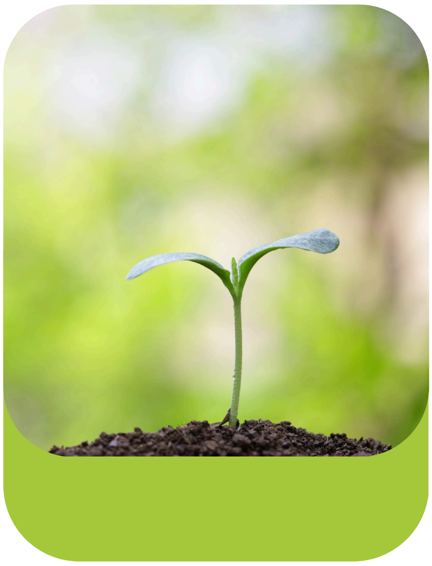
Interreg

Co-funded by the European Union

Italy – Croatia

GECO 2.2



WP2 – UPGRADING OF THE GECO2 PROJECT TOOLS

D.2.1.1 Comparative test study

Activity 2.1 – Comparative test study beetween GECO2 calculation system and the main international standard

Author:
Vincenzo Verrastro - CIHEAM Bari

verrastro@iamb.it

INTRODUCTION

The Paris Agreement (UNFCCC — United Nations Framework Convention on Climate Change) and the implementation of the United Nations Sustainable Development Goals are considered some of the most significant accomplishments of today's society.
Today, various policies and voluntary commitments promote sustainability transition and the use of climate claims to communicate climate pledges to the public by actors, including companies, organizations, cities, and governments.
Despite these developments, it has become evident that the current progress and measures are insufficient to combat climate change. Due to the worsened situation, simply reducing emissions is inadequate: Finding ways to remove accumulated CO_2 from the atmosphere is also necessary.
Carbon offsetting has been discussed for over two decades, and its long-awaited market growth has just started during the last few years. Carbon offsetting is considered an important mechanism that enables easy access to reduce emissions and remove carbon outside the company's supply chain.
Today, there is a very urgent need to address climate change and its impact on the environment, and more specifically on agriculture, towards a sustainable future.
As one of the most significant contributors to GHG emissions, agriculture plays a crucial role in mitigating climate change. In this line, the direct emissions of GHGs from agriculture reach 0.442 Gt CO2eq. and account for approximately 10% of total EU emissions. Furthermore, Europe's ambition to move towards a low-carbon economy by 2050 means that the non-Emissions Trading Scheme (ETS) GHG emissions must be reduced by 30% until 2030, compared to 2005 levels.
The agricultural sector also faces several challenges in relation to climate change, including increased frequency of extreme weather events (heat waves and mega-fires, heavy rainfalls and floods, tornadoes, and tropical cyclones), water scarcity, soil degradation, and changing patterns of pests and diseases.
These challenges not only threaten food security and rural livelihoods but also result in an increased carbon footprint of the sector.
Low-carbon certifications have emerged as an effective tool to incentivize and recognize good agricultural practices that promote sustainable farming techniques and minimize carbon emissions. They enable farmers and agricultural producers to determine, reduce, and offset their carbon footprint, as well as to ensure transparency and accountability throughout the supply chain.
Through the adoption of these tools, agricultural producers can implement climate-smart practices such as precision farming, agroforestry, and improved livestock management while at the same time decreasing GHG emissions and enhancing resilience and productivity.

Certification schemes often complement and promote environmental legislation compliance. Also, the outcome of the use of sustainability standards to enable compliance with environmental policies introduced by governments, may also contribute to the improvement in the effectiveness of certification schemes
An alternative low-carbon certification scheme may be related to the increase in soil organic carbon (SOC) stocks in agricultural soils. It is known that SOC removes carbon dioxide from the atmosphere and contributes towards achieving carbon neutrality. However, an increase in SOC levels assumes that farmers invest in modern agricultural management practices prior to obtaining a private soil carbon certificate that may compensate for incurred costs. In these schemes, farmers need to register their fields with commercial certificate providers who certify SOC increases, while certificates may be sold as voluntary emission offsets on the carbon market

The purpose of this analysis is:

- to identify and critically examine the most established and operational low-carbon certification systems in agriculture
- evaluate their effectiveness in reducing GHG emissions and promote sustainable farming practices

1. REVIEW OF CONCEPT OF CERTIFICATION

Certification is a procedure by which a third party provides written assurance that a product, process, or service along the supply chain conforms with certain standards.
Certification systems are a crucial component of many industries and ensure that their owners possess the necessary qualifications to perform their duties competently and safely. The most common types of certification systems include professional certification, management system certification, and product certification. Certification of products is a process by which a third party confirms that a product meets certain standards or criteria, mainly related to quality, safety, and environmental impact. Once a product has been certified, it is given a mark or label that indicates its compliance with these standards. There are several international standards that govern the certification of products.
These include the International Organization for Standardization (ISO), the British Standards Institution (BSI), the French Ministry for Ecological Transition (METS), the International Reference Life Cycle Data System (ILCD), the World Resources Institute (WRI), the World Business Council for Sustainable Development (WBCSD), the Product/Organization Environmental Footprint (P/O EF) and The European Food Sustainable Consumption and Production (SCP) Round Table.

Certification in the agricultural sector provides a mechanism to verify and communicate the quality and sustainability of agricultural products.
Eco/green certification systems in agriculture have attracted great interest in recent years to promote sustainable practices and meet consumer demand for environmentally friendly products. They aim to quantify and reduce GHG emissions associated with agricultural production as well as promote sustainable farming practices by considering factors such as manure management, fertilizer application, and energy use.
The scope of eco/green certification has expanded beyond individual products to cover entire supply chains, addressing also social and economic dimensions.
Various certification schemes have been established globally to address different aspects of agricultural production, including organic farming, fair trade practices, sustainable agriculture, and low carbon/GHG emissions.
These schemes involve a set of standards and criteria that farmers must meet to obtain certification for their products.
Organic certification is one of the most well-known and widely practiced forms of agricultural certification. It ensures that agricultural products are produced without the use of synthetic fertilizers, pesticides, and genetically modified organisms (GMOs). Furthermore, in the last years, a lot of emphasis has been given to standardization, certification, and development of biobased slow-release fertilizers (SRFs), such as biochar, to reduce operating costs and environmental impacts, improve crop growth and quality, and thus promote sustainable agriculture
The low-carbon certification systems aim to establish a baseline scenario, facilitate effective carbon reduction measures, and define a crediting period to incentivize and reward farmers for their efforts in mitigating GHGs (Figure 1).
The baseline scenario serves as the reference point and is crucial for quantifying the carbon reduction achieved through sustainable farming practices. It considers factors such as farm management practices, inputs, and historical emission data.

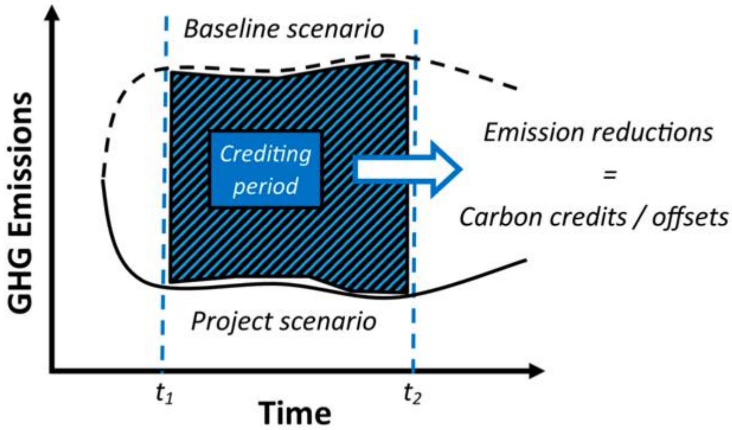


Figure 1. Typical quantification of carbon emission reductions for a predefined crediting period.

The crediting period refers to the duration over which carbon reduction activities are measured and credited. The duration of the crediting period can vary depending on the certification system and the specific agricultural activities being assessed. For example, some systems may involve shorter crediting periods when practices have an immediate carbon reduction impact.
The crediting period allows farmers to track and measure their progress in reducing emissions, providing them with a clear incentive to continue implementing sustainable practices.
Certification providers have a significant role in the field of eco/green certification, both at European and global levels. However, it is important to note that the certification process primarily relies on data collection from farmers that is subsequently utilized to calculate emissions

2. OVERVIEW OF THE EXISTING LOW-CARBON CERTIFICATION SYSTEMS

So far, only a few certification systems, covering a small number of agricultural products, are available in Europe and elsewhere.
Furthermore, a major issue of concern is the legitimacy of these systems regarding the degree of inclusiveness and transparency of the decision-making process for setting standards.
Most of these standards do not explicitly target climate change mitigation; however, some requirements are likely to enhance reduction in GHG emissions and carbon storage.
Hereby some examples of previous certification processes and carbon calculators are reported, that were acted before GECO2 project:

Solagro (EU) (https://carbone.solagro.org/)
In 2010, the European Commission, following a request from the European Parliament, carried out a pilot project on the ***"certification of low-carbon farming practices in the European Union"*** to promote reduction in GHG emissions in the sector. The overall aim was to incorporate into policies initiatives that would be implemented by European farmers in order to promote the reduction in GHG emissions in agriculture and produce agricultural products with carbon-neutral or low-carbon-footprint farming practices.
The project included the following stages:

(i) a review of existing farm-level lifecyclebased climate-related certification and labeling schemes,
(ii) the development and testing of a user-friendly open-source carbon calculator suitable for assessing the lifecycle of GHG emissions from different types of farming systems across the entire EU,
(iii) the design/assessment of policy options for promoting low-carbon farming practices.

The aim of the SOLAGRO Carbon Calculator is to assess GHG emissions from farming practices and to suggest climate change mitigation and sequestration actions at farm level. The Carbon Calculator reports the carbon footprint at the farm scale and for the main products of the farm. Mitigation actions are evaluated according to their GHG profile.
The Carbon Calculator is designed for the main farming systems through the EU-27 but is not adapted to all farms. The difficulties to run a GHG assessment in some specific farms is related mainly to the availability of emissions factors for this type of farm. For example, in horticulture systems, there are no emission factors for flowerpots and plants.
The evaluation of greenhouse gases does not go beyond the gates of the farm. The final version of the Carbon Calculator only includes a cradle to farm approach.

The end-of-life of some inputs is not considered because they are occasional: machinery, raw materials from buildings, pesticides and antibiotics.
The first step for data entry in the Carbon Calculator is to define and quantify the production of relevant products at farm level. What is an agricultural product corresponding to its physical form beyond farm gate (before processing). The user can select up to a maximum of five different products from a drop-down menu
The presentation of results for detailed GHG emissions (by sources and gases) is based on the Organisational Environmental Footprint "OEF" guide:
• GHG emissions from direct activities (non-mechanical sources, enteric fermentation, manure management, direct and indirect emissions from soils, and burnt crop residues),
• GHG emissions from indirect activities: consumption of purchased electricity and other indirect energy sources like collective irrigation or water pumping, fuel from thirds (contractors, etc.), all other indirect sources from manufacturing and transportation (e.g. agrichemical production and product processing).

Carbon Calculator
GHG Assessment (annual flow) of the farm
Solagro
V2-16 (32 bits)

Assessment
F_DairyCrops 166,3 ha
Dairy with crops 3,0 AWU
France 2010

Detailed GHG emissions sources and carbon storage

Current situation (tonnes / year)	tCO_2	tCH_4	tN_2O	tHFC (in CO_2e)	tCO_2e	
1 GHG emissions from direct activities	**150**	**45**	**1**	**3**	**1 495**	**82%**
1-1 Machines and equipment	102	0	0	3	**105**	**6%**
Mobile machines	102			0	**102**	**6%**
Fixed machines	0			3	**3**	**0%**
1-2 Process emissions	48	45	1		**1 390**	**76%**
Enteric fermentation		31			**785**	**43%**
Manure management		13	0		**338**	**19%**
Direct N_2O emissions from soils			1		**215**	**12%**
Indirect N_2O emissions from soils			0		**52**	**3%**
Crop residues burnt		0	0		**0**	**0%**
2 GHG emissions from indirect activities	**48**	**0**	**0**	**0**	**327**	**18%**
2-1 GHG emissions of energy used on the farm and purchased by thirds	35	0	0		**35**	**2%**
Electricity purchased (i.e. on the grid)	28				**28**	**2%**
Collective irrigation (electricity or fuel for pumping)	8				**8**	**0%**
Fuels from thirds (operations done by contractors)	0				**0**	**0%**
2-2 GHG emissions for other purchased inputs	12	0	0		**292**	**16%**
Mineral and organic fertilisers (processing and transportation)					**65**	**4%**
Other crop inputs (seeds, pesticides)					**4**	**0%**
Secondary inputs (plastics and other petrochemicals)					**3**	**0%**
Purchased feedstuff					**197**	**11%**
Other animal inputs (purchased animals, rearing costs)					**0**	**0%**
Farm buildings and materials					**5**	**0%**
Machinery (and other equipments)					**6**	**0%**
Fuels manufacturing and transportation	12				**12**	**1%**
3 Total GHG emissions	**197**	**45**	**1**	**3**	**1 822**	**100%**
4 Additional environnemental information	**92**	**0**	**0**	**0**	**92**	
Changes in carbon stocks in natural infrastructures	30				**30**	**2%**
Changes in carbon stocks due to changes in soil management practices and land use	62				**62**	**3%**
Avoided GHG emissions due to the use of renewable energies in the farm instead of non renewable ones	0				**0**	**0%**
Avoided GHG emissions from the production and sale of renewable energies	0				**0**	**0%**

Figure 5: Detailed GHG emissions sources and carbon storage at farm scale reported by the Carbon Calculator

Fig. 1: Screenshot of the SOLAGRO carbon calculator tool.

The intention for the SOLAGRO Carbon Calculator is to create a tool, easy to understand and friendly to use. A simple and accessible user interface has been developed. Users with basic computer and agronomic knowledge should be able to carry out an assessment with the Carbon Calculator.
The tool is developed on Excel with Visual Basics for Applications (VBA) for macros and user forms. The Excel options must be modified for that use. The data needed (questionnaire) to run the Carbon Calculator has been defined based on the implementation of the methodology. Additional data are required linked to methodology developments, about climatic conditions, soil type, pH, etc. to describe the environment of the farm.
The findings of this study indicated that there exist multiple options for using a farm-level carbon calculator for promoting low-carbon farming practices in the EU. It was concluded that it is possible to envisage a certification scheme based on this calculator that would inform the granting of subsidies or assist in allocating support for rural development measures addressing climate change issues.

Low-Carbon Label (France) - (https://label-bas-carbone.ecologie.gouv.fr/)
The low-carbon label (LCL, "Label bas carbone" in French) is an official certification label created in 2018 by the French Ministry for the Ecological Transition (MTES) and the Institute for Climate Economics (I4CE) that aims to reduce GHG emissions in France by 2050. The label focuses on evaluating and acknowledging projects that successfully reduce GHG emissions, promotes a rigorous and transparent approach to emissions accounting, and emphasizes the importance of the development of robust methodologies and third-party verification.
Public consultation is conducted for these methodologies that undergo review by a technical and scientific committee. Upon approval from the regulator, they become official for the Low-Carbon Label (LCL) and can be used by project developers to certify emission reductions.
By obtaining the "Label Bas Carbone", businesses and projects gain recognition for their efforts in reducing emissions and can establish themselves in the market as leaders in environmental sustainability.
So far, LCL has established 11 approved low-carbon methods/practices for 5 sectors, including agriculture, forestry, building, transportation, and the maritime industry, while 24 others are still under development.
In the case of agriculture, LCL is designed based on the **Carbon Agri method** to recognize and reward farmers and agricultural businesses that implement measures to reduce GHG emissions and contribute to sustainable agricultural production.
The system is based on the calculation of Carbon Credits for Orchard plantation, sustainable management of hedges and crop-livestock and livestock farming. His peculiarity it's the use of

different standards for achieving the measure of Carbon stocks. Some of the different methodologies are:

ABC'Terre

ABC'Terre is a robust and innovative method for calculating carbon storage in agricultural soils and GHG emissions from cropping systems. It innovates by bringing to the attention of local actors the effect of their agricultural practices, according to their soils, on the evolution of the long-term carbon stock and the GHG emissions of their cropping systems. It is based on the method of calculation implementing a specifc algorithm in a system based on the **Registre Parcellaire Graph** (CAP declarations from farmers, anonymised).
The tool makes it possible to spatially cross-reference the rotations thus reconstituted, with data from the **Regional Soil Repository**, a regional geographical database of soils, to obtain rotational rotations by soil type in a territory. The configuration of a farm typology makes it possible to better characterize these rotational rotations by type of soil, and *a posteriori*, to associate cultivation practices more precisely.
A method has been developed within the framework of ABC'Terre to characterize the organic carbon contents of soil types of the Regional Soil Reference System (RRP) from the Soil Analysis Database. The BDAT provides up-to-date data on the organic carbon content of agricultural soils, located at the municipal level over a large part of metropolitan France.

HAL method

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not.
The project was able to detect at least 20 non exhaustive different methodologies of soil stocking carbon evaluation, according to different climatic conditions, cultivation types and/or soils. (https://hal.inrae.fr/hal-03212854v2/document)
By the way, and using several database, obtaining this certification, agribusinesses and farms demonstrate their dedication to mitigating climate change and showcase their efforts to operate in an environmentally responsible manner. In this context, LCL also provides consumers with a recognizable label that signifies the environmental responsibility and carbon consciousness of the purchased agricultural products.
The **Carbon Agri method** provides guidelines and specific calculation factors to estimate emissions from various agricultural activities. It considers regional and sector-specific data to ensure accuracy and relevance to the French agricultural context. The method takes into account factors such as crop type, livestock species, and specific farming practices to tailor emission calculations to individual farms. The certification process typically involves an audit or assessment conducted by qualified professionals who evaluate the farm's practices and the carbon reduction efforts taken. The assessment may include data collection, farm visits, and review of documentation to ensure compliance with the certification standards.

To calculate the carbon footprint using the Carbon Agri method, farmers need to collect relevant data for their agricultural practices, such as crop areas, livestock numbers, feed consumption, and energy use.
This information is then used in combination with the calculation factors provided by the Carbon Agri method to estimate GHG emissions. The Carbon Agri method uses either the **CAP'2ER® tool** at level 2 (mixed farming and livestock farming) or any other tool that has been acknowledged as methodologically equivalent and certified by an independent third-party organization.
The application of the Carbon Agri method allows farmers to assess their emissions, identify emission hotspots, and develop targeted strategies to reduce their carbon footprint. Farmers aiming to obtain the "Label Bas Carbone" certification must demonstrate their commitment to reducing carbon emissions through the implementation of sustainable practices. Relevant activities that may be implemented include precision agriculture techniques to optimize fertilizer and water usage, conservation tillage or cover cropping to improve soil health and sequester carbon, and exploring the use of renewable energy for on-farm operations.

LEAF Marque Standard (UK) (https://leaf.eco/leafmarque/standard)

The LEAF Marque Standard is a certification program developed in 2015 by LEAF (Linking Environment and Farming), a non-profit organization committed to promoting sustainable agriculture. The standard provides a framework for assessing and recognizing environmentally responsible and socially sustainable farming practices. The LEAF Marque Standard sets out a checklist of criteria and requirements that farmers must comply with to obtain the certification.
These criteria include biodiversity conservation, soil and water management, energy efficiency, waste management, wildlife habitats, and social aspects such as worker welfare and community engagement.
One of the key features of the LEAF Marque Standard is the implementation of strategies to reduce GHG emissions and enhance carbon sequestration in soils and vegetation.
These may include practices such as agroforestry, cover cropping, and conservation tillage. By increasing the organic matter content in soils and promoting vegetation growth, farms can actively sequester carbon from the atmosphere, contributing to the mitigation of climate change.
The LEAF Marque Standard also places a strong emphasis on soil health.
Farmers are required to implement practices that maintain and enhance soil quality, such as minimizing soil erosion, promoting organic matter content, and managing nutrient inputs effectively. Soil health is crucial for long-term agricultural sustainability, as it directly impacts crop productivity, water retention, and carbon sequestration.
The method do not imply carbon calculation methods but more an actuation of protocols at soil level and the appointment of a label of approval or a developmental activity (on-going).
The latest version, 16, of the LEAF Marque Standard that was issued on 1 October 2022 and became effective on 1 April 2023 incorporates advancements and updates to ensure that certified

farms continue to meet the highest sustainability standards. The standard, which is updated biannually, incorporates the latest research and technological advancements to ensure that certified farms are at the forefront of sustainable agriculture. Furthermore, v. 16 places increased emphasis on holistic farm management and the integration of sustainable practices across the entire farm system.

Life ClimaMED Certification Tool (Mediterranean Region) - (english version is not avaialble anymore: https://www.lifetaskforce.gr/en/)

The LIFE-ClimaMED certification tool is being developed in the frame of the LIFE17 CCM/GR/000087 project "Innovative technologies for climate change mitigation by the Mediterranean agricultural sector". This tool, using real-time measurements (Tier 3), is validated and demonstrated in 15 fields located in various regions of Greece, involving the cultivation of olive trees, grapes, vegetables, cereals, and pistachio trees.

The infrastructure needed for data collection at the field level involves the following:

(i) a Light Detection and Ranging (LiDAR) device with an integrated internet connection card that is installed in fields and measures GHGs,
(ii) a meteorological station,
(iii) a solar panel as an alternative electricity source,
(iv) a telemetry system for data transmission (LoRa),
(v) a web GIS-based platform for data collection, processing, and visualization (see Figure).

This platform also serves as the interface between producers and the Greek Ministry of Rural Development and Food (MINAGRIC), which will issue the relevant emissions certificate based on data processing in each field. In addition to MINAGRIC, the proposed certification system requires the involvement of producers, equipment suppliers, the Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid Schemes (OPEKEPE), and external certifiers.

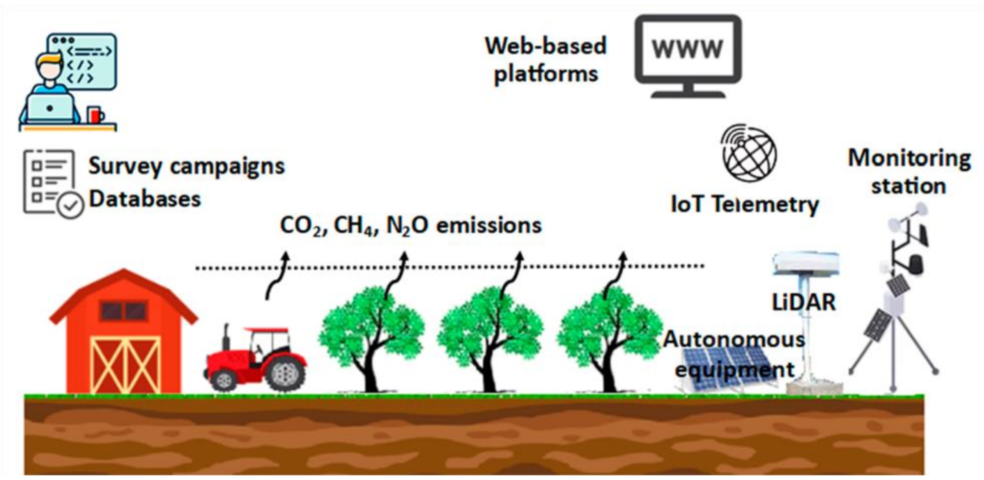


Figure: Schematic diagram of the components of the Life ClimaMED infrastructure

The LiDAR device operates in the near-infrared spectrum and measures three GHGs, namely, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The device is safe for outdoor use due to its low optical power and does not pose any health risk to humans, animals, or birds.
The LoRa telemetry system is a network that collects and manages real-time data from agricultural operations for monitoring farm activities, GHG emissions, and climatic parameters. It consists of IoT devices and sensors that monitor various parameters, such as temperature and humidity; the recorded values are transmitted via the LoRaWAN protocol that is suitable for rural areas and allows long-range communication with low energy consumption. The telemetry system also includes various interfaces and an electronic environment where users can view maps, charts, and real-time data. The system is userfriendly, requires minimal maintenance, and offers scalability and interoperability. It also supports WiFi and Ethernet connections for devices with higher data requirements, such as cameras or LIDAR systems.
The "Center for Monitoring and Management of Greenhouse Gases (CMM)" is the operational hub developed for MINAGRIC to monitor and manage GHG emissions. The platform collects, processes, and evaluates records from LIDAR devices and meteorological stations installed on participating fields, providing a comprehensive and visualized real-time view of the emissions of all three GHGs. In addition to individual records per field, the platform enables MINAGRIC to monitor the overall evolution of CO_2, N_2O, and CH_4 emissions for all participating fields.
Finally, producers receive via the platform a statement of their emissions for each gas (CO_2, CH_4, and N_2O) per cultivated hectare and per kilogram of produced product. The objective of MINAGRIC is to engage as many producers as possible in this system, thereby collecting the maximum amount of data from the country's cultivated land. This will allow the authorities to gain insight into emissions from the agricultural sector and to encourage and support producers in reducing these emissions.

NON -EU countries

KOREA

A system, based on the Framework Act on Low Carbon, Green Growth, was launched in 2014 by the Republic of Korea (ROK), aiming to achieve the GHG reduction target in the agricultural sector.
The ROK has introduced the Low-Carbon Agricultural and Livestock Product Certification System to gain various benefits, such as generating new income for farmers and enhancing their competitiveness by introducing low-carbon farming techniques. This system refers to a national certification approach applied to a limited number of agricultural products, i.e., 51 categories, such as food crops, vegetables, fruits, and special crops, when their life cycle carbon emissions are lower compared to the national average emissions of the same product types.
The Ministry of Agriculture, Food and Rural Affairs of the ROK officially introduced this system in 2015, and until 2019, 830 agricultural products were certified as low-carbon ones. According to the

Foundation of Agricultural Technology, Commercialization and Transfer (FACT), which is a certification body, as of December 2020, 4700 farms (706 cases) and 5657 hectares obtained certification.
In March 2022, FACT was rebranded as the Korea Agricultural Technology Promotion Agency (KOAT) to enhance the economic impact of agricultural R&D and promote industrial advancement. **Based on this system, lowcarbon certification can only be applied to farms that have received the existing eco-friendly (organic, pesticide-free) or Good Agricultural Practices (GAP) certification.**
These practices use the following:

- Technology to reduce consumption of fertilizer and pesticides, such as circulation farming, green manure cultivation, and eco-friendly control.
- Energy-saving technologies for agricultural machinery, such as direct planting and no tillage.
- Heating energy-saving technologies such as multi-layer insulation curtains, water curtain cultivation, geothermal heat pumps, etc. The key is to reduce carbon emissions by using agricultural water management technology.

Low-carbon certified agricultural products can be purchased through premium distribution networks such as department stores, large marts, and eco-friendly stores. As the public's awareness of the environment increases, the impact of the low-carbon certification mark on consumers' purchase of agri-food is expected to grow fast. Farmers are hoping for more drastic marketing and support for expanding sales channels to boost consumption of certified agricultural products.
However, recent data indicate that the number of certified farms in Korea is small, and this reveals that the low-carbon certification system is still in the initial stage, achieving a very small annual reduction of almost 70,000 metric tons of CO_2eq, far away from the 2030 target that aims to reduce GHG emissions in agriculture, forestry, and livestock industries by 7.9% (about 1.9 million metric tons of CO_2eq) compared to 2012 values.

USA

In 2022, in the United States, where the US Department of Agriculture (USDA) launched the Partnerships for Climate-Smart Commodities program. Its main objective is to expand markets, leverage GHG emissions reduction for climate-smart commodities, and position American producers as global leaders in climate-smart agricultural production.
The anticipated benefits of the selected projects are as follows:

- Provide technical and financial assistance to producers to implement climate-smart production practices on a voluntary basis on working lands.

- Pilot innovative and cost-effective methods for quantification, monitoring, reporting, and verification of GHG benefits.
- Develop markets and promote the resulting climate-smart commodities.

3. OVERVIEW OF THE GECO2 METHODOLOGY

The GECO2 methodology was developed as part of the Interreg V-A Italy-Croatia Cross-Border Cooperation Program, which is financed by the European Regional Development Fund (ERDF). The GECO2 (Green Economy and CO2) project focuses on the development of a voluntary market for carbon credits in agriculture, with the aim of reducing greenhouse gas emissions and encouraging sustainable practices in rural areas of the Adriatic regions of Italy and Croatia.
The methodology of the project is based on the establishment of local markets through three key protocols: Market protocol (rules and market structure), Calculation system protocol (calculation of the balance of CO_2e emissions and removals) and Cultivation protocol (a set of recommended agricultural practices for carbon sequestration and increasing ecosystem resilience).
As part of the project, specialized digital tools were developed – CAFÉ (Carbon Fixing Elaborator) for calculating carbon sequestration on farms and COFFEE (Carbon Offsetting Emission Elaborator) for calculating the carbon footprint of loan buyers. All transactions, calculations and data are monitored through the MAP platform, which serves as a public registry and a tool for transparent monitoring of the carbon market.
The project involves a wide range of stakeholders, including farmers, buyers, technicians and public administration. During the pilot phase, more than 160 farms in seven regions were involved, and ten key agricultural practices aimed at preserving soil, reducing emissions and increasing biodiversity were defined.
GECO2 represents a practical model for the development of local carbon markets and at the same time contributes to the objectives of the EU Green Deal, the Farm to Fork Strategy and the Nature Restoration Regulation, in particular through measures to improve soil organic carbon stocks and preserve landscape diversity.

4. PRIVATE INTERNATIONAL STANDARDS FOR CARBON CERTIFICATION

The Voluntary Carbon Market consists of several standards, which are the centre of operations in the market. They act as the market regulators, providing the certification and issuance of the carbon credits, but also safeguarding the quality and credibility of the credits.
These standards include a complete set of rules, requirements and methodologies, and they lead regulatory procedures and a validation and verification system which is usually outsourced by third parties.
Voluntary carbon credits experience generally lower transaction costs that those generated in the compliance market. Besides, the VCM created a niche for micro-scale projects that are too small to justify the administrative effort of compliance schemes or for initiatives that are not covered yet.
Some of the most known VCM standards are:

1. **Verra or Verified Carbon Standard (VCS)**
2. **Gold Standard (GS)**
3. **American Carbon Registry (ACR)**
4. **Climate Action Reserve (CAR)**

1) VERRA (https://registry.verra.org/app/search/VCS)

Verra is **the leading global Carbon Standard**, helping to address the world's toughest environmental and social challenges by developing and managing **standards that help the private sector, countries, and civil society achieve ambitious Sustainable Development and Climate Action Goals**.
Verra is **a Washington, D.C.-based NGO founded in 2007** by environmental and business leaders who saw the need for **greater quality assurance in Voluntary Carbon Markets**. It now serves as a secretariat for the various standards it develops and programs it manages, as well as an incubator for new ideas that can generate significant environmental and social value on a large scale.
Verra acts the Volontary Carbon Standard (VCS) program. The VCS program enables certified projects to **turn greenhouse gas (GHG) emission reductions and removals into tradable carbon credits**. Since its launch in 2006, the VCS program has become **the largest voluntary greenhouse gas program in the world**. VCS projects include dozens of technologies and measures that result in reductions and removals of greenhouse gas emissions, including **the**

conservation and restoration of forests and wetlands, the **management of farmland**, **the improvement of transportation efficiency,** and many others.

2) GOLD STANDARD
The **Gold Standard Foundation** was **established in 2003 by WWF and other international NGOs** to ensure that projects that reduce carbon emissions have **the highest levels of environmental integrity** and also contribute **to sustainable development.**
With the adoption of the Paris Climate Agreement and the Sustainable Development Goals, the foundation launched **a best practice standard for climate action and sustainable development**, Gold Standard for the Global Goals, to maximize impact, creating **value for communities and the planet**.
The Gold Standard Impact Registry (GS). The GS is **a standard that sets out the requirements for implementing projects for maximum positive impact on climate and development** and for measuring and **reporting results in the most credible and efficient way**.
The GS is the second most widely used voluntary GHG program in the world, after the Verra VCS. **Over 1,100 certified projects have collectively reduced or removed approximately 210 million tons of carbon emissions and other greenhouse gases from the atmosphere**.

3) **American Carbon Registry (ACR) – (https://acrcarbon.org/about-us/)**
The American Carbon Registry (ACR) is a carbon offset program operated by Winrock International, founded in 1996 as the world's first voluntary private greenhouse gas registry. ACR develops rigorous, science-based standards and methodologies for quantifying, monitoring, and reporting greenhouse gas emission reductions and removals, as well as providing carbon credit registration, issuance, and verification services. ACR operates in both the voluntary and regulatory markets, including the California Cap-and-Trade market.

4 Climate Action Reserve (CAR)
The **Climate Action Reserve (CAR)** was established in 2001 by the State of California as the California Climate Action Registry (CCAR), recognizing early efforts in calculating and reporting emissions. The California Registry has helped over 400 businesses, government agencies, and municipalities in California voluntarily calculate and report their greenhouse gas emissions. His extensive experience in emissions accounting has translated into expertise in emissions reduction accounting for North American carbon markets. After the passage of the Global Warming Solutions Act in 2006, the CAR evolved into a major carbon credit program, developing and updating voluntary carbon protocols. The CAR is widely recognized for its forest protocols, which are designed to be context-specific, including the well-established U.S. Forest Protocol and the Mexico Forest Protocol, while actively developing new protocols for other Latin American countries. These protocols provide robust social and environmental safeguards that project developers must comply with to maximize co-benefits and the provision of ecosystem services for landowners and local communities.

It focuses on high-quality clearing projects, based on methodologies that ensure a static basis and reduce the risk of overcredit. CAR-certified projects support environmental and community co-benefits and often reduce local air pollution, restore habitats and ecosystems, and stimulate the growth of new green technologies.

5 COMPARISON BETWEEN VERRA STANDARDS AND GECO2 STANDARD

The two standards will be compared in the results they can achieve on real farms, even if the purposes of them is quite different.
Specifically, GECO2 project develops a "certification scheme" and, after this, generates a voluntary market for carbon credits in a cross-border system based on agriculture between two European countries (Italy and Croatia).
Verra, certifies and manages the register of carbon credits generated by own projects to reduce emissions, according to carbon farming practices. It is the global benchmark for carbon certification (VCS).
Searching within the wide database of VERRA of carbon capture projects (registry.verra.org) no matches were found about Italian and/or Croatian farms.
Comparison so has been established for the same parameters in common between GECO2 standard and VERRA ones.
In the following table a comparison with comments it's listed:

Type of parameter	**VERRA data**	**GECO2 data**	**Comments**
Soil data	Ph, Texture, OM (Organic Matter), Depth, Drainage type, **SOC (Soil Organic Carbon),**	Ph, Texture, OM (Organic Matter), Depth, Drainage type	VERRA standard includes also SOC parameter who is crucial for the determination of CC (Carbon Credits)
Crop and Field management	Data open for all **crops type**, including age, residual biomass use, tillage typologies, presence/absence of cover crops,	Data limited to **perennial crops**, including age, residual biomass use, tillage typologies, presence/absence of cover crops,	No differences in the analysis of crops managements. Verra has a wider range of data availability.
Agronomic inputs	Regenerative practices included in fam	Soil analysis (when available) and Farmer	GECO2 standard relies more on

	managing such as reduced tillage and cover cropping, soil sampling and biogeochemical models	book record analysis including fertilisers and pesticides.	referred data coming from the obligation of the farmers that applies to CAP funds in Europe. Verra applies models of development of soil management.
Energy	VERRA relies on the gross amount of energy utilised within the farm, but only from fossil fuels, necessary to define the project baseline.	GECO2 collects all the sources of energy available in farms, including renewables ones able to establish the farmer baseline	GECO2 is more precise than VERRA because includes a balance between the sources of energy (fossils against renewables) at farm level
Conservation practices	Process, composting, cover crops, ecosystem services are calculated in each farm calculated as trial actuation	Process, composting, cover crops, ecosystem services are calculated in each far calculated as tons used	GECO2 quantifies the amounts of green manure and/or byproducts reused within the farm , while VERRA keeps recording of the case without registering.

5.1 International carbon credits and EU climatic changes

This part of the analysis deals with the international carbon credits and the EU climatic changes position about.
The EU fights global climate change through domestic action and international cooperation and has an extensive toolbox to deliver on its domestic climate targets. In addition, the EU has signed the Paris Agreement, Article 6 of which includes tools for international cooperation. This note explains the historic and potential role of international carbon credits in the EU, considering the recent debate.

Cooperation mechanisms under Article 6 of the Paris Agreement
In November 2024, the 29th Conference of the Parties (COP29) to the United Nations Framework Convention on Climate Change (UNFCCC) finalised the rules to put Article 6 of the Paris Agreement into operation.
Key agreements include the transition of the Clean Development Mechanism (CDM) to the new Paris Agreement Crediting Mechanism (PACM), including afforestation and reforestation projects, with the negotiations involving several different elements.
The new rules set the foundation for cooperation on climate action and can be split into three approaches, each including a different instrument:

- Article 6.2 provides the basis for the bilateral transfer of mitigation outcomes between countries to achieve the objectives of their nationally determined contributions (NDCs);
- Article 6.4 allows for trade in carbon credits facilitated via a centralised UN supervised mechanism;
- Article 6.8. sets the rules for enhanced financial support, technology transfer and capacity-building.

Both Articles 6.2. and 6.4 are market-based, as they work on the principle of buying and selling emission reductions, while Article 6.8 is non-market-based.
The progress at COP29 completed the provisions from COP26. The rules aim to increase environmental integrity (to guarantee that carbon offset credits represent actual emissions reductions), transparency and accountability, including bilateral carbon deals between countries through Article 6.2. Furthermore, they set the Article 6.4 framework on common standards for a future international carbon market, including the operation of the PACM. While remaining a voluntary instrument, the PACM enables credits on emissions reductions or carbon removal activities in a host party or by a project developer. Such credits can then be sold to a buyer party or entity for its compliance obligations, providing climate finance to sellers of these credits. The PACM allows new activities starting from 1 January 2021 to be considered for Article 6.4 Emission Reductions (A6.4ERs), though the first such credits are unlikely before 2026, pending further development of procedures, methodologies and standards.

In May 2025, the PACM Supervisory Body adopted targeted standards on conservative baselines and leakage, boosting environmental integrity safeguards and updates to activity cycle procedures. A 5 % share of the proceeds from the transferred credits will go to an Adaptation Fund, financing climate adaptation projects in developing countries. In addition, Article 6.4 requires the mandatory cancellation – rather than being used to meet own emissions reduction targets – of a minimum 2 % of credits to deliver overall mitigation in global emissions (OMGE). Past experiences with international credits in the EU emissions trading system The World Economic Forum defines offsetting as paying others to reduce or remove emissions to compensate for one's own emissions. From 2013 to 2020, the EU emissions trading system (EU ETS) allowed the international offsetting of emissions through joint implementation (JI) activities and the CDM. JI provided for the creation of Emission Reduction Units (ERUs) and the CDM for certified emission reductions (CERs). Commission Regulation (EU) No 1123/2013 empowered EU ETS operators to offset up to 4.5 % of their verified emissions with international credits. From 2021 onwards (Phase 4), the EU decided not to allow international credits under the EU ETS; provisions regulating these instruments remain in Article 11b 'Project activities' and Article 21 'Reporting by Member States' of the EU ETS Directive 2003/87/EC. The decision to stop using ERUs and CERs took place amidst arguments over lack of integrity, greenwashing, over-crediting and environmental concerns.
The over-supply of international credits through the EU ETS contributed to keeping prices of EU allowances down and reduced the EU carbon market's effectiveness in achieving decarbonisation. If international credits were readmitted, these concerns would remain today.
Currently, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is the only window linking the EU ETS Directive (Article 11a, 12(6-9)) with international offsetting. Aircraft operators flying between the European Economic Area (EEA) and a non-EEA country applying CORSIA are temporarily exempted from EU ETS surrender requirements until the start of 2027. One CORSIA Eligible Emissions Unit (EEU) equals one metric tonne of CO2 equivalent emissions reduction. The Commission requires detailed reporting and EEU eligibility for the use of CORSIA. In 2026, the Commission will evaluate inter alia the environmental integrity of CORSIA credits, with the option to revert to EU ETS allowances for international flights or to keep the ongoing temporary limitation of the EU ETS to flights in the EEA. Beyond CORSIA, Sweden is so far the only EU country that has signed international bilateral agreements – with Rwanda, Zambia, and Nepal. Article 6.2 internationally transferred mitigation outcomes (ITMOs) can be used to achieve Sweden's national target of reaching net zero greenhouse gas emissions by 2045. Norway, not subject to the EU climate law but covered by the EU ETS, also uses ITMOs for its own NDC.

Prospects for international credits in EU climate policy

The EU has stopped the use of international carbon credits in the EU ETS since 2021. However, the public consultation on the EU ETS Directive, open until 8 July 2025, asks if a similar approach to offsets, particularly removal credits, should be a characteristic that a potential partner must have for linking with the EU ETS.

The questionnaire shows that the Commission is exploring possible international offsetting linkages with the EU ETS. The results of the consultation will feed the evaluation towards the 2026 overall EU ETS review.
Article 1(2) of the EU Carbon Removal Certification Framework (CRCF) Regulation (EU) 2024/3012 excludes the use of its certified units to achieve third-party NDCs or international compliance schemes.
This clause is subject to review by 31 July 2026 (Article 18(4)).
The European Climate Law (Regulation (EU) 2021/1119) mandates EU targets for 2030 (Article 4) and 2050 (Article 2), to be delivered through domestic EU net emissions reductions. The Commission is expected to publish a legislative proposal in summer 2025 to amend the European Climate Law with an intermediate 2040 target of net 90 % emissions reductions compared to 1990 levels. The current EU NDC towards 2030 specifies the domestic nature of its 2030 target, which is to be achieved without contributions from international credits.
Due to hesitation among Member States concerning an ambitious 2040 target, Climate Commissioner Wopke Hoekstra has said that he is exploring flexibilities.
<u>This could mean opening the door to international carbon credits</u>.
The Commissioner also confirmed that the 2040 target should inform the EU's NDC submission. Shortly ahead of the 10 February 2025 deadline to submit new NDCs with a view towards 2035, UNFCCC Executive Secretary Simon Stiell gave Parties an extension, to submit by September.
The notion of linking the 2040 target with international credits sparked debate among political groups' representatives in the European Parliament; the 2040 target requires adoption by Parliament and the Council.
The German government's coalition agreement includes a climate and energy section, and outlines support for limited, highly qualified and credible CO_2 reductions in non-European partner countries in relation to the EU 2040 target. KOBiZE, under the Polish Ministry of Climate and Environment, has previously argued to re-open the EU ETS to international offsets. The French government launched a coalition pledge in support of high integrity international carbon credits.
NGOs Bellona and Carbon Market Watch, and the European Scientific Advisory Board on Climate Change, have expressed opposition to relying on international carbon credits for the EU 2040 target.
Such a strategy effectively moves decarbonisation investments outside Europe, contrary to the recommendations of the Draghi Report. They also note the high risk of international credits failing to present realistic and permanent emissions reductions. WWF and Bruegel argue that international credits could undermine the integrity of EU decarbonisation, while the Jacques Delors Centre notes it is a possible Pandora's box.
The European University Institute recently released a publication supporting the integration of high-quality international carbon credits into the EU ETS.
(see link: https://cadmus.eui.eu/entities/publication/e78651da-feeb-4990-8de6-0283ff48ce65)

Brussels-based think-tank ERCST and the German Association of Industrial Energy Consumers (VIK) recently encouraged the EU to explore the integration of international credits into the EU ETS.

5.2 The European research strategy to calculate GHG and carbon credits standards

In the frame of EU research programme Horizon Europe, several projects are dealing with GHG evaluation and/or Carbon credit markets and with Monitoring, Reporting and Verification of Soil Organic Carbon.
Hereby the most relevant for GECO 2.2 project.

1) **MRV4SOC (https://mrv4soc.eu)**

MRV4SOC aims to account for changes in as many Carbon pools as possible, estimate Green House Gases (GHG) and full Carbon budgets, couple Carbon and Nitrogen cycles, quantify Soil Organic Carbon (SOC) accumulation, and assess the results of traditional management practices and Carbon farming. The consortium is investigating methodologies that account for the full GHG and C budget meeting the QU.A.L.ITY criteria (QUantification, Additionality and baselines, Long-term storage, and sustanabilITY). The results of this project will contribute building a Monitoring, Reporting, and Verification framework for the EU land sector.
Soil can store more carbon from the atmosphere than it emits, acting as a sink. Unfortunately, climate change and socio-economic pressures have contributed to land degradation and a loss of biomass, ultimately reducing its sink capability. The result is a rise in atmospheric greenhouse gas concentrations and risks for food production. Sustainable land management practices can turn carbon sources into sinks.
The project uses state-of-the-art technologies, including spectrometry, satellites, and drones to acquire reliable data on carbon sequestration and greenhouse gas emissions linked to land use. The acquired in-situ and remote sensing data will be used to develop geostatistical and process-based models in 15 demo sites covering 9 land use/ land cover classes. The demo sites have been chosen considering the variability of climate and socio-economic conditions in Europe.
MRV4SOC is a 3-year project funded by the European Union that started in June 2023.

Challenges
1 The impacts of climate- change and socio-economic pressures in soil organic carbon accumulation are hard to separate
2 Soil diversity across Europe and at different geographical scales adds layers of complexity to the development of transparent, robust, and cost-effective Monitoring, Reporting, and Verification schemes
3 There is a general widespread distrust in the Voluntary Carbon Market, a method to reduce and regulate greenhouse gas emissions

The project's demo sites were chosen among those with a long series of historical data to represent the European soil diversity.
MRV4SOC features 15 demo sites located in 6 European and Associated Countries with heterogeneous abiotic and biotic conditions, different land use/ land cover, and economic conditions: Belgium, Spain, Italy, Germany, Czechia, and Norway.

2. EJPSOIL (https://ejpsoil.eu)

The EJP SOIL (European Joint Programme on Soil) project is an initiative that aims to create an integrated research system at European level for the sustainable management of agricultural soil. The main objective is to develop a framework that supports land management in a smart and sustainable way, contributing to food security, climate change adaptation and mitigation, and the development of the bioeconomy.
Focus on Output - Soil information Assessing & Monitoring
Since soil is a non-renewable resource, consistent and accessible information about its condition is crucial to prevent degradation and guide evidence-based policies that restore soil health and promote sustainable management. Within this framework, eight EJP SOIL research projects and a dedicated work package have made significant contributions to harmonizing, organizing, and storing soil-related knowledge. During the EJP SOIL program, the European soil landscape underwent major developments, including the launch of the European Soil Observatory (EUSO) in 2021, the Mission Soil initiative, the Soil Monitoring and Resilience Directive proposal (European Council, 2024), and the anticipated ESA satellites in 2028.

Framework & Indicators
Assessing soil health necessitates agreement on its definition and its quantification with relevant soil health indicators (e.g. Faber et al. 2023). Indicators are assessed using target and/or threshold values, which define achievable levels of the indicators or functions (e.g. Matson et al. 2024).

BIBLIOGRAPHY

Peer reviewed articles
Acutis, M.; Tadiello, T.; Perego, A.; Di Guardo, A.; Schillaci, C. & Valkama, E. 2022. EX-TRACT: An excel tool for the estimation of standard deviations from published articles. Environmental Modelling & Software, 147: 1-9.
Assennato F.; Smiraglia D.; Cavalli A.; Congedo L.; Giuliani C.; Riitano N.; Strollo A.; Munafo M. 2022. The Impact of Urbanization on Land: A Biophysical-Based Assessment of Ecosystem Services Loss Supported by Remote Sensed Indicators. Land, 11 (2).

Janku J.; Jehlicka J.; Hermanova K.; Toth D.; Maitah M.; Kozak J.; Vopravil J.; Vacha R.; Jacko K.; Herza T. 2022. An overview of a land evaluation in the context of ecosystem services. Soil and Water Research, 17 (1), 1-14.

Policy briefs and notes

Faber, J. H., Cousin, I., Meurer, K. H. E., Hendriks, C. M. J., Bispo, A., Viketoft, M., ten Damme, L., Montagne, D., Hanegraaf, M. C., Gillikin, A., Kuikman, P., Obiang-Ndong, G., Bengtsson, J., & Taylor, A. R. (2023). Soil health and ecosystem services: monitoring and evaluation. EJP SOIL policy brief. Zenodo.

Matson, A., Fantappiè, M., A. Campbell, G., F. Miranda-Vélez, J., H. Faber, J., Carvalho Gomes,L., Hessel, R., Lana, M., Mocali, S., Smith, P., Robinson, D., Bispo, A., van Egmond,F., Keesstra, S., P.A. Saby, N., Smreczak, B., Froger, C., Suleymanov, A., & Chenu, C.(2024). A framework for setting soil health targets and thresholds in agricultural soils. EJP SOIL policy brief. Zenodo.

Deliverables and reports

Pavlu, L., Sobocka, L., Boruvka, L., Penizek, V., Adamczyk, B., Baumgarten, A., Castro, I.V., Cornu, S., De Boever, M., Don, A., Feiziene, D., & Vervuurt, W. 2021. Towards climate-smart sustainable management of agricultural soils: Deliverable 2.2 Stocktaking on soilquality indicators and associated decision support tools, including ICT tools. EJP SOIL Work Package 2 Deliverable. Wageningen University & Research.

Datasets

Hessel, R., & Trip, M. (2024). SERENA EJPSOIL NL EROSION SOILLOSS (Version 1) [Dataset].

Hessel, R., & Trip, M. (2024). SERENA EJPSOIL NL GHG NEP (version 1) [Dataset].

Oorts, K., Josipovic, D., Luts, D., & Salomez, J. (2024). SERENA EJPSOIL BE Flanders SOCLO-SS SOC 0-20cm cookbook (2024) [version 2 Dataset]. Databank Ondergrond Vlaanderen

Webinars & Educational Materials

Bispo, A., Fantappiè, M., van Egmond, F., Smreczak, B., Bakacsi, Z., Hessel, R., Wetterlind, J., Siebelec, G., & Jones, A. T. (2022). Examen des systèmes de suivi des sols existants pour ouvrir la voie à l'Observatoire Européen des Sols. EJP SOIL snack card.

Janku, J., Jehlicka, J., Hermanova, K., Toth, D., Maitah, M., Kozak, J., Vapravil, J., Vacha, R.,Jacko, K., & Herza, T. (2022). How to evaluate a land? – In the context of ecosystem services. EJP SOIL snack card.

Innovation and Methods for data acquisition

In recent years, soil sensing technologies (both proximal and remote) have emerged as a promising solution to speed up and reduce the cost of soil surveys. The current performance of proximal sensing techniques for soil property estimation was evaluated, including the effect of different spectral transformation, model calibration and transfer approaches for soil property estimation using existing soil spectral libraries (e.g. Metzger et al. 2023). SOC content prediction using remote sensing has been improved using temporal mosaics from time series, available information on soil texture, and accounting for soil moisture (e.g. Urbina-Salazar et al. 2021).

Peer reviewed articles

Lopez-Nunez, R. 2022. Portable X-ray Fluorescence Analysis of Organic Amendments: A Review. Applied Sciences-Basel, 12(14).

Bazzi, H; Baghdadi, N; Nino, P; Napoli, R; Najem, S; Zribi, M; Vaudour, E. 2024. Retrieving Soil Moisture from Sentinel-1: Limitations over Certain Crops and Sensitivity to the First Soil Thin Layer. Water, 16(1): 40.

Ben Dor, E; Efrati, B; Amir, O; Francos, N; Shepherd, J; Khosravi, V; Gholizadeh, A; Klement,A; Boruvka, L. 2024. A standard and protocol for in-situ measurement of surface soil reflectance. Geoderma, 447: 116920.

Datasets

Castaldi, F. (2024). D3.2_20240117_ProbeField_Preprosessed_Spectra_V1 [Data set]. Zenodo.

Castaldi, F. (2024). D3.3_20230919_ProbeField_Aligned_Spectra_V1 [Data set]. Zenodo.

Gabriel, J. L., San-Juan-Heras, R., Delgado, M. del M., Lazaro, A., & Rodríguez-Martín, J. A. (2024). Soil grid data for agricultural fields in Spain for STEROPES (EJP Soil) project (ECe, texture, soil organic carbon, pH) [Data set]. Zenodo.

Webinars & Educational Materials

Blanchy, G., Albrecht, L., Koestel, J., & Garré, S. (2023). Empowering environmental research:NLP for metadata extraction. EJP SOIL snack card.

Fohrafellner, J., Zechmeister-Boltenstern, S., Murugan, R., & Valkama, E. (2023). Quality assessment of meta-analyses on soil organic carbon. EJP SOIL snack card.

Knadel, M., Castaldi, F., Barbetti, R., Ben Dor, E., Gholizadeh, A., & Lorenzetti, R. (2022). No "One-technique-fits-all": multiple techniques should be used for sound data analysis. EJP SOIL snack card

Harmonised soil information, data and monitoring systems

While Europe is relatively data rich, the existing soil information is not harmonized and little shared on national and INSPIRE portals by public institutions (e.g. Cornu et al. 2023, Fantappie et al. 2021). A draft general agreement for specific data sharing has been proposed, as well as a metadata catalogue of soil datasets and subsequent workflow, guidance and tools to harvest and provide such metadata of soil datasets. Soil monitoring systems across countries studied differ in sampling designs, protocols, analytical methods, and revisit frequencies (Bispo et al. 2023; Froger et al., 2024; Meurer et al., 2024) which can lead to non-comparable data at national and international levels.

Peer reviewed articles

Froger, C. Tondini, E. Arrouays, D., Oorts, K., Poeplau, C., Wetterlind, J., Putku, E.,Saby, N. P. A., Fantappie, M., Styc, Q., Chenu, C., Salomez, J., Callewaert, S., Vanwindekens, F. M., Huyghebaert, B., Herinckx, J., Heilek, S., Harbo, L. S. Gomesi, L. D. C., Lazaro-Lopez, A., Rodriguez, J. A., Pindralk, S., Smreczak, B., Beno, A., Bakacsi, Z., Teuling, K., van Egmond, F., Hutar, V., Palka, B., Abraham, D., Bispo, A. 2024. Comparing LUCAS Soil and National Systems: Towards a Harmonized European Soil Monitoring Network. Science and Remote Sensing, 9: 100118.

Meurer, KHE; Hendriks, CMJ; Faber, JH; Kuikman, PJ; van Egmond, F; Garland, G; Putku, E; Barancikova, G; Makovnikova, J; Chenu, C; Herrmann, AM; Bispo, A. 2024. How does national SOC monitoring on agricultural soils align with the EU strategies? An example using five case studies. European Journal of Soil Science e13477, (1-20).

Vanino, S.; Pirelli, T.; Di Bene, C.; Bøe, F.; Castanheira, N.; Chenu, C.; Cornu, S.; Feiza, V.; Fornara, D.; Heller, O.; Kasparinskis, R.; Keesstra, S.; Lasorella, M.V.; Madenoğlu, S.; Meurer, K.H.E.; O'Sullivan, L.; Peter, N.; Piccini, C.; Siebielec, G.; Smreczak, B.; Thorsøe, M.H.; Farina, R. 2023. Barriers and opportunities of soil knowledge to address soil challenges: Stakeholders' perspectives across Europe. Journal of Environmental Management, 325: 116581.

Policy briefs and notes

Mason, E., Froger, C., Bispo, A., Fantappiè, M., Hessel, R., van Egmond, F., Wetterlind, J., Bożena, S., Bakacsi, Z., & Chenu, C. (2023). Soil monitoring systems challenges / recommendations towards harmonization. EJP SOIL policy brief.

Deliverables and reports

Andrenelli, M. C., Armolaitis, K., Aponte, C., Arrouays, D., Assennato, F., Bakacsi, Z., Barbetti,R., Basile, A., Bevivino, A., Bispo, A., Blombäck, K., Borůvka, L., Buttafuoco, G., Cagnarini, C., Calzolari, C., Callewaert, S., Cockx, K., Cousin, I., D'Avino, L., ... Wetterlind, J.(2023). Deliverable 6.5 Guidelines for accounting and mapping agricultural soil carbon, fertility and degradation changes at different scales. EJP SOIL Work Package 6 Deliverable.

Bispo, A., Arrouays, D., Saby, N., Boulonne, L., Fantappiè, M., Armolaitis, K., Bakacsi, Z.,Baumgarten, A., Brenna, S., Dernova, V., van Egmond, E., Hessel, R., Hutar, V., Kasparinskis, R., Knotters, M., Meuli, R. G., Nuutinen, V., Oorst, K., O'Sullivan, L., ... Wetterlind, J. (2021). Proposal of methodological development for the LUCAS programme in accordance with national monitoring programmes. EJP SOIL Work Package 6 Deliverable

Fantappiè, M., Peruginelli, G., Conti, S., Rennes, S., Le Bas, C., van Egmond, F., Smreczak, B.,Wetterlind, J., Chenu, C., Bispo, A., Oorts, K., & Bulens, J. (2021). Report on the nationaland EU regulations on agricultural soil data sharing and national monitoring activities. EJP SOIL Work Package 6 Deliverable.

Datasets

Fantappie, M., Bispo, A., Wetterlind, J., Smreczak, B., van Egmond, F., Bakacsi, Z., Farkas-Iványi, K., & Molnár, S. (2023). EJP SOIL project, WP6 – Questionnaire for supporting harmonised soil information and reporting.
Poeplau, C., Don, A., Flessa, H., Heidkamp, A., Jacobs, A., & Prietz, R. (2020). First German Agricultural Soil Inventory – Core dataset. OpenAgrar.

Webinars & Educational Materials

Bispo, A., Fantappiè, M., van Egmond, F., Smreczak, B., Bakacsi, Z., Hessel, R., Wetterlind, J., Siebelec, G., & T. Jones, A. (2022). A review of existing soil monitoring systems. EJP SOIL snack cards.
Murugan, R., Meurer, K., Fohrafellner, J., Kasper, M., Ecker, E., Bergese, F., Mason, E., & Zechmeister-Boltenstern, S. (2024). A participatory meta data catalogue for sharing data. EJPSOIL snack card.
Vašát, R., Vacek, O., & Borůvka, L. (2023). Spatial structure of pedodiversity. EJP SOIL snack card

Focus on Output - Fostering Adoption

The adoption of sustainable soil management practices remains low across Europe (e.g., Heller et al., 2024). While some barriers are biophysical, many are socio-economic, including limited access to knowledge and technical advice, economic constraints, insufficient incentives, ineffective policies, and deeply rooted farming traditions and perceptions (Vanino et al., 2023; Thorsøe et al., 2023). The EJP SOIL program worked to bridge the gap between science and policy to encourage broader adoption of these practices. Efforts included evaluating available tools, exploring methods for stakeholder engagement, and developing strategies to create incentives.

Support tools evaluation

To make decisions about soil management that are conducive to soil health, land managers and other stakeholders need reliable information and appropriate tools. Decision Support Tools (DSTs) may serve multiple functions e.g., practical decision making, registration, and monitoring. Substantial differences exist in current fertilisation guidelines across Europe, in the content, in soil test methods and how crop nutrient requirements are calculated, in the format and in their delivery (Higgins et al. 2023).

Deliverables and reports

Dara Guccione, G., Pirelli, T., Phillips, A., & Varia, F. (2021). Resources, Infrastructure and Capabilities Inventory (RICI) online platform for policy stakeholders. EJP SOIL Work Package 8 Deliverable.
Higgins, S., Kadziuliene, Z., & Paz, A. (2021). Stocktake study and recommendations for harmonizing methodologies for fertilization guidelines. EJP SOIL Work Package 2 Deliverable.

Incentives and policy evaluation

The EJP SOIL concentrated on existing European policies (e.g., Farm2Fork strategy), on policies under development (Carbon Removals and Carbon Farming Regulation, Soil Monitoring and

Resilience Directive) as well as on existing incentives, such as carbon faming schemes). Economic incentives for C sequestration, i.e. carbon farming schemes were inventoried and analysed, which allows to drive recommendations (e.g. Cruiscoli et al. 2024). Scenario modelling helps assessing the effect of policies or monitoring the policy goals set (e.g. Farm to Fork goals for 2030 and 2050).

Peer reviewed articles

Bellassen V.; Angers D.; Kowalczewski T.; Olesen A. 2022. Soil carbon is the blind spot of European national GHG inventories. Nature Climate Change, 12: 324-331.
Criscuoli, I., Martelli, A., Falconi, I., Galioto, F., Lasorella, M. V., Maurino, S., Phillips, A., Bonati,G., Guccione, G. D. 2024. Lessons learned from existing carbon removal methodologies foragricultural soils to drive European Union policies. European Journal of Soil Science, 75 (5), e13577.
Di Gregorio, L., Nolfi, L., Latini, A., Nikoloudakis, N., Bunnefeld, N., Notarfonso, M., Bernini, R.,Manikas, I., Bevivino, A. 2024. Getting (ECO)Ready: Does EU Legislation Integrate Up-to-Date Scientific Data for Food Security and Biodiversity Preservation Under Climate Change?Sustainability 2024, 16(23), 10749.

Policy briefs and notes

Chenu, C. (2022). Contribution of the EJP SOIL programme to the Soil Health call for evidence 2022-03-15
Criscuoli, I., Galioto, F., Martelli, A., Falconi, I., Dara Guccione, G., & Hvarregaard Thorsøe, M.(2024). Towards a regulation on carbon removals in the EU: lessons learned from existing experiences. EJP SOIL policy brief. Zenodo.

Deliverables and Reports

Castanheira, N., Paz, A., & Gonçalves, M. C. (2022). Knowledge and sustainable management of agricultural soils in Portugal: Barriers and opportunities. Congresso Ibérico das Ciências do Solo 2022.
Farina, R., Di Bene, C., Marchetti, A., Piccini, C., & Vanino, S. (2021). Report on barriers andopportunities (knowledge and policy) at regional, national and EU levels for further harmonization and collaboration concerning research, data training, and education. EJP SOIL Work Package 2 Deliverable.
Keesstra, S. D., Jacob, M., Maenhout, P., Verzandvoort, S. J. E., Ruysschaert, G., Huber, S., Schwarzl, B., Huygebaert, B., Jacob , M., Hvarregaard Thorsøe, M., Vervuurt, W., & de Haan, J. J. (2021). Towards climate-smart sustainable management of agricultural soils: Deliverable 2.5 Report on identified regional, national and European aspirations on soil services and soil functions. EJP SOIL Work Package 2 Deliverable. Wageningen University & Research.

Datasets

Astover, A., Escuer-Gatius, J., & Don, A. (2021). Questionnaire and survey results to the report "Inventory of the use of models for accounting and policy support (soil quality and soil carbon)" [Data set].

Webinars & Educational Materials

Bellassen, V., Angers, D., Kowalczewski, T., & Olesen, A. (2022). Soil Carbon – the blind spot of European national GHG Inventories. EJP SOIL snack card.
Schmaltz, E. M., Johannsen, L. L., Hvarregaard Thorsøe, M., Tahtikarhu, M., Rasanen, T. A., Darboux, F., & Strauss, P. (2024). Policy challenges for soil erosion control. EJP SOIL snack card.
Thorsøe, M.H (2024). Carbon farming schemes – Analysis and online Map. EJP SOIL snack cards.