Research Institute of Organic Agriculture FiBL
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Measuring soil carbon – the Eddy Covariance Technique

Climate Farm Demo and Climate Smart Advisors

Thematic Exchange Events, 11.11.2024

Lin Bautze (lin.bautze@fibl.org), Marco Toni (marco.tonni@agronomisata.it) and Andrea Pitacco (andrea.pitacco@unipd.it)

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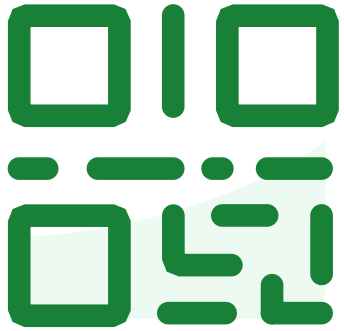

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CLIMATE FARM DEMO

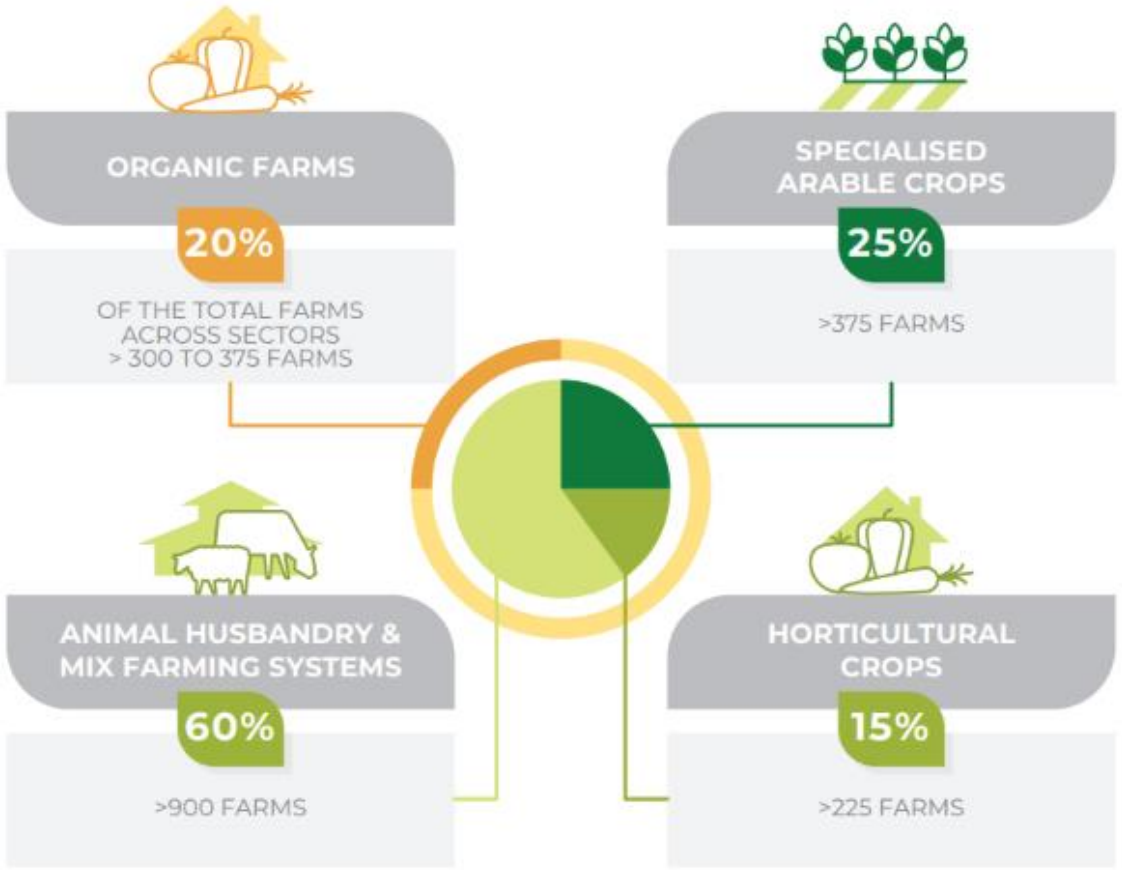
Funded by the European Union

This project has received funding from the Horizon Europe research and innovation programme under Grant Agreement No 101060212.0

Climate Farm Demo

A European-wide Network of Pilot Farmers implementing and demonstrating Climate Smart Solutions for a carbon neutral Europe

Climate Farm Demo (2022 – 2029)



65 Partners
16 Academic and Universities
19 Advisory Services
16 Farmer Organisations
11 Applied Research Institutes
3 NGOs

27 Countries + **24** CAP Networks
1,500 Pilot Demonstration Farmers
4,500 On-farm demonstration events
250,000 Actors engaged in peer-to-peer learning
10 Living Labs to co-create new practical solutions

CLIMATE FARM DEMO

12 Adaptation and Mitigation **Thematic Areas**

- Grassland management
- Forage production
- Crops management
- Soil health and biodiversity
- Agroforestry and relation to landscape
- Energy management
- Biogas production
- Water management
- Herd management
- Manure storage and spreading
- Additives for reducing enteric methane emissions
- Rewarding mechanisms

CLIMATE FARM DEMO

www.climatefarmdemo.eu

LinkedIn: **/climatefarmdemo**

X: **@ClimateFarmDemo**

Facebook: **/climatefarmdemo**

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Introducing CSA

[Lies Debruyne] mod. by Marco Tonni

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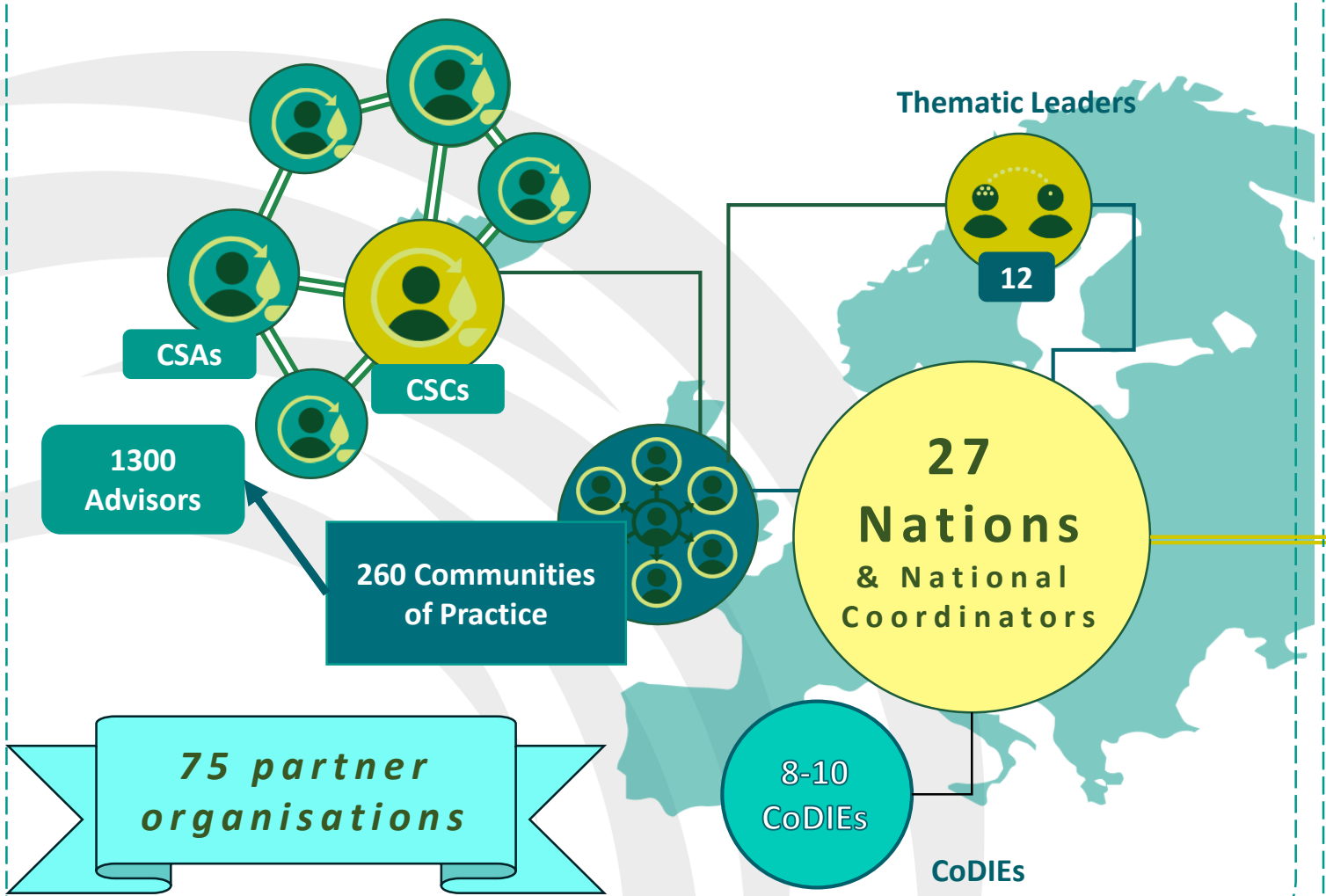
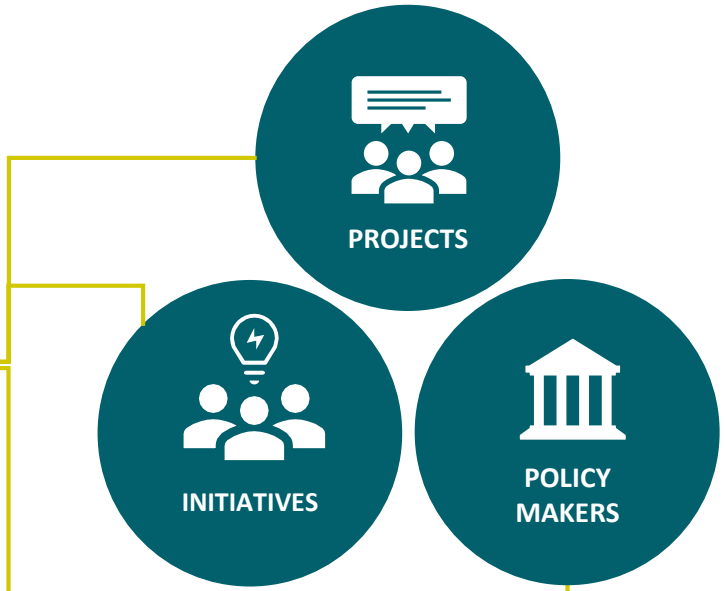
EUROPEAN-LEVEL NETWORK

WITHIN CSA NETWORK



BEYOND CSA NETWORK



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Thematic areas

- Crops management
- Grassland management
- Forage production
- Agroforestry and relation to landscape
- Herd management
- Manure storage and spreading
- **Soil health and biodiversity**
- Additives for reducing enteric methane emissions
- Energy management
- Biogaz production
- Water management
- Rewarding mechanisms

12 thematic areas, each with a Thematic Leader to support knowledge exchange

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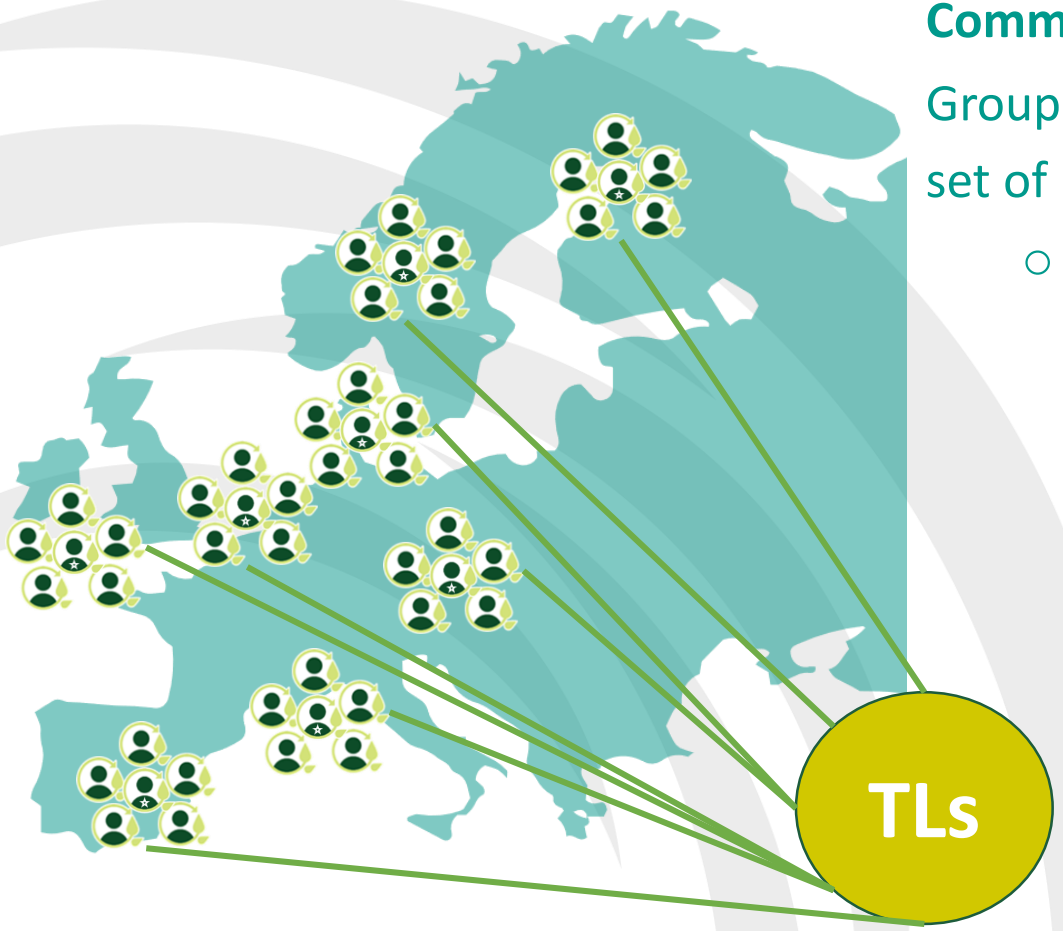
STRENGTHENING THEIR CAPACITY IN PROVIDING TARGETED ADVICE.



Communities of Practice (CoP) - 260 CoPs over 7 years

Group of advisors who share a common concern, set of problems or interest in a topic.

- **Sharing best practices** and **creating new knowledge** to advance professional practice.

Thematic Leader – 12 Areas

Connect COPs to support knowledge exchange

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Thematic Area Description

Soil Health and Biodiversity, SH&B

Marco Tonni (IT)

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it's a matter of... **h**

Soil is the **h**eart of (life on) Earth**h**

Definition of soil… from an ancient era:

Soil is the result of the alteration of rocks exposed to the atmosphere, subject to the action of various physical, chemical, and biological factors, which over time completely transform them from their original characteristics." Soil forms through a slow and lengthy process of **physical disintegration and chemical alteration of rocks, influenced by** both atmospheric conditions and living organisms, including plants and animals

But… We need to change our perspective!

Here's a new definition, just one of the possibles:

Soil is humanity's most valuable resource; it is through the soil and its rich **biodiversity** that **plants can produce** the world's entire food supply.

No biodiversity ➔ no soil

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Soil health and biodiversity
SH&B

change the way to act

Only by changing our point of view, we will be able to keep the focus on respect for the soil, which is essential to guarantee the continuity of agricultural production and of humanity itself.

Knowledge ⟷ **Awareness**

re-think the technical approach to the production

↓

believe in the possibility to be sustainable

↓

- share knowledge with farmers
- search which tools and behaviours are the best for our goals AND for farms

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Soil health and biodiversity
SH&B

road to

Seminars & scientific resources

COPs activities

Interaction with CFD

Results from field trials, CoDIE

↓

Knowledge & Awareness

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Soil health and biodiversity
SH&B

road to

Seminars & scientific resources

Arguments for the future:

- What are: soil's fundamental characteristics & functions
- How to: measure soil health, biodiversity, functionality
- What happens: impacts and quality improvement
- What to do: strategies

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Thematic Area Description

Soil Health and Biodiversity, SH&B

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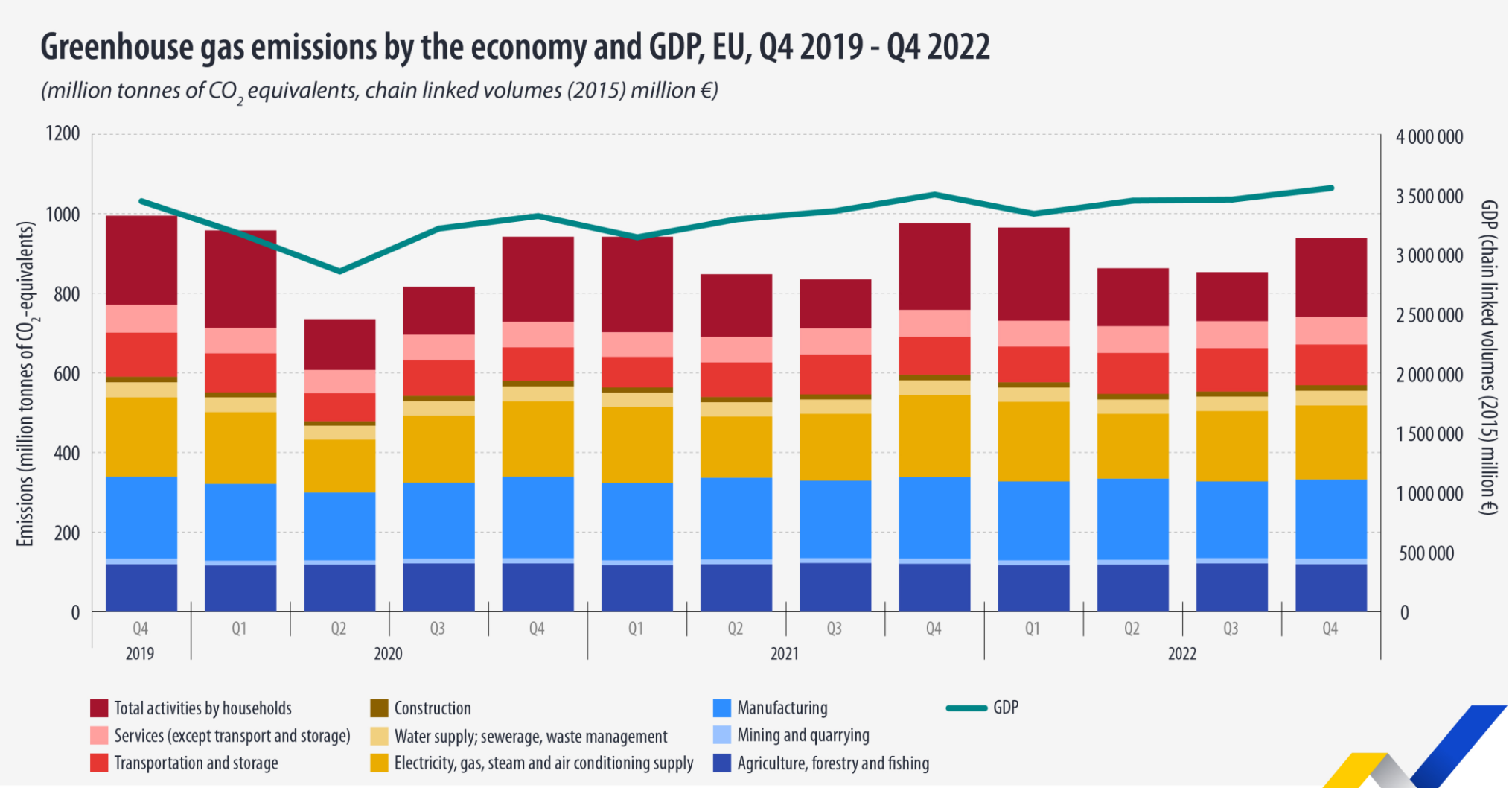
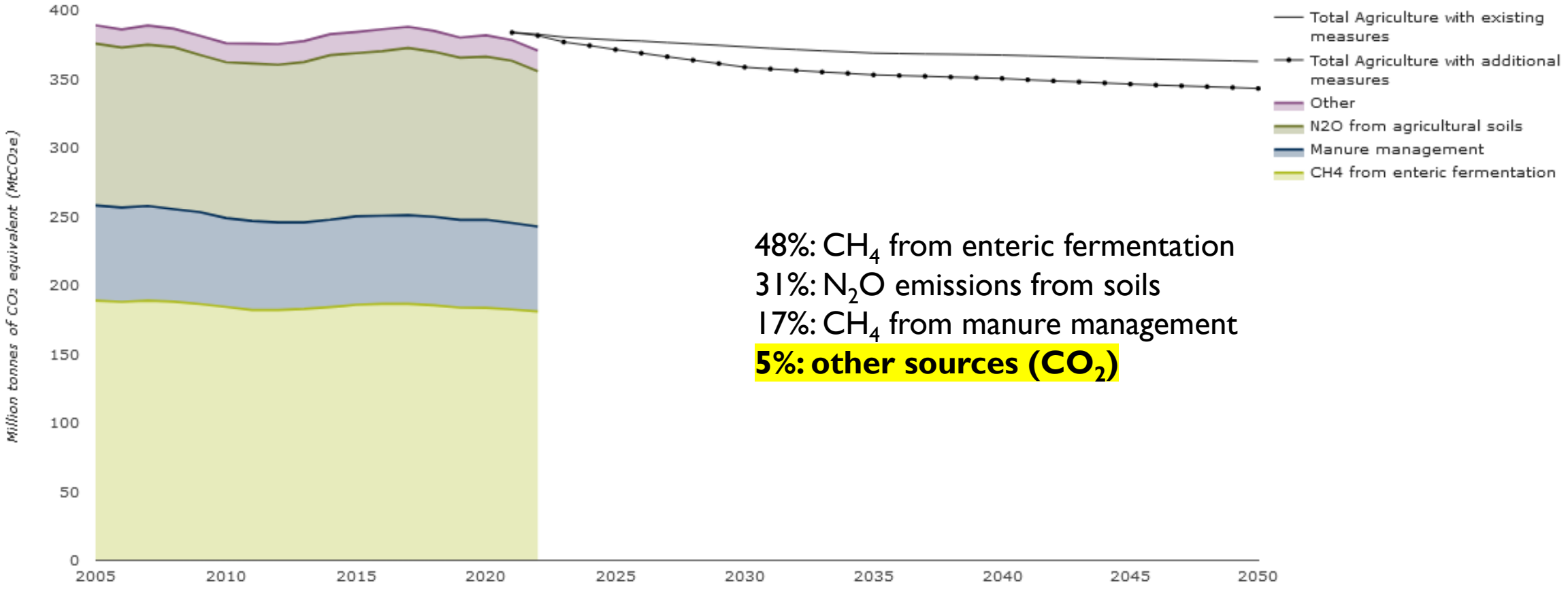
The role of soil organic carbon and measuring techniques

Climate Farm Demo, Thematic Exchange Events. Lin Bautze (lin.bautze@fibl.org) and Markus Steffens (markus.steffens@fibl.org), 11.11.2024

Climate relevance of soil organic carbon



Climate relevance of soil organic carbon



48%: CH_4 from enteric fermentation
31%: N_2O emissions from soils
17%: CH_4 from manure management
5%: other sources (CO_2)

European Environment Agency, 2023: Greenhouse gas emissions from agriculture in Europe

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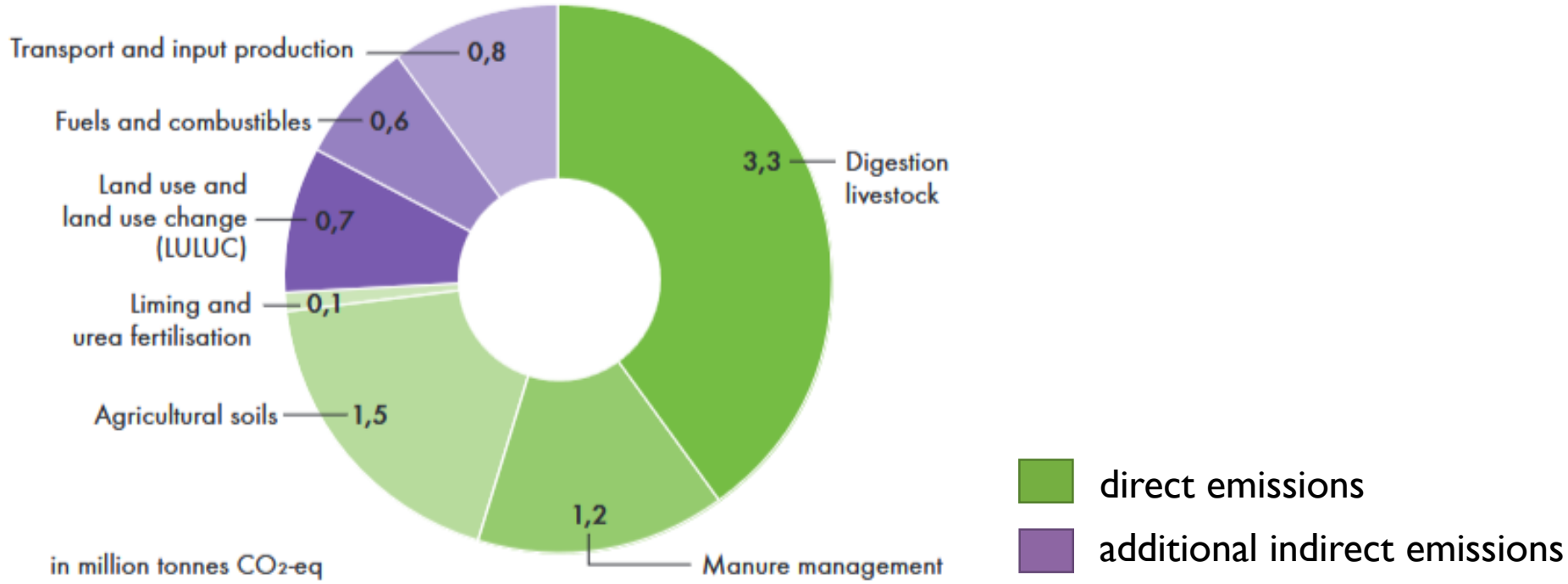
Climate relevance of soil organic carbon

Figure 2: Total cross-sectoral greenhouse gas emissions of Swiss agriculture in 2015



FiBL Figure Source: https://www.fibl.org/en/shop-en/1349-soil-and-climate

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How much of the global carbon is stored in the soils?

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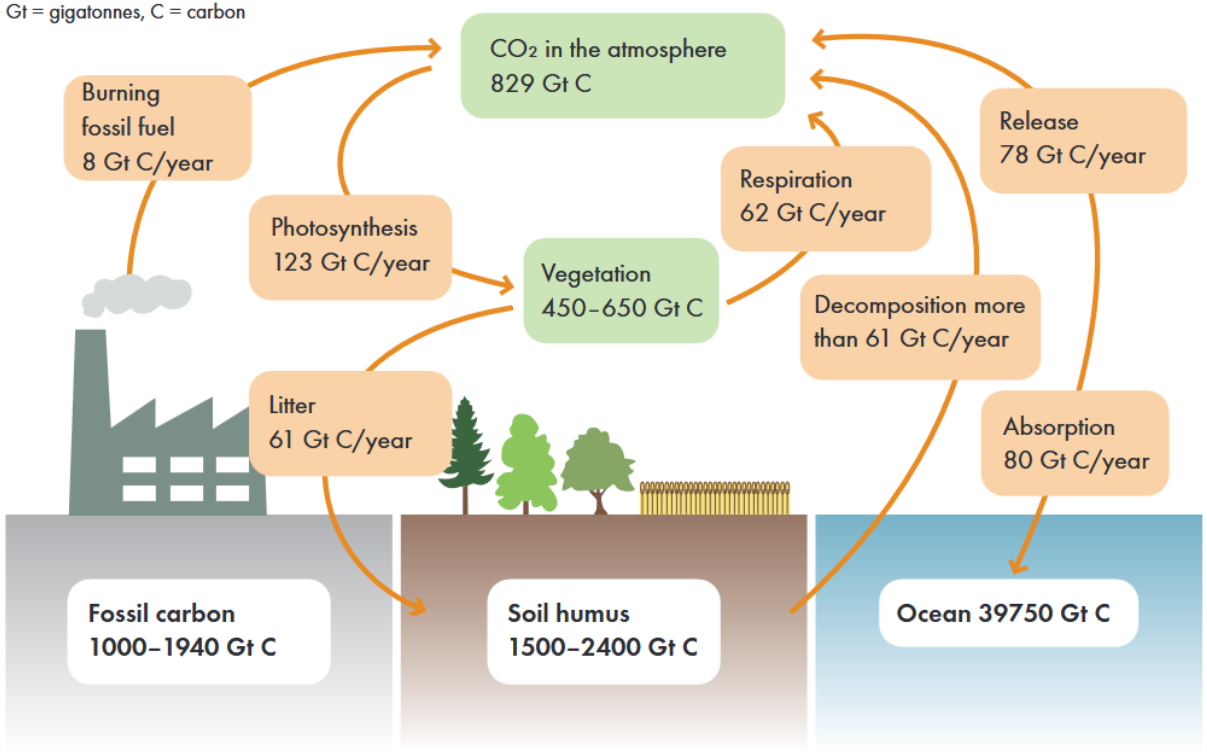
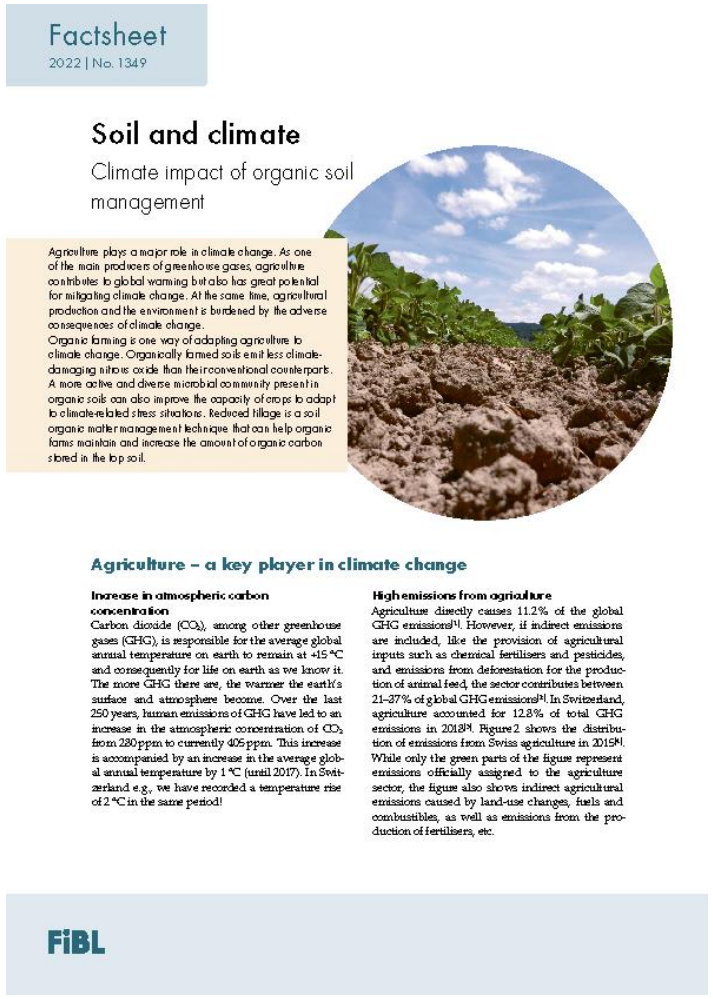
Climate relevance of soil organic carbon

Figure 1: Simplified representation of the global carbon cycle

Gt = gigatonnes, C = carbon



Humus build-up and decomposition play an essential role in the carbon cycle relevant to the climate. The CO_2 content of the atmosphere is currently increasing by 3.3 Gt C annually. C exchange with carbonate rocks, by far the largest carbon sink, is much slower and is therefore not listed here. Source: Graphic designed by Heinz Flessa, adapted by FiBL, using IPCC data[2]



Factsheet
2022 | No. 1349

Soil and climate

Climate impact of organic soil management

Agriculture plays a major role in climate change. As one of the main producers of greenhouse gases, agriculture contributes to global warming but also has great potential for mitigating climate change. At the same time, agricultural production and the environment is burdened by the adverse consequences of climate change.
Organic farming is one way of adapting agriculture to climate change. Organically farmed soils emit less climate-damaging nitrous oxide than their conventional counterparts. A more active and diverse microbial community present in organic soils can also improve the capacity of crops to adapt to climate-related stress situations. Reduced tillage is a soil organic matter management technique that can help organic farms maintain and increase the amount of organic carbon stored in the top soil.

Agriculture – a key player in climate change

Increase in atmospheric carbon concentration

Carbon dioxide (CO_2), among other greenhouse gases (GHG), is responsible for the average global annual temperature on earth to remain at +15 °C and consequently for life on earth as we know it. The more GHG there are, the warmer the earth's surface and atmosphere become. Over the last 250 years, human emissions of GHG have led to an increase in the atmospheric concentration of CO_2 from 280 ppm to currently 405 ppm. This increase is accompanied by an increase in the average global annual temperature by 1 °C (until 2017). In Switzerland e.g., we have recorded a temperature rise of 2 °C in the same period!

High emissions from agriculture

Agriculture directly causes 11.2% of the global GHG emissions[1]. However, if indirect emissions are included, like the provision of agricultural inputs such as chemical fertilisers and pesticides, and emissions from deforestation for the production of animal feed, the sector contributes between 21–37% of global GHG emissions[3]. In Switzerland, agriculture accounted for 12.8% of total GHG emissions in 2018[4]. Figure 2 shows the distribution of emissions from Swiss agriculture in 2015[4]. While only the green parts of the figure represent emissions officially assigned to the agriculture sector, the figure also shows indirect agricultural emissions caused by land-use changes, fuels and combustibles, as well as emissions from the production of fertilisers, etc.

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Figure Source: https://www.fibl.org/en/shop-en/1349-soil-and-climate

Links and relevance of soil organic carbon

Increasing soil carbon in agricultural soils is relevant:

- Better aggregate stability
- Reduced soil erosion
- Increased soil water holding capacity
- Higher microbial activity → nitrogen availability
- Increased microorganism / soil biodiversity
- …..

AND mitigation of further GHG emissions from the agricultural sector.

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Factors influencing soil organic carbon

- Soil type
- Climate (temperature, precipitation)
- Management practices
- Input / Output of organic matter (fertilizer, plants)
- Soil biodiversity (e.g. bacteria, fungi, earthworms)

Analytical quantification of soil organic carbon

Method	Advantages	Disadvantages
Visual Evaluation of Soil Structure (VESS)	- Fast and cheap	- Not quantitative
Loss-on-Ignition (LOI)	- Cheap	- Inaccurate
Dry combustion (elemental analysis)	- Gold standard technique - Highest accuracy - Measures total nitrogen, too (and total sulphur with modifications on the instruments)	- Expensive equipment - Measures total C (for organic carbon, carbonates have to be measured separately)
Wet oxidation with dichromate (Walkley Black)	- Measures organic carbon directly (not total C) - Established methodology	- Underestimates organic carbon - Generates hazardous waste
Infrared spectroscopy	- Fast and cheap - Potential for field application	- Expensive equipment - Currently no global calibration available - Precision controlled by calibration

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Challenges of measuring soil organic carbon

- different soil potential

Journal of Environmental Management
Volume 330, 15 March 2023, 117142

Research article

Carbon farming: Are soil carbon certificates a suitable tool for climate change mitigation?

Carsten Paul [a], Bartosz Bartkowski [b], Cenk Dönmez [a i], Axel Don [c], Stefanie Mayer [d], Markus Steffens [e], Sebastian Weigl [a], Martin Wiesmeier [d f], André Wolf [g], Katharina Helming [a h]

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https://doi.org/10.1016/j.jenvman.2022.117142

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Highlights

- Soil-based carbon certificates are sold as voluntary emission offsets.
- Private certification schemes provide financial incentives for carbon farming.
- However, they are not a suitable tool for climate change mitigation.
- Permanence, additionality and monitoring are not ensured; leakage effects may occur.

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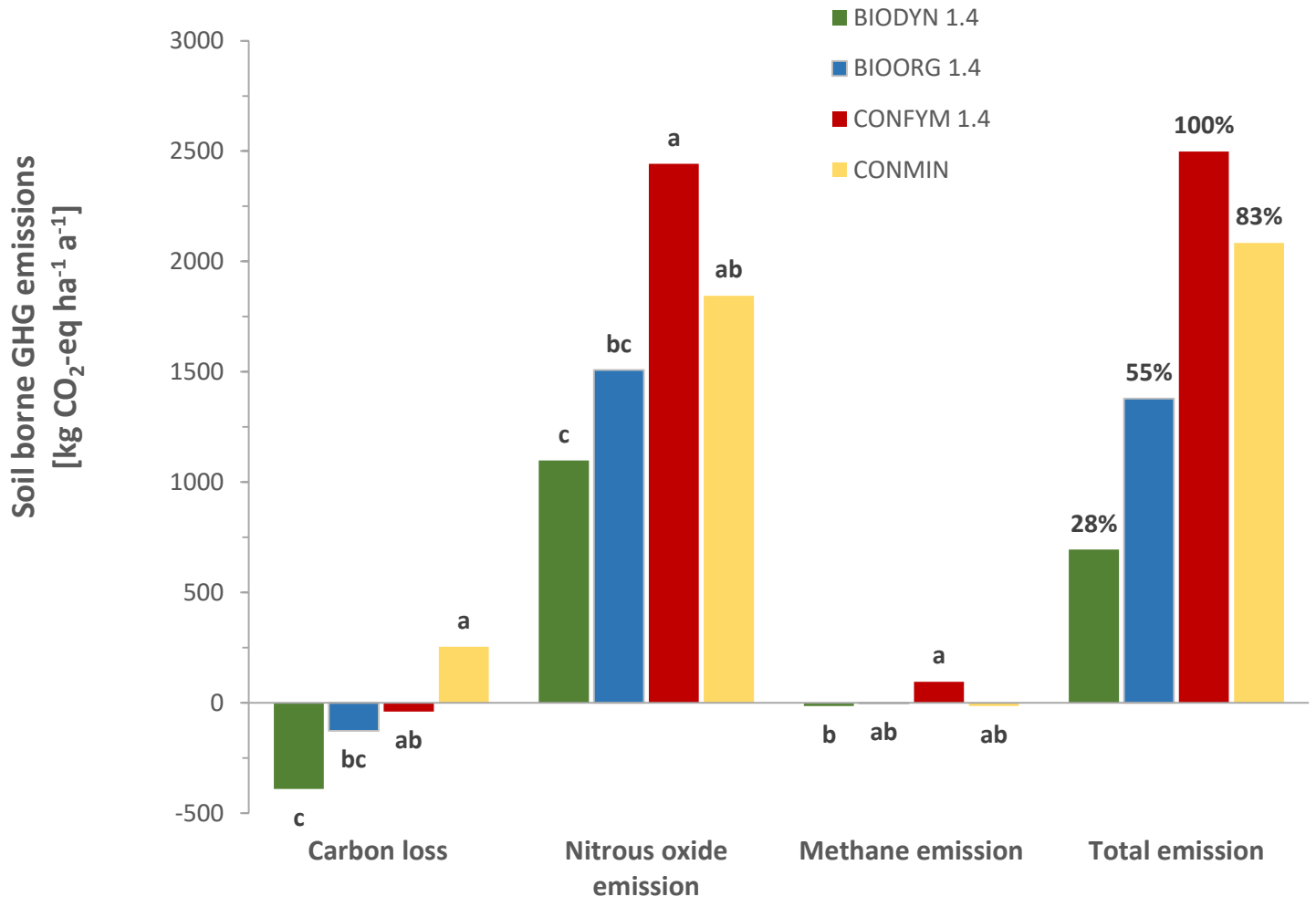
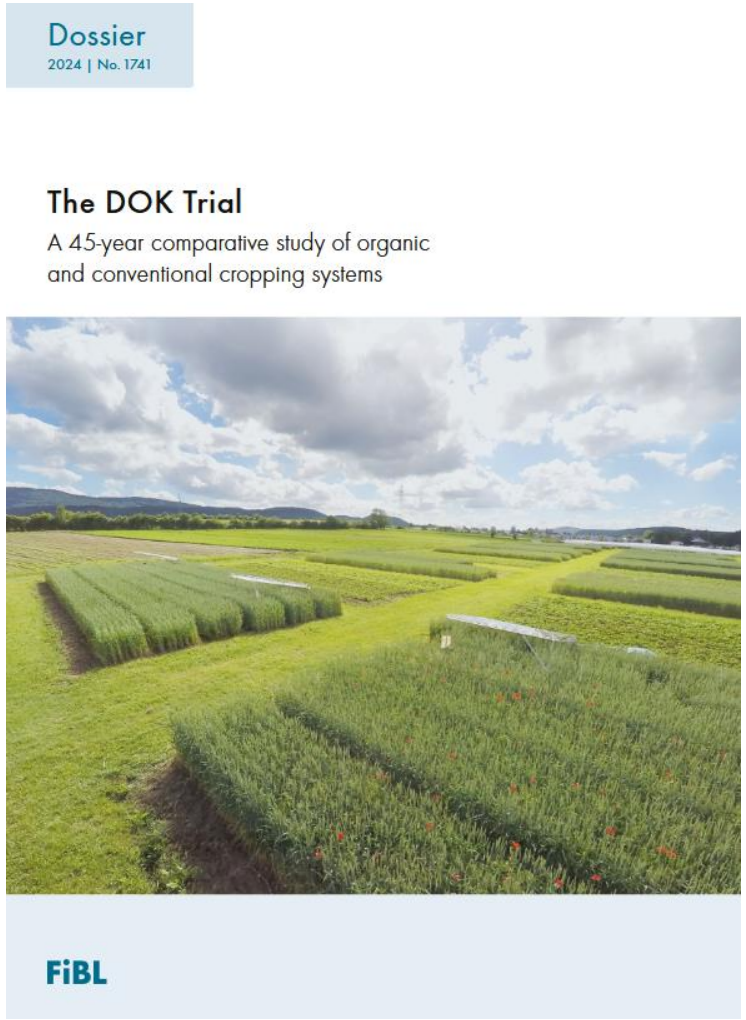
Organic carbon stocks of different soil types (0-100 cm)

Pararendzina	Regosol	Parabraunerde	Pseudogley	Humusgley	Erdniedermoor
13,4 t C_{org}	65,1 t C_{org}	78,4 t C_{org}	82,1 t C_{org}	131,7 t C_{org}	692,7 t C_{org}

Flessa, H., Don, A., Jacobs, A., Dechow, R., Tiemeyer, B., Poeplau, C. (2019): Humus in landwirtschaftlich genutzten Böden Deutschlands. Ausgewählte Ergebnisse der Bodenzustandserhebung. Bundesministerium für Ernährung und Landwirtschaft (BMEL), Bonn, Deutschland.

DOK-trial: Synthesis climate effect of organic agriculture





https://www.fibl.org/de/shop/1741-dok-dossier-en

Challenges of measuring soil carbon

- different soil potential
- additionality
- permanence
- potentially creates new emissions
- leakage effects

ELSEVIER

Journal of Environmental Management

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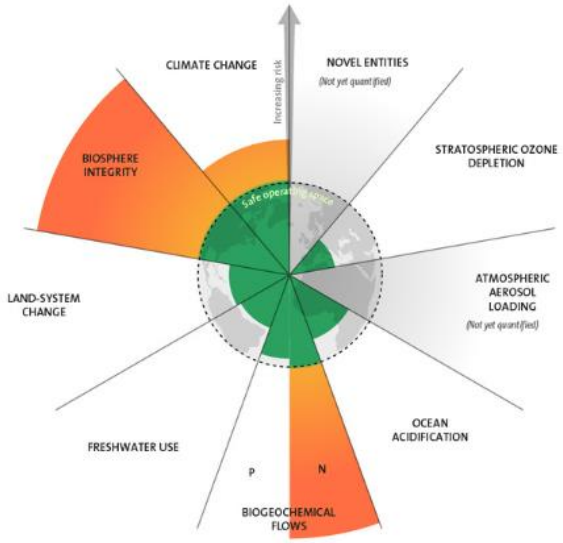
Soil carbon and climate tools

Many tools do not include SOC sequestration or changes, because:

- Measurement techniques need to improve
- Comparison between farms is difficult (different soil types etc.)
- Sequestration takes time
- Soils have a C sequestration limit
- What to do with plots/farms that reached this limit?

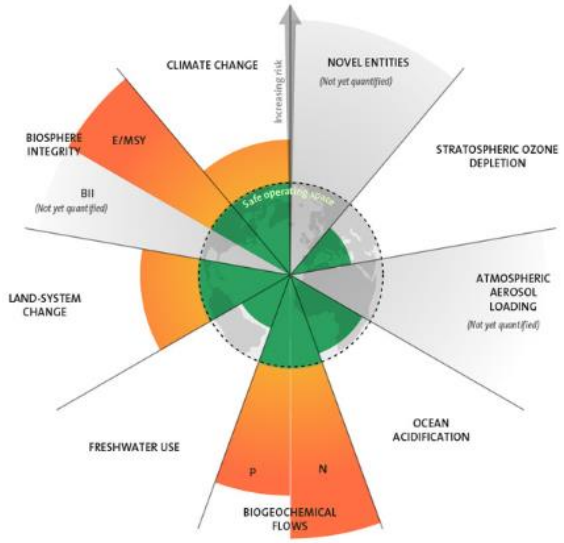
System transformation NOW!

2009



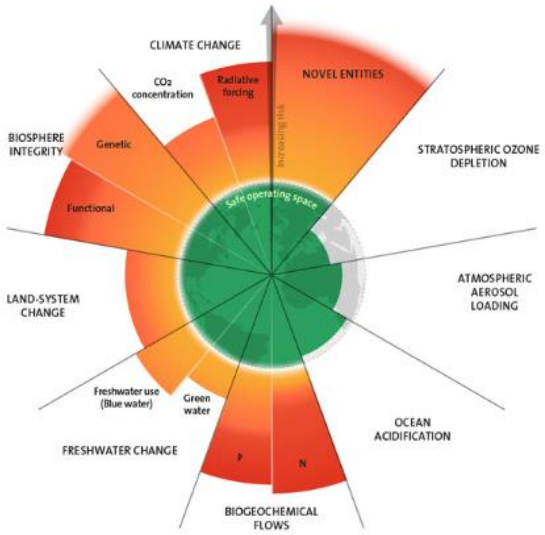
7 boundaries assessed,
3 crossed

2015



7 boundaries assessed,
4 crossed

2023



9 boundaries assessed,
6 crossed

https://www.stockholmresilience.org/research/planetary-boundaries.html

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Would the Eddy Covariance be a technique for you to use?

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What seminars related to soil health or organic agriculture would you be interested in for 2025?

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