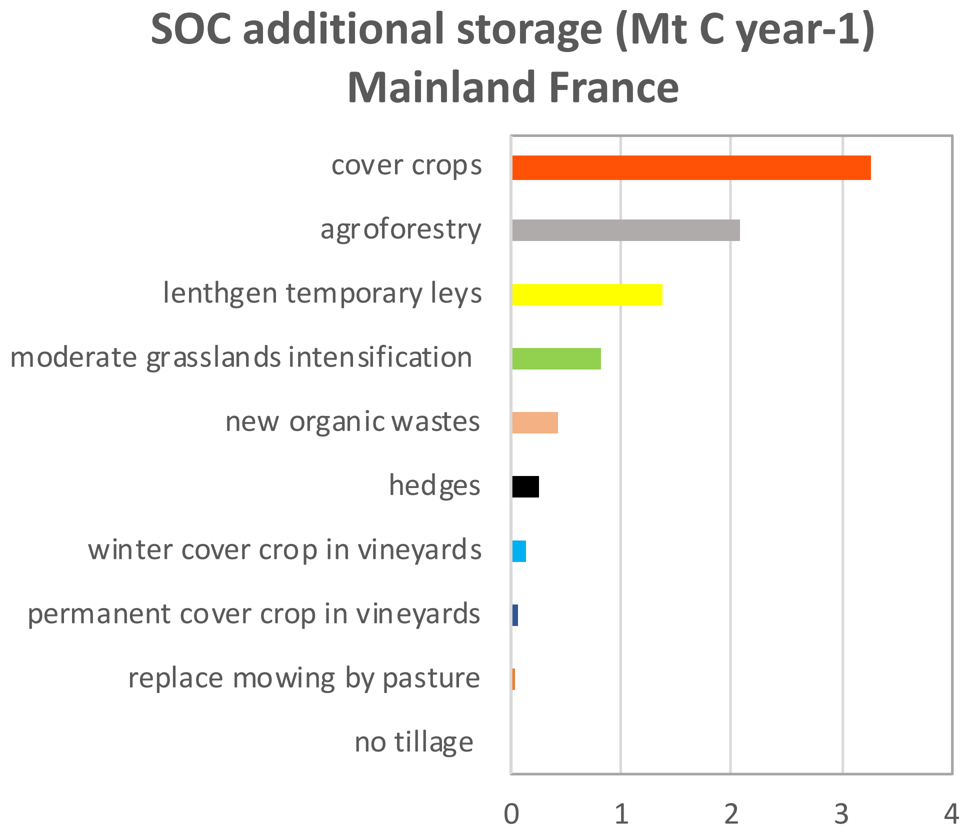
Rémi Cardinael[1,2,3], Viviane Umulisa[4,5], Anass Toudert[4], Alain Olivier[6], Louis Bockel[4] and Martial Bernoux[4]

SOC storage potential at regions/nations scales

e.g. France
Pellerin, Bamière et al. 2019
in press

Total French GHG emissions 458 Mt CO_2e 7%
French agricultural emissions 77 Mt CO_2e 41%
Total SOC stocks 3585 Gt C

SOC storage potential in agricultural soils ?



30 y, combination of practices:

+8.43 Mt C.y^{-1} -> 31 Mt CO_2e y^{-1}

Economic assessment ?

SOC storage potential at regions/nations scales

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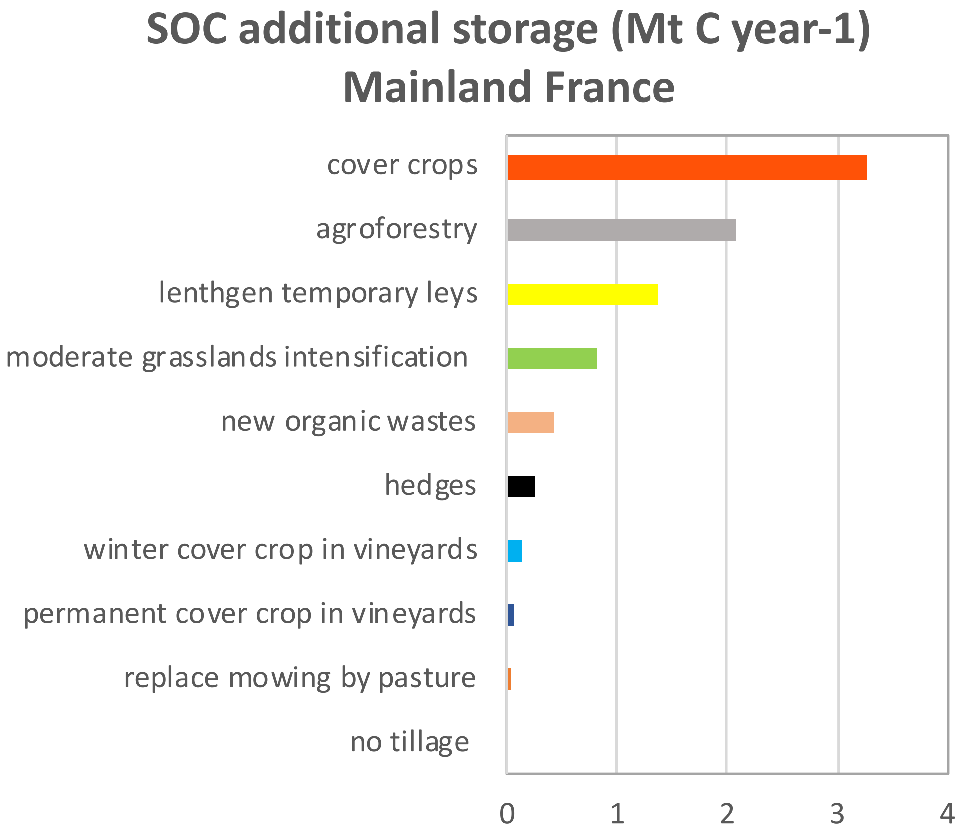

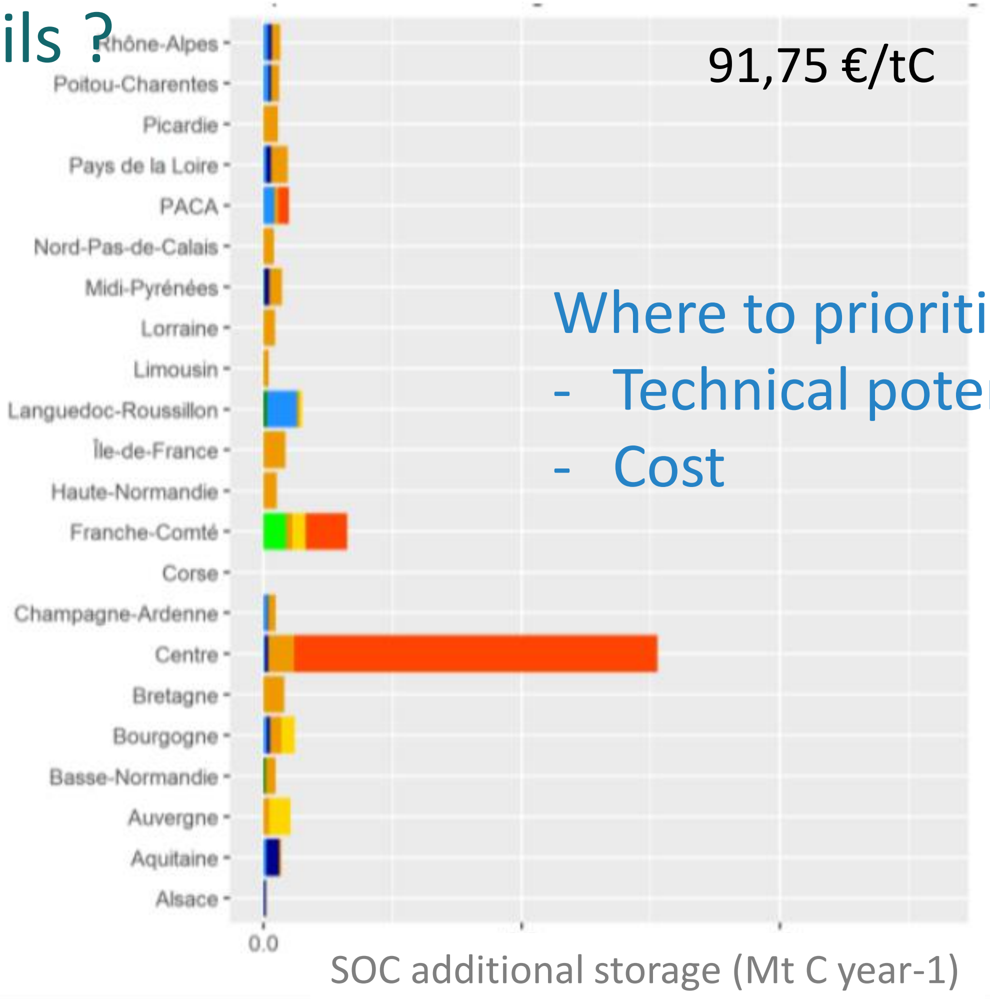

91,75 €/tC

Where to prioritize efforts?
- Technical potential
- Cost

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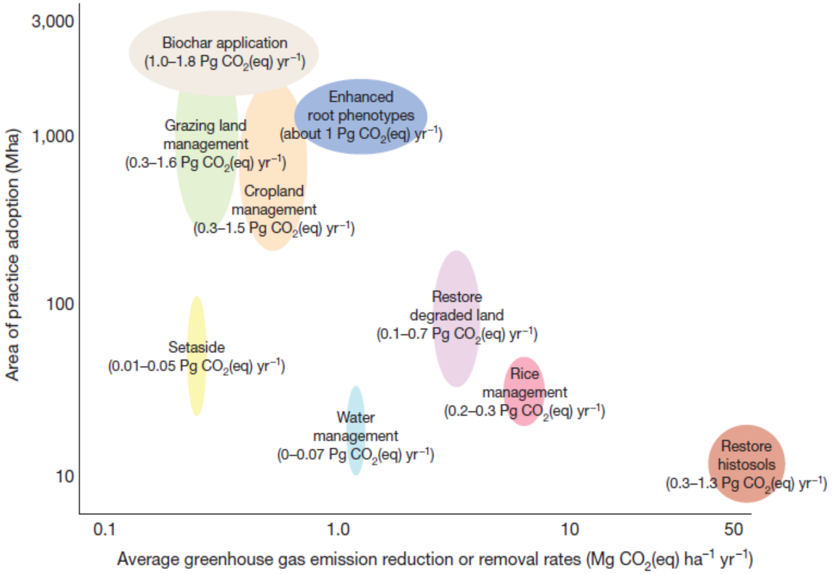
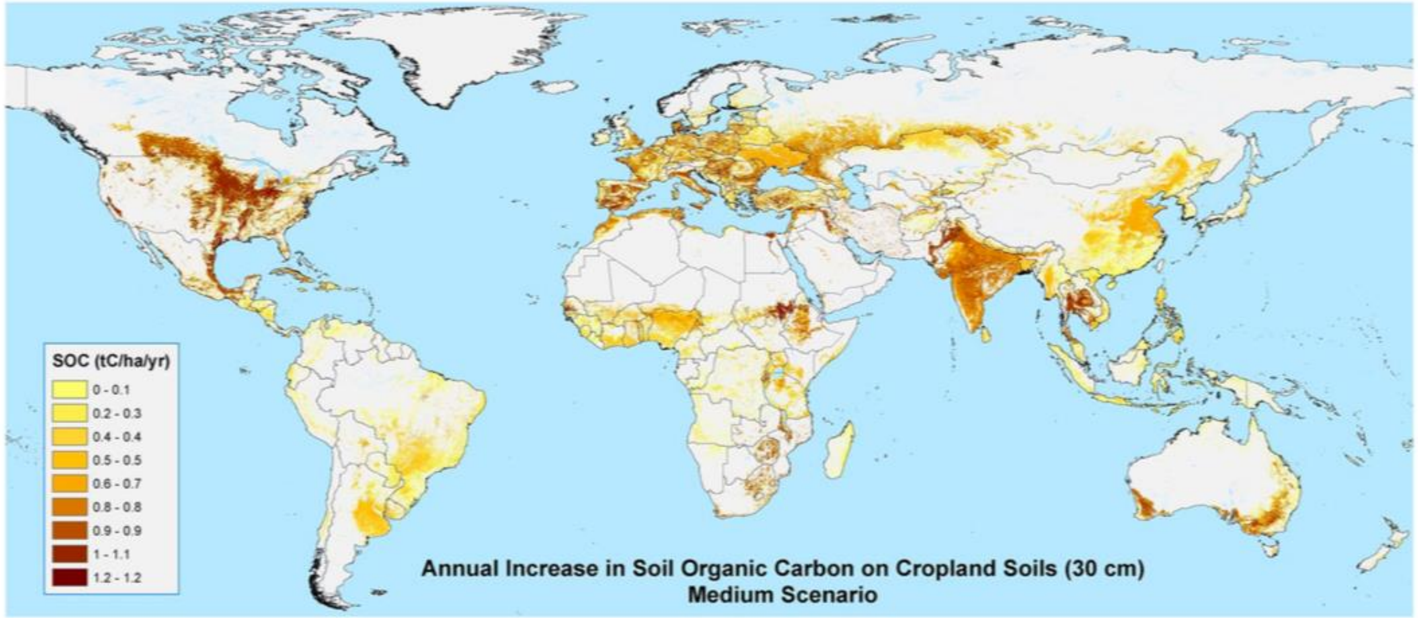
Global agricultural estimates



Paustian et al., Nature, 2016



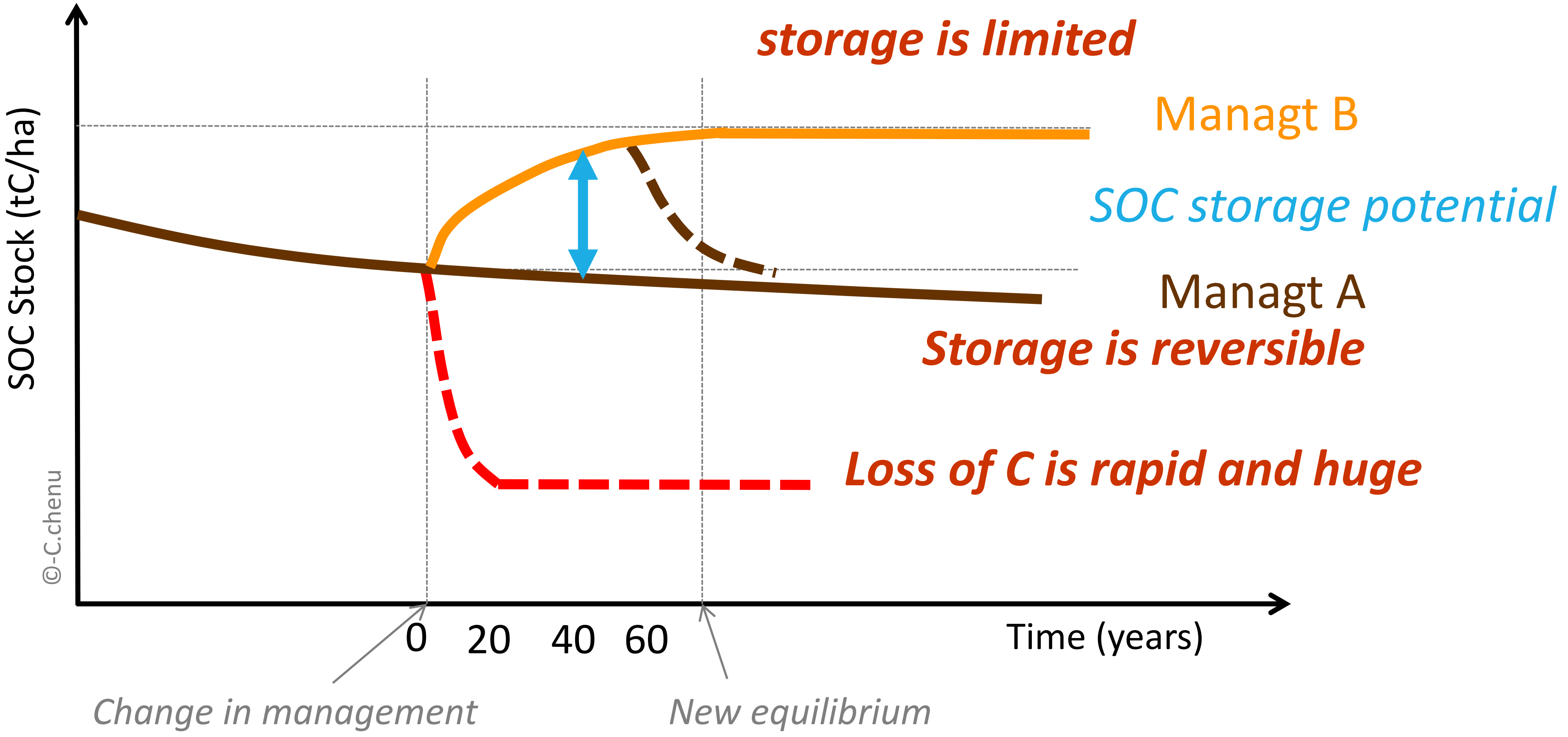
Zomer et al. , 2017

- Technical potential
- Data compilation, meta-analysis
- Large uncertainties

	GtC $year^{-1}$
Smith et al. 2008	1.4
Paustian et al. 2016	2.2
Zomer et al. 2017	0.9-1.7
Soussana et al. 2019	2.1

Maintain and increase soil carbon: limits, barriers, risks?

C storage : how much for how long ?



Storage is slow

Biophysical barriers to SOC storage

water

Biomass production

Trost et al. 2013, Nath et al. 2018…

nutrients

Biomass production
SOM stabilization

Kirkby et al. 2014
Van Groenigen et al. 2017

- N surpluses in intensive agriculture systems
- Biological N fixation
- Livestock & urban waste recycling

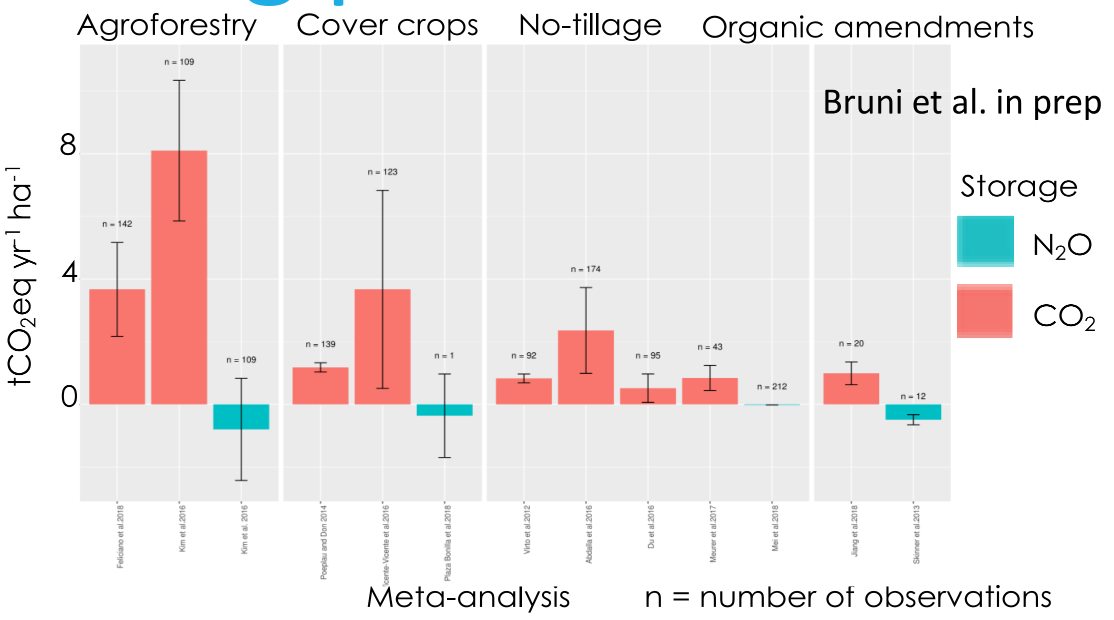
Soussana et al. 2017

biomass

soils

Technical, economic, social, cultural, legal barriers

Risks of SOC storage or SOC storing practices



- Negative environmental impacts ?
  - GHG emissions
  - Water quality
  - Pesticides
  - Resources consumption : water, nutrients
- Negative social impacts ?
  - Land use change to « carbon farming »
  - Pressure on land tenure and family farming

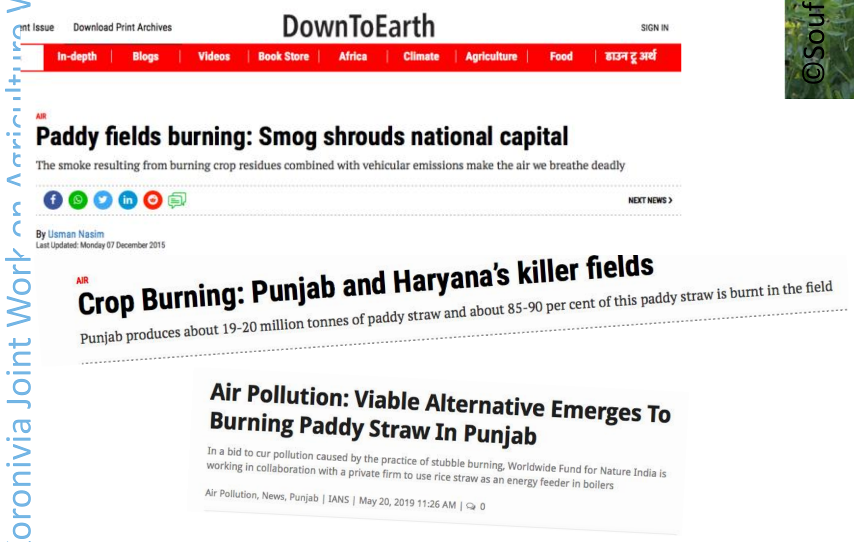
Selection of management options

No regret options ?

food production, adaptation, mitigation, environment, co-benefits.

Farmers - Society

Stop burning crop residues



DownToEarth

Paddy fields burning: Smog shrouds national capital

The smoke resulting from burning crop residues combined with vehicular emissions make the air we breathe deadly

By Usman Nasim
Last Updated: Monday 07 December 2015

Crop Burning: Punjab and Haryana's killer fields

Punjab produces about 19-20 million tonnes of paddy straw and about 85-90 per cent of this paddy straw is burnt in the field

Air Pollution: Viable Alternative Emerges To Burning Paddy Straw In Punjab

In a bid to cur pollution caused by the practice of stubble burning, Worldwide Fund for Nature India is working in collaboration with a private firm to use rice straw as an energy feeder in boilers

Air Pollution, News, Punjab | IANS | May 20, 2019 11:26 AM

Cover crops

Agroforestry

Piliostigma, Sahel :
+ yields & + stability
+ WUE, + water + nutrients

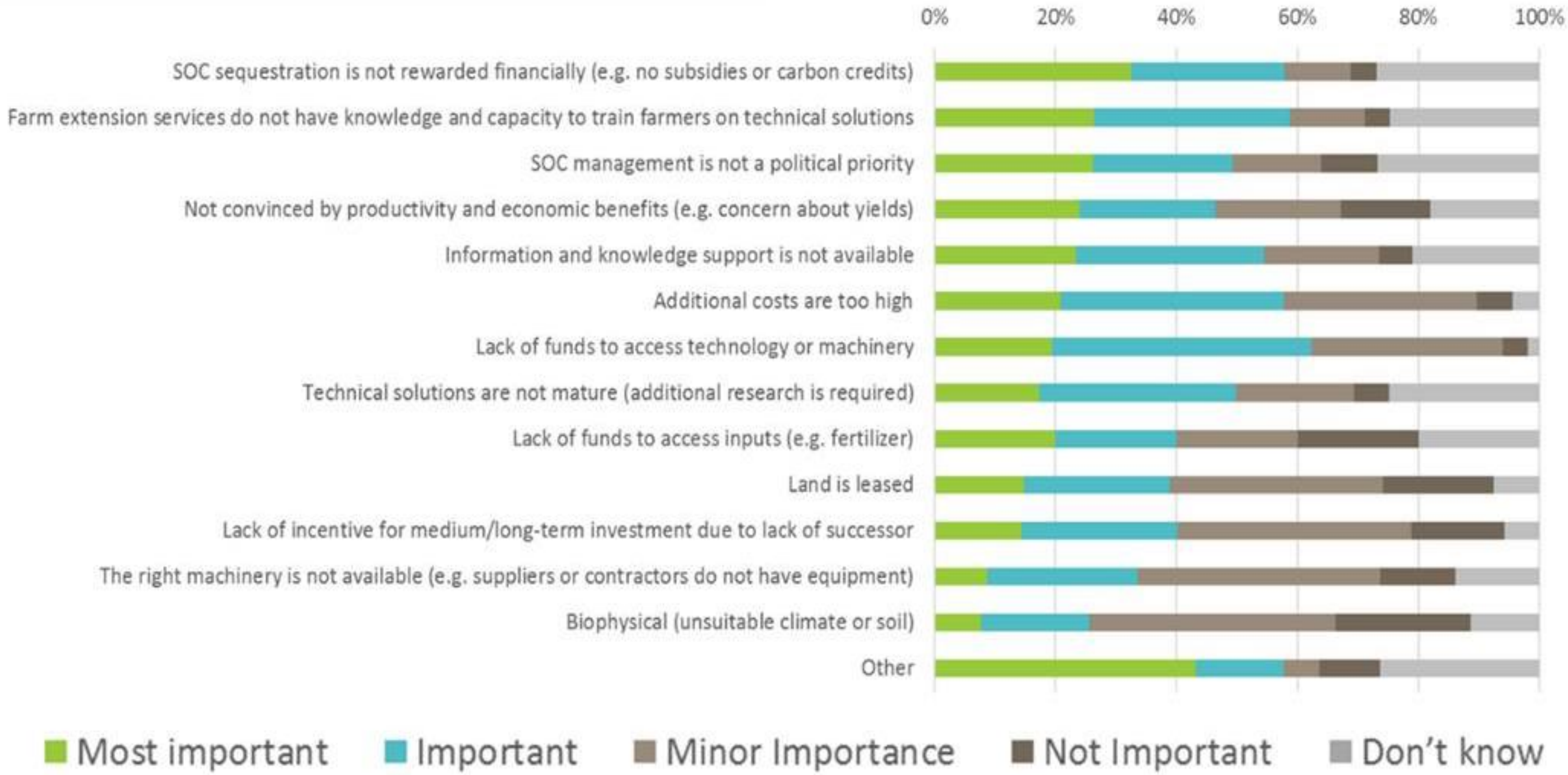
Restore degraded land

Bright et al. 2017

Challenges for implementation?

Barriers to implementation

Stakeholders consultation. Farmers (world, ≈ 1500)



https://www.circasa-project.eu

Enabling environment

Economic returns
Training, capacity building
Extension services & support
Credit, investment
Land tenure security
Incentives

Take-home messages

Soil carbon is key to address vulnerabilities of agriculture to climate change and food security issues

- Preserving and increasing soil organic carbon brings **multiple benefits**
- Increasing soil C in agricultural soils is **feasible**, but heterogeneous
- **Not a single good practice** but adequate combination of practises in a given context
- Associated **risks** : can be predicted, should be avoided
- **Spatially differentiated**: potentials, constraints, benefits. Spatially target the action
- There are “**no regret**” options
- **Technical potential >> socio-economic potential**


Thank you for your attention
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