Carbonica

Low-carbon Farming: building a sustainable future

White paper

Overview of EU Policies in the Context of Carbon Farming

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Executive Summary

The White Paper **Overview of EU Policies in the Context of Carbon Farming** is the first in a series of policy white papers that will be developed under the CARBONICA project. Serving as a starting point, it provides an overview of the carbon farming practices, their benefits and challenges, and analysis of the existing EU policies and regulations, examining how they address and integrate the concept of carbon farming.

Chapter 1: Introduction

Chapter 1 of this white paper explores the aims and key objectives of the CARBONICA project, providing a detailed overview of the main activities designed to achieve these goals. It also highlights the key policy dimensions of the project. This white paper is one of the expected project results, contributing to its overall objectives. The CARBONICA project, through this white paper, offers a comprehensive overview of the carbon farming concept, its practices, and related policies. This initiative supports the development of a scalable and sustainable carbon farming model that can be effectively implemented across the EU and beyond.

Chapter 2: Background

This chapter provides a foundational understanding of carbon farming, explaining its importance and relevance in addressing climate change. It highlights the growing need for carbon farming solutions, the economic and environmental benefits, and the existing policies and regulations that support its adoption.

Chapter 4: Key Carbon Farming Practices

This chapter outlines the core techniques used in carbon farming, including cover cropping, no-till farming, agroforestry, and soil carbon sequestration methods. It provides a practical overview of how these practices contribute to climate resilience and sustainable agriculture.

Chapter 5: Impacts of Carbon Farming Approaches

This chapter explores the positive outcomes of carbon farming, such as reducing greenhouse gas (GHG) emissions, improving soil health, enhancing biodiversity, and increasing water retention. It also discusses its role in climate adaptation and mitigation strategies.

Chapter 6: Challenges in Implementing Carbon Farming

Despite its benefits, carbon farming faces several barriers, including economic constraints, technical challenges, policy gaps, and market limitations. This chapter examines these obstacles and their impact on widespread adoption.

Chapter 7: Strategies for Scaling Carbon Farming Adoption

To overcome challenges, this section discusses policy incentives, financial mechanisms, technological advancements, and educational programs that can accelerate the adoption of carbon farming on a broader scale.

Chapter 8: Statistical Insights on Carbon Farming

This chapter presents data-driven insights on carbon farming, including GHG emissions from agriculture, adoption rates across regions, and the potential impact of carbon sequestration on climate targets.

Chapter 9: EU Policy Framework for Carbon Farming

This chapter provides a comprehensive analysis of EU policies supporting carbon farming, focusing on the Common Agricultural Policy (CAP), European Climate Law, Biodiversity Strategy 2030, EU's Digital Strategy and Smart Specialization Strategies. It begins with an in-depth examination of how carbon farming is integrated within the CAP, covering funding mechanisms, regulatory frameworks, and policy incentives. Subsequent sections explore the role of carbon removal and carbon farming within the EU's broader climate objectives, emphasizing their contribution to biodiversity conservation, digital innovation, and smart specialization. The chapter highlights the synergies between carbon farming, sustainability goals, and digital advancements, underscoring the importance of policy alignment for a resilient and climate-smart agricultural sector.

Chapter 10: Policy Recommendations to Support Carbon Farming

This chapter provides overview of identified policy recommendations based on secondary research and directed to enhance financial support, improve monitoring frameworks, integrate carbon farming into climate strategies, and encourage private sector involvement that can be further discussed within the Policy masterclasses.

Chapter 11: Conclusion

Finally, the white paper presents its conclusions in Chapter 12, ssummarizing key findings, challenges, and policy implications and reinforcing the need for stronger regulations, investment, and stakeholder collaboration to make carbon farming a mainstream climate solution.

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Glossary of terms and abbreviations used

List of Abbreviations and Acronyms	
MAPs	Multi-Actor Platforms
S3	Smart Specialization Strategies
IES	Innovation Ecosystem
CF	Carbon Farming
SOC	Soil Organic Carbon
CAP	Common Agricultural Policy
FAO	Food and Agriculture Organization
EU	European Union
CRC-F	A Carbon Removals Certification Framework
MFF	Multiannual Financial Framework
LULUCF	Land Use, Land-Use Change, and Forestry
GAECs	Good Agricultural and Environmental Conditions
UAA	Utilized Agricultural Area
NECP	National Energy and Climate Plan
NBS	Nature-Based Solutions
CSAF	Climate-Smart Agriculture and Forestry
CRP	Conservation Reserve Program
FSA	Farm Service Agency
EQIP	Environmental Quality Incentives Program
NGOs	Non-Governmental Organizations
ICAR	Indian Council of Agricultural Research
VCS	Verified Carbon Standard
BCX	Bursa Carbon Exchange

1 Introduction

1.1 CARBONICA Project

The Carbon Initiative for Climate-Resilient Agriculture (**CARBONICA**) is a four-year project, funded by the EU's Horizon Europe research and innovation programme. Launched in January 2023, the project is implemented by a consortium of 14 partners from Greece, North Macedonia, and Cyprus.

At the heart of CARBONICA's vision is the establishment of the CARBONICA Excellence Hub, designed to connect the innovation ecosystems of the three Widening Countries while enhancing their technological readiness as service providers. The project leverages cutting-edge technologies such as Earth Observation (EO), remote sensing, in-situ data collection, and digital agriculture to advance carbon farming. By providing access to excellence for key stakeholders across the Quadruple Helix model (Academia, Industry, Government, and the Public), CARBONICA aims to strengthen regional innovation capacity through a long-term joint Research and Innovation (R&I) strategy in the field of carbon farming.

The project is structured around four interconnected objectives:

- Strengthen place-based innovation and excellence in carbon farming within the Widening Countries, fostering collective understanding and widespread adoption of sustainable practices.
- Establish long-term, cross-border collaborations among Quadruple Helix actors, encouraging knowledge exchange, entrepreneurial skills development, and capacity-building in carbon farming.
- Design, validate, and implement pilot projects and demonstrators, laying the foundation for a comprehensive long-term R&I strategy, action plan, and policy recommendations.
- Bridge the gap between science and industry by creating business opportunities, attracting innovators and investors, and improving the uptake of carbon farming solutions.

CARBONICA's objectives are achieved through a series of structured activities.

A comprehensive analysis of barriers, drivers, and gaps in regional innovation excellence for carbon farming has been conducted across the three participating countries, including an end-user needs assessment. Multi-Actor Platforms (MAPs) are established and fully operational at national levels involving Quadruple Helix stakeholders and serve as hubs for capacity building, knowledge exchange, and training. Brain Gain Strategies are being developed and implemented to attract and retain talent, ensuring sustainable innovation ecosystems. These efforts will be consolidated into a Guide for Carbon Farming Solutions.

CARBONICA fosters collaborative R&D efforts, enabling key stakeholders to develop, monitor, and update a joint R&I strategy and an action/sustainability plan. Prototypes of carbon farming solutions are being developed and tested on various crops across the three participating countries to assess their impact on the carbon footprint of agricultural production. The economic and technical feasibility of these solutions will be evaluated, leading to investment recommendations and the creation of a roadmap for carbon farming certification protocols for agri-food products.

To ensure the long-term sustainability of the CARBONICA Excellence Hub, tailored business development services are being designed to support technology providers and end-users. Led by experienced consortium members, these services include mentoring, coaching, and workshops, offering multidisciplinary, holistic support to foster business growth and innovation in carbon farming.

The CARBONICA project aims to establish a structured pathway for policy reforms, through evidence-based, tailored recommendations informed by project findings.

By integrating research, policy development, and business innovation, CARBONICA aims to establish a sustainable and scalable model for carbon farming, contributing to the EU's climate goals and digital strategy.

1.2 Policy dimensions in CARBONICA project

The policy task within the **CARBONICA** project is focused on establishing a structured pathway for supporting policy reforms, aiming to develop more efficient and impactful policies. The project will generate policy recommendations that are evidence-based, tailored, and effective, informed by its findings. These recommendations will facilitate the wider adoption of carbon farming, positioning it as a recognized climate mitigation strategy.

To achieve this, policy recommendations will be formulated for the current legislative framework, including the Green Deal, EU Climate Strategy, and Smart Specialization Strategies (S3). They will be co-developed and validated through participatory methodologies, ensuring a learning-centered policy transformation that engages key stakeholders.

Key Actions within CARBONICA project include:

- Establishing a Policy Network

A network of policymakers at the EU, national, and regional levels will be developed to enhance engagement and extend the project's outreach. This network has already been established at the national level across the three participating countries (Cyprus, Greece, and North Macedonia) through CARBONICA's Multi-Actor Platforms (MAPs) (WP1, T1.2). These policymakers will play an active role in shaping and refining policy recommendations.

- Developing Policy White Papers

The project will produce a series of policy white papers to drive policy reforms. The first white paper provides a comprehensive overview of carbon farming concept and examines current key EU (including the Green Deal, EU Climate Strategy, and Smart Specialization Strategies) policies addressing carbon farming. The second white paper will present mapping of the existing policies, institutions and regulations related to carbon farming within the three widening countries (Cyprus, Greece, and North Macedonia) involved in the CARBONICA project, analysis of the Smart Specialization Strategies (S3) while also outlining the methodology for the policy master classes. Subsequent white papers will deliver recommendations for policymakers, synthesizing the insights gained from the policy master classes.

- Organizing Policy Master Classes

Four policy master classes will be held—one in each Innovation Ecosystem (IES) and one in Brussels—as one-day idea-generation workshops. These sessions will facilitate collaboration among stakeholders from diverse sectors, including agriculture, environment, education, and research & innovation (R&I). During these workshops, policy recommendations will be co-created, discussed, and validated, ensuring that they are both practical and impactful.

2 Background

2.1 Understanding the Context and Importance of Carbon Farming

Climate change is one of the most urgent global challenges, driven significantly by greenhouse gas (GHG) emissions from various sectors, including agriculture, which accounts for 10-12% of global emissions. This sector's emissions primarily come from methane produced by livestock, nitrous oxide released from synthetic fertilizers, and carbon released from land-use changes like deforestation. As global demand for food rises, the agricultural sector faces increased pressure to enhance production, often leading to practices that further elevate emissions. This intensification exacerbates environmental impacts, creating a feedback loop that accelerates climate change. Addressing these challenges requires a critical shift towards sustainable farming practices that balance food security with environmental stewardship, aiming to reduce emissions while sustaining agricultural productivity.

One such promising solution is **carbon farming**. Carbon farming encompasses a range of agricultural practices aimed at enhancing the capture and storage of carbon in soils and vegetation, which in turn helps reduce atmospheric GHG levels. This concept relies on a set of agricultural practices aimed at **increasing carbon sequestration**—the process of capturing and storing carbon dioxide (CO_2) from the atmosphere in soils and vegetation. Plants absorb CO_2 during photosynthesis, and when they die, the carbon stored in their biomass is transferred to the soil as organic matter. This contributes to soil fertility and structure, while simultaneously reducing the overall concentration of GHGs in the atmosphere.

Carbon farming (CF) refers to a suite of agricultural practices to enhance the uptake and storage of carbon dioxide (CO_2) in soil. This process begins with plants absorbing CO_2 from the atmosphere through photosynthesis. The absorbed CO_2 is then converted into soil carbon as plant roots and other organic matter decompose and are broken down by soil microbes. The stored carbon takes the form of organic matter, particularly humus, enriching soil fertility and structure.

The European Commission defines **carbon farming** as *"a green business model that rewards land managers for adopting improved land management practices that increase carbon sequestration in living biomass, dead organic matter, and soils. This is achieved by enhancing carbon capture and reducing carbon release into the atmosphere while adhering to ecological principles that support biodiversity and natural capital."*[1]

Carbon farming presents a comprehensive strategy for mitigating climate change by effectively managing carbon pools, flows, and greenhouse gas emissions at the farm level. It involves the meticulous stewardship of land, livestock, soils, and vegetation, regulating the release and uptake of key greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These practices, which are critical in the agricultural sector, make carbon farming a viable strategy for sustainable food production and environmental conservation.

[1] European Commission. (2021). *COMMISSION STAFF WORKING DOCUMENT Sustainable carbon cycles - Carbon farming.* https://climate.ec.europa.eu/document/download/d3529f84-0f18-40ee-ab72-124ba786fb5a_en

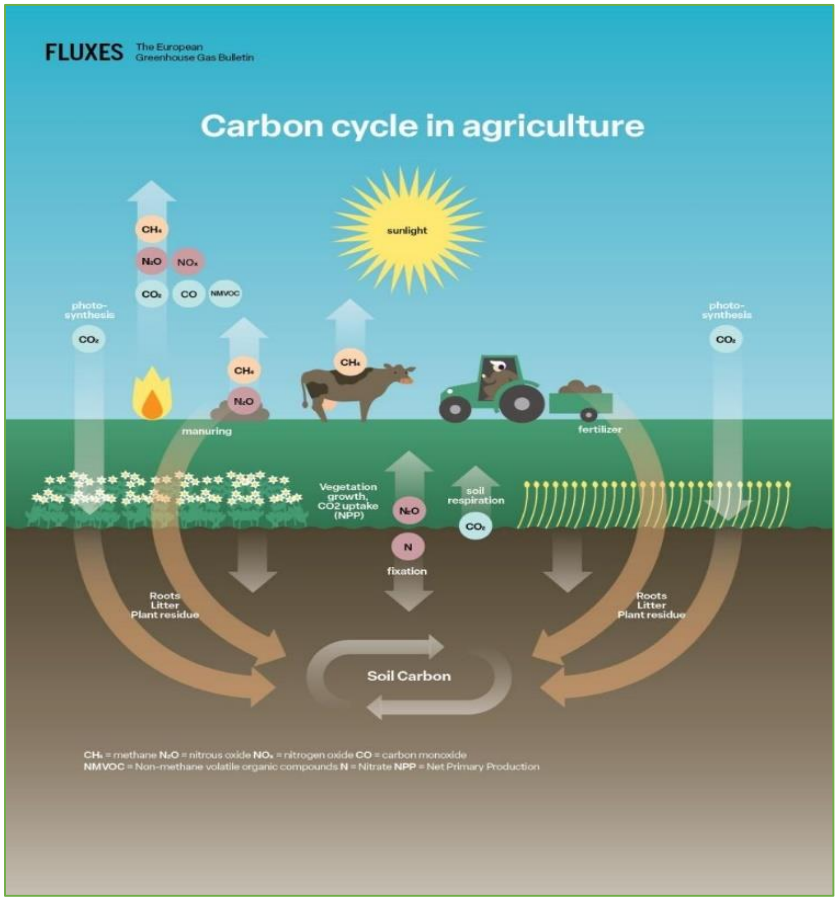


Figure 2.1 The carbon cycle between soil and atmosphere

(Reprinted from https://www.icos-cp.eu/fluxes/2/carbon-farming-path-more-sustainable-agriculture)

Carbon farming is relevant to both farmers and society. For farmers, adopting carbon farming practices can lead to multiple benefits, including improved soil fertility, increased crop yields, reduced input costs, and greater resilience to climate change impacts. For society, the benefits extend to improved air and water quality, enhanced biodiversity, and climate change mitigation through reduced GHG emissions.

CF practices can significantly mitigate climate change by enhancing soil organic carbon (SOC), which not only sequesters CO_2 but also improves soil health. This white paper addresses the significance of carbon farming and its potential to transform agricultural practices in a way that supports both environmental and economic goals. While the EU has already made considerable strides in promoting carbon sequestration through various initiatives such as the Common Agricultural Policy (CAP) and the European Green Deal, challenges remain in scaling carbon farming practices. These include issues related to policy alignment, financial incentives, and technical implementation at the farm level.[2]

[2] European Commission. (2019). *The European Green Deal*. European Commission; European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

2.2 The Growing Need for Carbon Farming Solutions

The urgent need to address climate change drives the need for CF. As shown in figure 3.2 EU GHG Emissions from agriculture in EU have reached 13% of total GHG emissions in 2022 (EC, DG AGRI)[3].

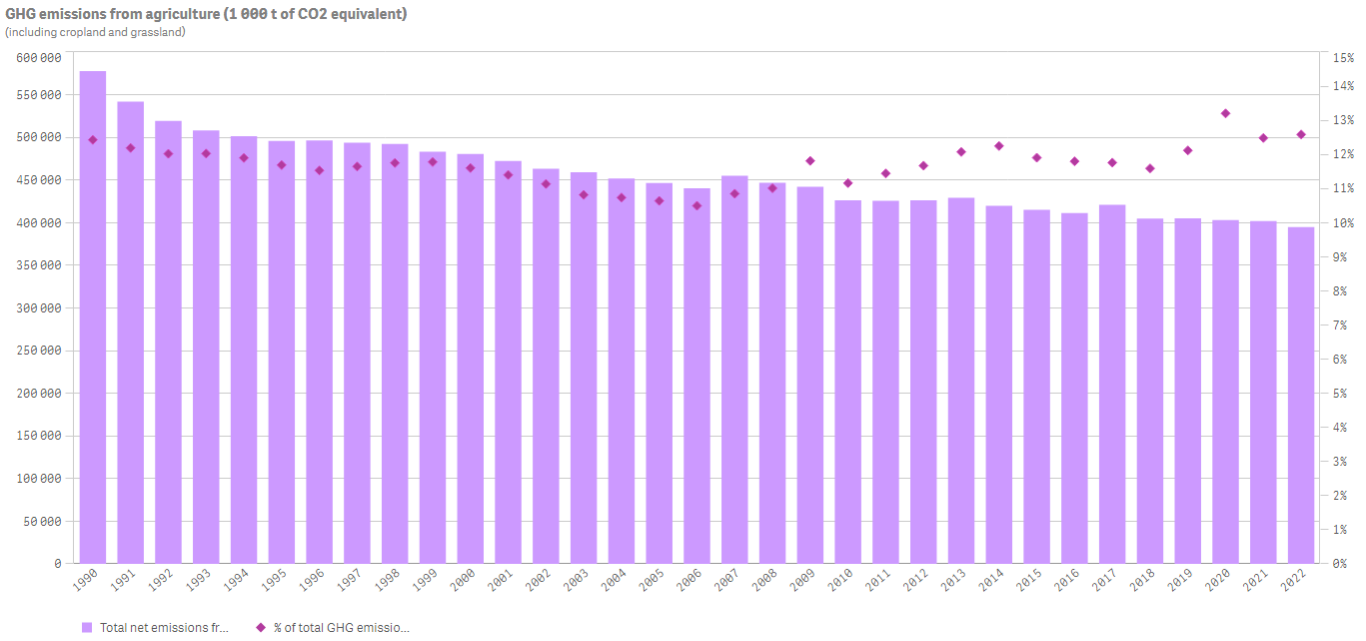


Figure 2.2 GHG emissions from agriculture (1000t of CO2 equivalent)

https://agridata.ec.europa.eu/extensions/DashboardIndicators/Climate.html

By adopting CF practices, farmers can reduce their carbon footprint, improve soil health, and contribute to national and international climate goals.

The need for carbon farming stems from the significant role that agriculture plays in contributing to global greenhouse gas (GHG) emissions. According to the Food and Agriculture Organization (FAO), agriculture, forestry, and other land-use practices are responsible for approximately 24% of global GHG emissions. This includes emissions from soil management, livestock production, and deforestation. Livestock alone contributes 14.5% of total anthropogenic GHG emissions, equating to 7.1 gigatons of CO_2-equivalent per year.

Carbon farming offers a comprehensive approach to mitigating these emissions by focusing on sustainable land management practices that enhance carbon sequestration and reduce GHG emissions. By integrating trees and crops with livestock in agricultural production, carbon farming can significantly increase carbon storage in soils and vegetation, helping to mitigate climate change. Moreover, agroforestry, cover cropping, reduced tillage, organic farming, and improved livestock and manure management contribute to agricultural systems' overall sustainability and resilience.

Carbon farming includes a range of agronomic practices - land use changes, and more technological solutions. Practices such as cover crops, improved rotations, peatland restoration, or expanding agroforestry systems rely on and work with natural processes in agroecosystems. On the one hand, they may decrease agricultural output since they can involve reduced intensity of production per hectare or land retirement. On the other hand, they can deliver many co-benefits for the environment and the sustainability

[3] European Commission, Directorate General for Agriculture and Rural Development. (2024). Climate Change and Air Quality. https://agridata.ec.europa.eu/extensions/DashboardIndicators/Climate.html

of agriculture. Furthermore, they can increase resilience against climate impacts, thus contributing to improved stability of yields and benefiting the farm business through more efficient use of crop nutrients and livestock feeding regimes and diversification of crops. (Carbon farming Making agriculture fit for 2030, 2021). [4]

2.3 Benefits of Carbon Farming

Carbon farming offers a variety of benefits that support sustainable agriculture, environmental protection, and climate resilience. By prioritizing the improvement of soil health, reduction of inputs, and mitigation of greenhouse gas emissions, carbon farming helps to develop more efficient and resilient farming systems. Additionally, it fosters greater awareness of sustainable practices within the agricultural community and beyond (Pramanik et al., 2022).

Increasing Soil Organic Carbon (SOC) content in agricultural land has the following main positive effects:

Table 2.3 Positive effects of increasing SOC content in agricultural lands

Improved water holding capacity and workability of soils, productivity
Lower input costs (feed, fertilizer, energy)
Flood regulation, water quality Improved water retention, microclimate, soil health, biodiversity
Decreased nutrient runoff, decreased ammonia emissions
Educational role for farmers and wider society
Agricultural production becomes more resilient to the consequences of climate change in the form of droughts and heavy rainfall.
GHG emissions associated with agriculture can be reduced, since increase of SOC since soil organic matter is a nutrient source and buffer and especially when legumes are introduced in carbon farming systems the use of energy intensive mineral fertilizer can be reduced.

2.4 Policies and Regulations Supporting Carbon Farming

Policies and regulations at both the European Union (EU) and global levels play a crucial role in fostering the adoption of carbon farming as a key strategy for climate mitigation and agricultural sustainability. Their aim is to create a supportive framework that incentivizes sustainable agricultural practices, enhances carbon sequestration, and aligns farming activities with broader climate and environmental objectives.

- **Climate Mitigation**: Reduce greenhouse gas (GHG) emissions from agriculture by promoting practices that sequester carbon in soils and biomass.
- **Climate Adaptation**: Enhance the resilience of farming systems to climate extremes by improving soil health and biodiversity.
- **Sustainability**: Foster the integration of ecological principles into agriculture, ensuring long-term environmental, economic, and social sustainability.

[4] Mcdonald, H., Frelih-Larsen, A., Lóránt, A., Duin, L., Andersen, S., Costa, G., & Bradley, H. (2021). *Carbon farming Making agriculture fit for 2030*. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695482/IPOL_STU(2021)695482_EN.pdf

- **Economic Incentivization**: Provide financial mechanisms such as subsidies, grants, and carbon credits to offset the costs of implementing carbon farming practices.
- **Standardization**: Establish robust frameworks for monitoring, reporting, and verifying carbon sequestration efforts to ensure transparency and credibility in carbon markets

At the EU level, there are several policies and regulation related to carbon farming that both technology providers and farmers should adhere to. Their objectives are aimed at promoting sustainable agricultural practices, reducing greenhouse gas emissions, and enhancing carbon sequestration (Sustainable carbon cycles - Carbon farming, 2021) [5].

Table 2.4 EU Policies & Regulations on CF (ind.)

Common Agricultural Policy (CAP)	The CAP, a major EU policy, includes measures to promote sustainable farming practices and support farmers in their transition to more environmentally friendly approaches. The CAP encourages the adoption of agri-environmental practices, including those related to carbon farming.[6] • Promotes carbon farming through eco-schemes and agri-environmental measures. • Encourages practices like cover cropping, reduced tillage, and agroforestry to enhance carbon storage and biodiversity
European Green Deal	The European Green Deal is a comprehensive plan to make Europe climate-neutral by 2050. It sets targets to reduce greenhouse gas emissions and enhance carbon removals. Carbon farming is recognized as an important component in achieving these targets.[7] • Sets the overarching goal of making Europe climate-neutral by 2050. • Recognizes carbon farming as a vital tool in achieving this target by reducing emissions and enhancing carbon sinks.
Farm to Fork Strategy	The Farm to Fork Strategy is part of the European Green Deal and aims to create a more sustainable food system. It includes objectives to reduce the environmental impact of agriculture, improve soil health, and promote carbon sequestration through sustainable land management practices. Carbon farming appears in the Strategy as a new green business model that rewards farmers for removing CO2 from the atmosphere and thereby contributes to the sustainability of the EU food supply chain. The Strategy foresees a potential role for both the CAP and other public and private initiatives in financing carbon farming. It specifically highlights the eco-schemes under the 2023-2027 CAP as a key source of funding for carbon farming and other sustainable land use and management practices.[8] • Aims to create a sustainable food system by reducing agriculture's environmental impact and promoting carbon sequestration.
Climate Law	The EU Climate Law enshrines the commitment to achieving climate neutrality by 2050 and sets a binding target to reduce net greenhouse gas emissions by at least

[5]European Commission. (2021). *COMMISSION STAFF WORKING DOCUMENT Sustainable carbon cycles - Carbon farming.* https://climate.ec.europa.eu/document/download/d3529f84-0f18-40ee-ab72-124ba786fb5a_en
[6] European Commission. (2024). *CAP and the Environment.* Agriculture.ec.europa.eu. https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/cap-and-environment_en
[7] European Parliament. (2022). *Topics: Green Deal: Key to a Climate-Neutral and Sustainable EU.* https://www.europarl.europa.eu/topics/en/article/20200618STO81513/green-deal-key-to-a-climate-neutral-and-sustainable-eu#the-european-green-deal-goals-and-benefits-8.
[8] European Commission. (2020). *Farm to Fork Strategy.* Food.ec.europa.eu. https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

	55% by 2030. Carbon farming plays a crucial role in reaching these ambitious targets. (European Climate Law, 2021)[9] • Enshrines binding targets for GHG reductions, emphasizing the integration of carbon farming into national climate action plans.
Biodiversity Strategy 2030	The EU Biodiversity Strategy for 2030 is a plan to halt biodiversity loss, restore ecosystems, promote carbon farming, and ensure sustainable natural resource management by expanding protected areas, enhancing biodiversity in agriculture, reducing pollution, and addressing climate change, all while supporting environmental sustainability and human well-being.[10] • Highlights the role of regenerative farming practices in restoring ecosystems and enhancing biodiversity alongside carbon sequestration

By aligning policies and regulations at the EU and global levels, stakeholders can create a cohesive framework that supports the large-scale adoption of carbon farming. Several international agreements, development goals, market mechanisms, and country-specific initiatives provide a foundation for integrating carbon farming into climate action strategies and agricultural systems worldwide.

Table 2.1 Policies relevant to CF on a national and supra-national level (ind.)

Paris Agreement	The Paris Agreement, adopted in 2015, is a cornerstone of global climate action, urging nations to set ambitious targets through their Nationally Determined Contributions (NDCs). Carbon farming is increasingly recognized as a viable strategy within NDCs for reducing emissions and enhancing carbon sequestration in soils and vegetation. By incorporating carbon farming into their commitments, countries can advance toward achieving their climate targets while supporting sustainable agricultural development
United Nations Sustainable Development Goals (SDGs)	Carbon farming aligns closely with multiple SDGs, making it a key strategy for integrated global progress. It contributes to: • **SDG 13: Climate Action** by reducing emissions and sequestering carbon. • **SDG 15: Life on Land** through practices that restore degraded lands and promote biodiversity. • **SDG 2: Zero Hunger** by improving soil health and agricultural productivity, ensuring food security. By linking carbon farming to these goals, the SDGs highlight its role in addressing environmental, social, and economic challenges simultaneously
Voluntary Carbon Markets	Voluntary carbon markets offer financial incentives for farmers to adopt carbon farming practices. By earning carbon credits for sequestered carbon, farmers can sell these credits to organizations seeking to offset their emissions. This mechanism not only creates an economic opportunity for farmers but also supports broader climate mitigation efforts by incentivizing sustainable land-use practices.
Country-Specific Initiatives	National programs tailored to local contexts are driving the adoption of carbon farming. Examples include:

[9] European Commission. (2021). *European Climate Law*. Climate.ec.europa.eu. https://climate.ec.europa.eu/eu-action/european-climate-law_en.
[10] European Commission. (2020). *Biodiversity Strategy for 2030*. Environment.ec.europa.eu. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

- **U.S. Department of Agriculture's Climate Smart Agriculture** initiatives, which support sustainable farming practices and incentivize carbon sequestration.
- **India's National Agroforestry Policy**, promoting the integration of trees in agricultural landscapes to enhance carbon storage, biodiversity, and rural livelihoods.

These initiatives demonstrate how targeted policies can accelerate the adoption of carbon farming and contribute to global climate and development goals.

These global frameworks and initiatives provide a comprehensive and interconnected platform to scale carbon farming practices. They emphasize the need for collaborative action, innovative financing, and robust policies to unlock the full potential of carbon farming in mitigating climate change and fostering sustainable development.

3 Key Carbon Farming Practices

Carbon farming practices are management strategies designed to sequester carbon and/or reduce greenhouse gas (GHG) emissions (Baumber et al., 2019). According to the Natural Resource Conservation Service (NRCS), these practices, also known as conservation practices, enhance soil health and carbon sequestration while delivering key benefits such as improved soil water retention, better hydrological function, increased biodiversity, and greater resilience.

The most common carbon farming practices are:

3.1 Cover crops

Cover crops are planted between main crop seasons to protect and enhance soil quality. They prevent soil erosion, suppress weed growth, and improve soil structure by adding organic matter and supporting root development. Legumes and grasses are commonly used cover crops, each offering unique benefits. Legumes, like clover, naturally fix nitrogen in the soil, while grasses create strong root networks that prevent erosion. In addition to improving soil health, cover crops increase soil organic matter and store carbon, contributing to long-term soil fertility. Studies show that cover crops significantly reduce nitrate leaching, which benefits both the environment and crop yields (Thapa et al., 2018; Schon et al.,2024).

Figure 3.1 Cover crops practice

(Reprinted from https://www.covercropstrategies.com/articles/2974-study-on-cover-crop-mixtures-delivers-surprising-results).

3.2 Crop rotation

Crop rotation involves planting different crops in the same field over successive seasons to prevent the buildup of pests and diseases, maintain balanced nutrient levels, and improve soil structure. Deep-rooted crops help loosen compacted soil, while legumes naturally add nitrogen, enriching the soil. According to Eurostat (2024)[11], this practice is essential for maintaining soil health and increasing carbon sequestration.

[11] *Crop rotation*. (n.d.). Ec.europa.eu. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Crop_rotation

Figure 3.2 Crop rotation practice

(Reprinted from https://green.org/2024/01/30/crop-rotation-and-biofuel-production/)

3.3 Grasslands

Grasslands, when properly managed, are excellent carbon sinks, storing significant amounts of carbon in the soil. Techniques such as rotational grazing, reseeding, and nutrient management help maintain strong plant growth, prevent overgrazing, and enhance carbon storage. In rotational grazing, livestock are moved between different grazing areas, allowing plants to regrow and sequester more carbon in the soil. Well-managed grasslands also help retain water, prevent soil erosion, and promote biodiversity, making them valuable for both farming and the environment (Acharya et al., 2012).

Figure 3.3 Grassland management practice

(Reprinted from https://www.cleanenergywire.org/factsheets/carbon-farming-explained-pros-cons-and-eus-plans).

3.4 Improved soil structure

Soil structure plays a crucial role in water retention, root growth, and carbon storage. To improve soil structure, farmers can reduce soil compaction, add organic materials like compost, and minimize deep plowing. Well-structured soil holds more carbon, reduces erosion, and provides better-growing conditions for crops. These improvements make soil more resilient to environmental stresses, ensuring that organic carbon remains stored in the soil, and help mitigate climate change (Sharma, & Ramakrishna, 2021; Mcdonald et all., 2021).

Figure 3.4 Soil structure

(Reprinted from https://apnews.com/article/agriculture-soil-carbon-monitoring-reporting-emissions-legislation-f394f5eebfea8bf9e43f66cd7cafa802)

3.5 No-till and reduced tillage

No-till and reduced tillage practices minimize soil disturbance, helping maintain soil structure and reduce erosion. By leaving plant residues on the soil surface, these practices protect the soil and encourage beneficial organisms, such as fungi, that aid in carbon storage. Over time, no-till and reduced tillage improve soil fertility, enhance water retention, and strengthen the soil's ability to store carbon. These methods are essential for preventing the loss of organic matter that occurs with frequent plowing, contributing to better soil health and climate resilience (Busari et al., 2015).

Figure 3.5 Reduce tillage practice

(Reprinted from https://eos.com/blog/no-till-farming/)

3.6 Straw and harvest residues

Instead of removing or burning leftover plant materials, farmers can return straw and crop residues to the soil to improve its health. These residues decompose over time, enriching the soil with nutrients, enhancing its structure, and increasing carbon storage. This practice reduces the need for synthetic fertilizers and minimizes the overall environmental impact of farming. Proper residue management strengthens soil fertility and helps the soil function as a long-term carbon sink (Turmel et all., 2014).

Figure 3.6 Straw

(Reprinted from https://wikifarmer.com/agricultural-residues-biomass-and-their-management/)

4 Impacts of Carbon Farming Approaches

The implementation of carbon farming practices has shown a positive impact on various aspects of agricultural operations and environmental sustainability. These impacts include:

- **Optimization of agricultural inputs**

Carbon farming has optimized agricultural inputs such as seeds, fertilizers, and pesticides. Farmers have achieved better resource management and minimized input wastage by integrating carbon farming practices.

- **Soil preservation and enhancement**

Carbon farming has reduced soil degradation and increased soil organic matter. These practices have played a crucial role in maintaining soil health and fertility, ensuring the sustainability of agricultural lands for future generations.

- **Biodiversity preservation**

Carbon farming initiatives have significantly contributed to preserving biodiversity within agricultural landscapes. By promoting diverse planting and land management practices, carbon farming has provided a conducive environment for various plant and animal species, fostering a stronger connection between farmers and the natural environment.

- **Operational improvements through data utilization**

The availability of detailed data resulting from carbon farming practices has facilitated operational improvements for farmers. Access to comprehensive data has empowered farmers to make informed decisions, leading to more efficient and sustainable agricultural operations.

- **Enhanced energy and resource efficiency**

Carbon farming has contributed to overall improvements in energy efficiency, including direct energy sources such as fuel and gas and indirect sources like electricity. Additionally, carbon farming has led to the efficient use of materials for product storage, reducing waste and environmental impact.

- **Machinery and equipment utilization**

By adopting carbon farming practices, farmers have improved the efficiency and effectiveness of machinery during crop management and harvesting. This has resulted in higher productivity and reduced resource wastage.

The successful adoption of carbon farming practices hinges not only on agricultural techniques but also on supportive policies and strategies that address the broader challenges within the food system. While governments in the EU have primarily relied on strategies rather than regulatory measures, the inclusion of farmers and consideration of systemic barriers such as carbon leakage and competitive pressures are critical to ensuring a fair and effective transition.

The methods for implementing carbon farming are closely tied to the policy frameworks in place, with regional and national policies playing a crucial role in shaping the extent and success of these practices. Ensuring alignment between agricultural practices and climate goals is essential for the long-term viability of carbon farming.

5 Challenges in Implementing Carbon Farming

The adoption of carbon farming faces numerous challenges spanning policy, social, financial, and market dimensions.

Complex scheme designs and conflicting objectives between policymakers and farmers often create barriers, with farmers finding programs difficult to navigate or incompatible with their priorities. Personal factors, such as individual landholder interests and farm-specific characteristics, coupled with inadequate skills and management abilities, further limit adoption.

Socio-political issues, including political instability and a lack of awareness or information about the benefits and practices of carbon farming, exacerbate these barriers, leaving many farmers hesitant or uninformed.

Economic and financial constraints, such as high initial costs, concerns about yield impacts, and the burdensome process of certification and verification, discourage participation, particularly among resource-constrained farmers. These challenges indicate that financial incentives alone may not increase farmers' participation in carbon farming (Kragt et al. 2014).

Furthermore, market-related uncertainties—like fluctuating carbon prices, unclear benefits, and difficulties in selling carbon-related products—add to the complexity, while perceptions of inequity in policy benefits alienate potential adopters. Farmers believe that carbon farming policies reward improper land management practices, further deterring their participation (Sharma et al. 2021). Together, these challenges underline the need for simplified policies, targeted support, and effective communication to make carbon farming more accessible and appealing to farmers (Pramanik et al. 2022).

Table 5.1 List of challenges regarding CF adoption (ind.).

Complex scheme design and implementation	Carbon farming initiatives often involve complex procedures and requirements, which can be difficult for farmers to understand and follow. This complexity discourages many farmers from participating.
Conflicting goals	Policymakers and farmers often have different priorities. While policymakers focus on environmental benefits, farmers are more concerned with economic viability and productivity. This misalignment of goals causes reluctance among farmers to participate in carbon farming initiatives.
Personal and farm-specific factors	Adoption of new farming practices is influenced by landholders' personal interests and specific features of the farm or land. Inadequate skills or management abilities are significant barriers to adopting carbon farming practices.
Political instability	Political instability greatly affects the acceptance and implementation of carbon farming practices. An unstable political environment makes planning and investing in long-term projects like carbon farming initiatives difficult.
Lack of information	Farmers often have insufficient access to information regarding available options for carbon farming. Many farmers do not fully understand the concept of carbon farming and lack detailed information about its pros and cons.

High costs and low productivity concerns	High input costs and uncertainties about the impact of carbon farming on yield and farm productivity increase farmers' apprehensions about participating in carbon farming initiatives.
Lack of approved methods and procedures	There are no approved methods and procedures for carbon farming, leading to higher administrative expenses and difficulties in obtaining certification as a qualified carbon offset provider.

6 Strategies for Scaling Carbon Farming Adoption

Scaling the adoption of carbon farming requires targeted strategies that address the economic, technical, social, and policy-related barriers faced by farmers.

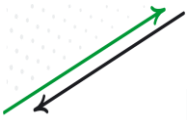
Simplifying scheme design and implementation is critical; programs should be user-friendly with clear guidelines and minimal administrative burdens, while digital platforms can streamline applications, monitoring, and reporting for farmers. Financial incentives play a pivotal role, including subsidies, grants, and low-interest loans to offset initial costs, along with hybrid payment models that combine practice-based and results-based approaches. Strengthening carbon markets to ensure fair and transparent pricing for carbon credits further enhances economic viability. Promoting knowledge and awareness through targeted educational campaigns, training programs, and peer-to-peer learning builds farmers' technical capacity and inspires widespread adoption. Advancing technology and innovation through investments in precision agriculture, Earth Observation tools, and research partnerships improves efficiency and reduces costs. Robust policy frameworks that align with international climate goals, like the European Green Deal and Farm to Fork Strategy and provide enforceable guidelines for carbon measurement and reporting are essential for trust and transparency. Collaboration among stakeholders, facilitated by platforms like the CARBONICA Excellence Hub, along with public-private partnerships and cooperative models, fosters innovation and resource sharing. Addressing market and economic uncertainties, such as stabilizing carbon credit prices and ensuring better market access for carbon farming products, reduces financial risks for farmers. Supporting ecosystem-based approaches, including agroforestry and peatland restoration, maximizes environmental co-benefits and integrates biodiversity goals into carbon farming. Finally, tailoring support to diverse farming contexts, from smallholders to large-scale farms, ensures localized solutions that address specific cultural, economic, and environmental conditions, driving the adoption of carbon farming practices on a global scale.

By creating enabling environments and providing comprehensive support, these strategies aim to encourage widespread implementation and integration of carbon farming practices into mainstream agriculture. Implementing these strategies will enable the effective scaling of carbon farming, positioning agriculture as a central contributor to climate mitigation and adaptation. These initiatives will not only boost carbon sequestration but also foster resilient, sustainable, and economically viable farming systems on a global scale[12].

[12] *Strategy for Mainstreaming Carbon Farming in Central Europe,* Interreg Central Europe. (2024). https://www.interreg-central.eu/wp-content/uploads/2024/10/CARBON-FARMING-D.3.1.1-1.pdf

Table 6.1 Initiatives for Scaling Carbon Farming Adoption

Initiatives	Activities
Simplifying Scheme Design and Implementation	• Develop user-friendly carbon farming programs with clear guidelines and minimal administrative burdens. • Use digital platforms and tools to streamline the application, monitoring, and reporting processes for farmers.
Enhancing Financial Incentives	• Provide subsidies, grants, and low-interest loans to offset the initial costs of adopting carbon farming practices. • Establish hybrid payment models combining practice-based and results-based approaches to ensure financial sustainability. • Strengthen carbon markets to offer fair and transparent pricing for carbon credits
Promoting Knowledge and Awareness	• Launch targeted educational campaigns to inform farmers about the benefits and practices of carbon farming. • Establish training programs and workshops to build farmers' technical capacity and management skills. • Leverage peer-to-peer learning and success stories to inspire adoption
Advancing Technology and Innovation	• Invest in precision agriculture and Earth Observation technologies to enhance the efficiency of carbon farming practices. • Develop cost-effective tools for monitoring, reporting, and verifying carbon sequestration outcomes. • Encourage innovation in carbon farming techniques through research and development partnerships.
Building Robust Policy Frameworks	• Align national policies with international climate goals to ensure consistency and support for carbon farming. • Integrate carbon farming into broader agricultural and climate action strategies, (Green Deal; Farm to Fork Strategy. • Provide clear and enforceable guidelines for carbon measurement, reporting, and verification to build trust and transparency.
Fostering Collaboration Among Stakeholders	• Create platforms to facilitate collaboration among farmers, policymakers, technology providers, and researchers. • Encourage public-private partnerships to accelerate innovation, financing, and the scaling of carbon farming initiatives. • Support cooperative models to enable small-scale farmers to access resources and share benefits.
Addressing Market and Economic Uncertainty	• Develop mechanisms to stabilize carbon credit prices and ensure predictable financial returns for farmers. • Promote long-term contracts and guarantees to reduce the economic risks associated with market fluctuations. • Facilitate better market access for products generated through carbon farming, such as sustainably produced crops and bio-based materials.



Supporting Ecosystem-Based Approaches	• Encourage practices such as agroforestry, peatland restoration, and grassland management to maximize environmental and agricultural co-benefits. • Integrate biodiversity and ecosystem restoration goals into carbon farming initiatives for broader sustainability.
Tailoring Support for Diverse Farming Contexts	• Customize programs and incentives to meet the unique needs of smallholders, large-scale farms, and different geographic regions. • Offer localized solutions that address specific environmental, cultural, and economic conditions.

7 Statistical Insights on Carbon Farming

The statistical data on carbon farming (CF) emphasizes its crucial role in mitigating global greenhouse gas (GHG) emissions, considering the significant contribution of agriculture to these emissions. In 2022, global GHG emissions experienced a 1.7% increase, reaching 53.8 billion metric tons of carbon dioxide equivalent ($GtCO_2e$), with CO_2 accounting for approximately 75% of these emissions, remaining the primary driver of climate change. Agriculture and forestry practices, heavily reliant on land use and biological processes, contribute substantially to these emissions, representing at least 24% of global carbon output. Notably, livestock alone accounts for 14.5% of anthropogenic GHG emissions globally, highlighting the sector's significant impact on the environment. These figures emphasize the potential of carbon farming, aimed at enhancing soil carbon sequestration and reducing GHG emissions, to play a pivotal role in addressing the climate crisis, particularly within agricultural and land use sectors.

In major global economies such as the United States, agriculture is responsible for 10.6% of total GHG emissions. Conversely, China, the world's largest emitter, has witnessed its CO_2 emissions increase by over 400% since 1990, driven by rapid industrialization and economic growth. In contrast, the U.S. managed to slightly reduce its emissions by 2.6% over the same period, despite remaining the largest historical contributor to CO_2 emissions globally. This contrast underscores the necessity for tailored carbon farming solutions to address the significant emissions resulting from agricultural practices within different economic and industrial contexts.[13]

Within the European Union (EU), agriculture remains a key source of emissions, contributing 9.3% of total GHG emissions (excluding Land Use, Land Use Change, and Forestry - LULUCF) between 2005 and 2018. The trend of fluctuating emissions in the EU underscores the need for sustainable practices such as carbon farming to be integrated into agricultural systems to achieve lasting reductions in emissions. Further examination of agricultural emissions within the EU reveals disparities between member states. Notably, nearly 60% of the EU's agricultural GHG emissions emanate from five countries: France, Germany, the United Kingdom, Spain, and Poland. Conversely, smaller countries such as Luxembourg, Cyprus, and Malta collectively account for only 0.3% of the EU's agricultural emissions. Moreover, some countries exhibit much higher shares of agricultural emissions relative to their total national emissions. For example, Ireland sees 32.7% of its total GHG emissions attributed to agriculture, followed by Denmark (22.9%), Latvia (22.3%), and Lithuania (21.1%). Conversely, countries like Malta (3%), Cyprus (5.7%), and Slovakia (6.3%) have relatively lower shares of agricultural emissions. This variation across the EU underscores the need for region-specific carbon farming practices and policies to maximize impact, reflecting the differing scales and intensities of agricultural production(Greenhouse Gas Emission Statistics - Carbon Footprints, 2024).[14] The Figure 7.1 shows the total GHG emissions from agriculture in metric tons of CO_2 equivalent with focus on Greece, Cyprus and North Macedonia as widening countries involved in CARBONICA project.

[13] *Global CO2 emissions by year 1940-2023 | Statista*. (2023). Statista. https://www.statista.com/statistics/276629/global-co2

[14] *Greenhouse gas emission statistics - carbon footprints*. (2024). Ec. europa.eu. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Greenhouse_gas_emission_statistics_-_carbon_footprints

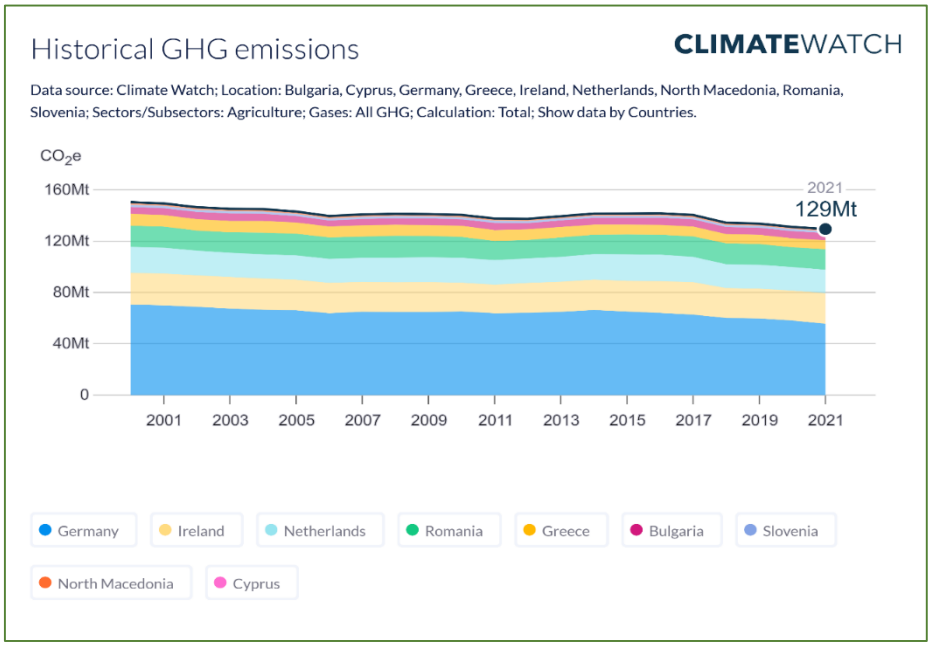


Figure 7.1 GHG emissions from agriculture

https://www.climatewatchdata.org/ghg-emissions?breakBy=countries&chartType=area&end_year=2021&regions=BGR%2CCYP%2CDEU%2CGRC%2CNLD%2CMKD%2CROU%2CSVN%2CIRL&sectors=agriculture&start_year=2000

Non-CO_2 greenhouse gas emissions from the European Union's agriculture sector fall under national targets set by the Effort Sharing Regulation (ESR). However, between 2005 and 2022, these emissions declined by only 5%, with estimates suggesting an additional 2% reduction between 2022 and 2023. Projections indicate that, under existing policies and measures, agricultural emissions will rise by 2030. Even with the implementation of currently planned additional measures, total emissions would still be just 7% below 2005 levels by 2030. This underscores the urgent need for further action to reduce non-CO_2 emissions in the sector.[15].

The successful adoption of carbon farming methods will heavily depend on policy support at both the global and regional levels. In the EU, where agricultural emissions have displayed an increasing trend, the implementation of carbon farming initiatives could offer a crucial solution to reduce emissions, improve soil health, and support biodiversity. Successful methods must align with broader climate goals and effectively address the specific challenges faced by the agricultural sector across different EU countries.

[15]*Greenhouse gas emissions from agriculture in Europe*. (2024). European Environment Agency. Www.eea.europa.eu. https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-agriculture

8 EU Policy Framework for Carbon Farming

Governments in the EU have primarily relied on strategies and plans rather than laws and regulatory measures to shape carbon farming policies.

Carbon farming has gained significant attention in recent years due to its potential to contribute to climate change mitigation. Policies promoting carbon farming are designed to create financial incentives, regulatory frameworks, and support systems that encourage the adoption of sustainable agricultural practices that sequester carbon. Many governments have implemented carbon credit systems, where farmers can earn credits for the carbon they sequester, which can then be sold on carbon markets to companies looking to offset their emissions. Additionally, national and regional agricultural policies link subsidies and grants to environmentally friendly practices, including carbon farming. These policies aim to integrate climate action into agriculture by providing economic benefits for farmers who contribute to carbon sequestration.

The implementation of carbon farming policies generally involves a mix of financial incentives, regulatory mandates, and educational support for farmers. Governments may offer tax incentives or direct payments for carbon sequestration efforts, while also establishing mandatory carbon emission reduction targets that agriculture sectors must meet. Voluntary carbon markets and certification programs help standardize the measurement and verification of carbon credits, ensuring credibility and encouraging farmer participation. Policies often include funding for research and extension services to provide farmers with the technical knowledge needed to implement carbon farming effectively. Together, these policy frameworks ensure that carbon farming is not only financially viable for farmers but also aligns with broader climate goals.

8.1 Overview of the EU Common Agricultural Policy (CAP)

The European Union's Common Agricultural Policy (CAP) is one of the EU's most significant and longest-standing policies, playing a pivotal role in shaping the agricultural landscape of Europe. Established in 1962, the CAP was initially designed to address post-war food shortages by increasing agricultural productivity, ensuring a stable supply of affordable food, and supporting farmers' livelihoods across Europe. Over the decades, the policy has evolved significantly to address new challenges, including environmental sustainability, rural development, and climate change. As of 2023, the CAP is undergoing substantial reforms to align with the EU's broader goals under the European Green Deal, reflecting the growing importance of sustainability and environmental stewardship in European agriculture.

The original objectives of the CAP were largely economic, focusing on boosting agricultural productivity to ensure food security and stabilizing markets to protect farmers' incomes. The CAP also aimed to ensure reasonable food prices for consumers, thus contributing to social stability and economic growth in the post-war period. To achieve these goals, the CAP initially relied heavily on market intervention mechanisms, including price supports, production quotas, and import tariffs. These measures were effective in increasing production but also led to unintended consequences, such as overproduction, environmental degradation, and trade distortions.

In response to these challenges, the CAP underwent significant reforms starting in the 1990s. The 1992 MacSharry reforms marked a pivotal shift in the CAP's approach by reducing price supports and introducing direct payments to farmers. These direct payments were decoupled from production levels, aiming to reduce the incentive for overproduction and mitigate its associated environmental impacts. The reforms also introduced measures to promote environmental protection and rural development, reflecting a growing recognition of the need to balance economic and environmental objectives in agricultural policy.

The reforms continued with the 2003 Fischler reforms, which further strengthened the shift away from market intervention towards direct support and rural development. The introduction of cross-compliance

requirements linked CAP payments to environmental and animal welfare standards, ensuring that farmers receiving support were also contributing to broader societal goals. The reforms also emphasized the importance of rural development, with a focus on diversification, innovation, and sustainability in rural areas.

Today, the CAP operates under two main pillars. The first pillar includes direct payments to farmers and market measures, which provide income support and stabilize agricultural markets. These payments are increasingly linked to environmental and climate-friendly practices, reflecting CAP's evolving priorities. The second pillar focuses on rural development programs that promote sustainable agricultural practices, environmental protection, and the development of rural areas. These programs are essential for addressing the unique challenges faced by rural communities, including depopulation, economic decline, and environmental degradation.

The latest CAP reform, which began in 2023, represents a significant step toward integrating environmental and climate goals into EU agricultural policy. This reform aligns with the European Green Deal, which aims to make Europe the first climate-neutral continent by 2050. The Green Deal sets ambitious targets for reducing greenhouse gas emissions, promoting biodiversity, and fostering sustainable resource use, all of which are now central to the CAP.

One of the key features of the 2023 CAP reform is the introduction of eco-schemes. A substantial portion of direct payments under Pillar 1 is now allocated to these eco-schemes, which are voluntary programs that incentivize farmers to adopt environmentally friendly practices. These practices include organic farming, agroforestry, conservation of biodiversity, and measures to reduce carbon emissions. The eco-schemes are designed to be flexible, allowing farmers to choose the practices that best suit their local conditions and farming systems.

Another important aspect of the 2023 reform is the strengthening of conditionality. Farmers receiving CAP payments must now comply with stricter environmental and climate conditions. This includes maintaining permanent grassland, protecting wetlands and peatlands, practicing crop rotation, and adhering to enhanced animal welfare standards. These conditions aim to ensure that CAP payments contribute to the EU's broader environmental and climate objectives while also supporting the long-term sustainability of European agriculture.

The reform also includes targeted support for young farmers and small farms. Generational renewal in agriculture is a key priority for the EU, as the farming population is aging, and there is a need to attract younger generations to the sector. The CAP provides financial incentives and training programs to encourage young people to take up farming and adopt innovative and sustainable practices. Small farms, which play a crucial role in maintaining rural vitality and biodiversity, receive enhanced support under the reform, recognizing their importance for the social and environmental fabric of rural areas.

In addition to environmental and social goals, the 2023 CAP reform places a strong emphasis on digital and technological innovation in agriculture. The CAP encourages the adoption of digital technologies, such as precision farming, data-driven decision-making, and smart farming systems. These innovations are expected to increase efficiency, reduce environmental impact, and improve the resilience of European agriculture to climate change. The use of digital tools also has the potential to enhance transparency and traceability in the food supply chain, contributing to food safety and quality.

The CAP plays a critical role in shaping the environmental landscape of Europe. By linking financial support to sustainable practices, the CAP incentivizes farmers to adopt methods that reduce greenhouse gas emissions, preserve biodiversity, and protect natural resources such as soil and water. The policy is also a key driver of rural development, supporting the diversification of rural economies, the preservation of cultural landscapes, and the provision of essential services in remote areas.

Economically, the CAP remains vital for the stability of the agricultural sector in the EU. It provides a safety net for farmers, particularly in times of market volatility, and supports rural communities by maintaining employment and encouraging economic diversification. The CAP also plays a role in ensuring food security

in Europe by supporting domestic production and reducing dependence on imports. However, the policy must continuously adapt to changing market conditions, global trade dynamics, and the evolving needs of consumers and society.

Looking ahead, the future of the CAP is closely tied to the EU's broader objectives, particularly in relation to climate change, sustainability, and food security. One of the main challenges will be balancing the economic viability of farms with the need for environmental sustainability. Ensuring that the CAP continues to provide economic support to farmers while also promoting practices that protect the environment and mitigate climate change will require careful policy design and implementation. This includes finding ways to make sustainable practices economically attractive and accessible to all farmers.

The CAP must also continue to adapt to the impacts of climate change. European agriculture is increasingly affected by extreme weather events, changing growing seasons, and shifting pest and disease patterns. The CAP will need to provide the tools and resources for farmers to adapt to these challenges while also contributing to the EU's climate goals. This includes supporting research and innovation in climate-resilient crops, sustainable water management, and agroecological practices.

Beyond farming, the CAP has a role in supporting the broader rural economy. This includes promoting rural tourism, local food systems, and renewable energy projects, which can provide additional income streams for farmers and contribute to the resilience of rural communities. The CAP also has the potential to support the transition to a circular economy in rural areas, by encouraging the use of agricultural by-products and waste for energy production, bioplastics, and other value-added products.

The European Union's Common Agricultural Policy remains a cornerstone of EU policy, shaping the future of agriculture and rural development across Europe. The 2023 reform marks a significant step towards aligning agricultural practices with the EU's environmental and climate goals. However, the CAP's success will depend on its ability to balance economic, social, and environmental objectives in a rapidly changing world. As the EU continues to strive for sustainability and resilience, the CAP will undoubtedly play a crucial role in achieving these goals. The policy must continue to evolve to meet new challenges and opportunities, ensuring that European agriculture remains competitive, sustainable, and capable of meeting the needs of future generations.

Figure 8.1 EU Common Agricultural Policy Objectives

https://www.gasnetworks.ie/biomethane-sustainability-report-2021.pdf

8.1.1 Integration of Carbon Farming in the CAP

Carbon farming has become an increasingly integral component of the EU's Common Agricultural Policy (CAP), reflecting the EU's broader commitment to sustainability and climate action. Within the framework of the CAP, carbon farming encompasses a range of agricultural practices aimed at capturing and storing carbon in soil and vegetation. These practices play a critical role in mitigating climate change by reducing greenhouse gas emissions from the agricultural sector, which is a significant contributor to the EU's overall carbon footprint.

- **Eco-Schemes**

One of the most significant innovations in the reformed CAP is the introduction of Eco-Schemes[16], which are voluntary programs designed to encourage farmers to adopt practices that provide clear environmental and climate benefits. Funded through direct payments, Eco-Schemes offer financial incentives to farmers who implement carbon farming practices. These practices are central to the CAP's green architecture, aiming to align agricultural activities with the EU's environmental and climate objectives.

Agroforestry is one of the key carbon farming practices promoted under Eco-Schemes. By integrating trees and shrubs into agricultural lands, agroforestry enhances carbon sequestration both above and below ground. Additionally, it provides multiple benefits such as increased biodiversity, improved water retention, and enhanced soil fertility.

Cover cropping is another practice supported by Eco-Schemes. By planting cover crops during fallow periods, farmers can protect the soil, reduce erosion, and increase organic matter, which in turn enhances the soil's ability to store carbon. This practice is particularly important in regions prone to soil degradation and erosion.

Reduced tillage is a practice that minimizes soil disturbance, thereby preserving soil structure and reducing the release of stored carbon. It also enhances soil moisture retention and promotes the accumulation of organic carbon, making it a vital component of carbon farming strategies supported by Eco-Schemes.

[16] *Eco-Schemes.* (2023). European Commission.https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/eco-schemes_en

The maintenance of permanent grasslands is also encouraged under Eco-Schemes. Permanent grasslands are significant carbon sinks due to their deep root systems, which store carbon in the soil for long periods. Protecting these grasslands from conversion to arable land is essential for maintaining their carbon sequestration potential and supporting biodiversity.

Overall, Eco-Schemes represent a flexible and farmer-friendly approach to promoting carbon farming, allowing Member States to tailor these schemes to their specific agricultural and environmental contexts.

- **Agri-Environment-Climate Measures (AECMs)**

Agri-Environment-Climate Measures (AECMs) have been a cornerstone of the CAP's Rural Development Programs for decades, offering financial support to farmers who voluntarily commit to environmentally beneficial practices over a multi-year period. These measures have been instrumental in fostering the adoption of carbon farming techniques, particularly those that focus on enhancing soil carbon sequestration.

No-till farming is one of the practices frequently supported under AECMs. By eliminating or significantly reducing tillage, this practice helps preserve soil structure, prevent erosion, and increase the organic matter content of the soil, all of which contribute to greater carbon storage.

Organic farming is another practice promoted through AECMs. Organic farming enhances soil health and biodiversity by avoiding synthetic fertilizers and pesticides, relying instead on natural processes to maintain soil fertility. The focus on soil organic matter in organic farming naturally leads to greater carbon sequestration, making it a key component of carbon farming strategies.

Cover cropping is also supported by AECMs, particularly as a practice that complements other soil management techniques. By planting cover crops, farmers can protect the soil from erosion, suppress weeds, and improve soil structure, all of which contribute to increased carbon storage.

In addition to these practices, AECMs also support other innovative approaches to carbon farming, such as the restoration of peatlands and the use of biochar, a form of charcoal that can enhance soil carbon storage. Through AECMs, the CAP provides a framework for farmers to engage in long-term, sustainable farming practices that contribute to climate mitigation and environmental protection.

- **National Strategic Plans**

The reformed CAP requires each EU Member State to develop a National Strategic Plan, which outlines how they intend to meet the CAP's overarching objectives, including those related to climate action and environmental sustainability. These strategic plans are essential for ensuring that carbon farming practices are integrated into national agricultural policies and tailored to the specific needs of each Member State.

In their strategic plans, Member States must detail how they will support carbon farming through Eco-Schemes, AECMs, and other rural development measures. This includes setting specific targets for carbon sequestration, identifying priority areas for intervention, and allocating resources to support farmers in adopting carbon farming practices.

For instance, a Member State with a high proportion of degraded soils might prioritize practices like cover cropping and reduced tillage to enhance soil carbon sequestration. In contrast, a country with extensive grasslands might focus on maintaining and restoring these areas to maximize their carbon storage potential.

The strategic plans also encourage innovation in carbon farming, promoting the use of digital tools and precision agriculture technologies to optimize carbon sequestration and monitor progress. By incorporating carbon farming into their strategic plans, Member States ensure that these practices are aligned with national and regional priorities, leading to more effective implementation and greater environmental benefits.

- **Pillar II – Rural Development**

The Rural Development Pillar (Pillar II) of the CAP plays a crucial role in supporting investments and practices that promote environmental sustainability, including carbon farming. Pillar II provides funding for a wide range of activities that enhance the resilience and sustainability of rural areas, including infrastructure development, innovation, and training related to carbon farming.

Reforestation and afforestation projects are key components of carbon farming supported under Pillar II. By planting trees on degraded or marginal lands, these projects can significantly increase carbon sequestration while also providing habitat for wildlife, reducing soil erosion, and improving water quality.

Restoration of degraded lands is another focus of Pillar II. Through targeted interventions such as soil rehabilitation and the reintroduction of native vegetation, these projects can restore the carbon sequestration potential of degraded areas and enhance their ecological value.

Precision agriculture technologies are also supported under Pillar II, particularly those that enable farmers to optimize their carbon farming practices. For example, precision farming tools can help farmers monitor soil carbon levels, adjust fertilization rates, and implement more efficient water management practices, all contributing to greater carbon sequestration.

By fostering innovation and knowledge transfer, Pillar II helps farmers implement effective carbon farming practices that contribute to long-term environmental and economic sustainability. This pillar is particularly important for supporting small and medium-sized farms, which may lack the resources to invest in carbon farming independently.

- **Sustainable Agriculture and Climate Action**

The CAP reform emphasizes the importance of sustainable agricultural practices as a core strategy for reducing the carbon footprint of agriculture. Carbon farming is inherently linked to this goal, as it offers a way to sequester carbon while maintaining or even enhancing agricultural productivity.

This focus on sustainability is part of the EU's broader Green Deal and Farm to Fork Strategy, which aims to make European agriculture more resilient, environmentally friendly, and aligned with climate goals. The Green Deal sets out the EU's ambition to become climate-neutral by 2050, and carbon farming is seen as a critical tool in achieving this target.

Under the Farm to Fork Strategy, carbon farming practices are promoted as part of a holistic approach to sustainable food production. By improving soil health, increasing biodiversity, and reducing the use of synthetic inputs, carbon farming contributes to more sustainable and resilient agricultural systems.

Incorporating carbon farming into the CAP allows the EU to take significant steps toward achieving its climate targets while also ensuring the long-term sustainability of its agricultural sector. Through a combination of financial incentives, technical support, and regulatory frameworks, the CAP provides a comprehensive approach to promoting carbon farming and enhancing the environmental performance of European agriculture.

The majority of soils in the EU are in a poor state, amongst others due to a loss of soil organic matter. Furthermore, 80% of habitats are degraded and the EU’s carbon sink is on a declining trend. The cost of this dire state of affairs is estimated at more than EUR 50 billion per year. Recognising soils’ central role in tackling the climate and biodiversity crises, the EU has committed to restoring all EU soils to a healthy status by 2050 and to boost carbon sequestration and storage in soils and in vegetation through its carbon farming initiative. In simple terms, land managers who sequester carbon in their soils or in vegetation (e.g. trees and hedges) would receive financial compensation.

Carbon farming has the potential to deliver significant benefits for climate mitigation, adaptation, soil health, and biodiversity when implemented through a holistic and “naturebased” approach, focused on ecosystem restoration. On agricultural land, practices such as peatland rewetting and restoration, agroforestry and the reintroduction of hedges, agroecology or regenerative farming, and the extensive

management of grasslands hold much promise for carbon sequestration. However, the specific design of the measures and incentives is critical to achieve these benefits.

A Carbon Removals Certification Framework (CRC-F) is being discussed by EU lawmakers and would establish a common governance system and methodologies for carbon farming schemes. This may help boost carbon farming, but how the certified “carbon removals” will be funded and used is paramount.

Financing carbon farming through the sale of carbon credits (or “offsets”) on voluntary carbon markets presents many pitfalls and should therefore not be promoted by the CRC-F. Instead, this new framework should seek to boost the use of public funding under the CAP to support the scale-up and roll out of carbon farming measures through a mix of practice- and result-based (or hybrid) funding. Only so can it ultimately reward farmers for “real” climate action.

The CAP contains the key building blocks of an effective policy package to upscale carbon farming: mandatory baselines (conditionality), voluntary support measures (eco-schemes and agri-environmental and climate measures), and support for on-farm investments. Furthermore, the “2nd Pillar” of the CAP includes a wide range of “soft measures” which can also make a crucial contribution to the implementation of carbon farming, such as knowledge exchange measures, cooperation among farmers, and extension/advisory services.

Member States are required to spend in principle at least 25 % of their 1st Pillar (or direct payments) budget allocation on eco-schemes and 35% of the 2nd Pillar budget for measures related to the environment and climate objectives. Overall, this should amount to around € 72bn of EU funding which Member States must allocate between 2023-2027 to interventions focused on climate and environmental objectives, including carbon farming. In comparison, the global voluntary carbon market was valued at USD 2bn in 2021.

Furthermore, the European Council committed to allocating 25% of the EU’s budget (Multiannual Financial Framework, MFF), and 40% of the CAP budget on climate action, through the so-called “climate mainstreaming” mechanism. This could deliver major progress for climate mitigation, however “climate mainstreaming” has been so far, and is likely to remain until 2027, mostly a creative accounting mechanism, strongly criticized by the European Court of Auditors and other experts.

8.2 The Role of the European Climate Law

The European Climate Law writes into law the goal set out in the European Green Deal for Europe’s economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. Climate neutrality by 2050 means achieving net zero greenhouse gas emissions for EU countries as a whole, mainly by cutting emissions, investing in green technologies and protecting the natural environment. The law aims to ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part.

The objectives are to establish a long-term direction for achieving the 2050 climate neutrality goal through comprehensive policies that are socially fair and cost-efficient. This includes setting a more ambitious EU 2030 target to guide Europe responsibly toward climate neutrality by 2050. Additionally, the objectives aim to create a robust system for monitoring progress, with provisions for further action, if necessary, to provide predictability for investors and other economic stakeholders. Ultimately, the goal is to ensure that the transition to climate neutrality is irreversible.

The European Climate Law sets a legally binding target of net zero greenhouse gas emissions by 2050. The EU Institutions and the Member States are bound to take the necessary measures at EU and national

level to meet the target, taking into account the importance of promoting fairness and solidarity among Member States.

The Climate Law includes measures to keep track of progress and adjust our actions, accordingly, based on existing systems such as the governance process for Member States' national energy and climate plans, regular reports by the European Environment Agency, and the latest scientific evidence on climate change and its impacts.

Progress will be reviewed every five years, in line with the global stock take exercise under the Paris Agreement.

The Climate Law also addresses the necessary steps to get to the 2050 target:

- Based on a comprehensive impact assessment, the EU has set a new target for 2030 of reducing net greenhouse gas emissions by at least 55% compared to levels in 1990. The new EU 2030 target is included in the Law.
- In July 2021, the Commission adopted a series of proposals to revise all relevant policy instruments to deliver the additional emissions reductions for 2030.
- The Law also includes a process for setting a 2040 climate target.

The Climate Law includes:

- A legal objective for the Union to reach climate neutrality by 2050.
- An ambitious 2030 climate target of at least 55% reduction of net emissions of greenhouse gases as compared to 1990, with clarity on the contribution of emission reductions and removals.
- Recognition of the need to enhance the EU's carbon sink through a more ambitious LULUCF regulation, for which the Commission made a proposal in July 2021, and which entered into force in May 2023.
- A process for setting a 2040 climate target, taking into account an indicative greenhouse gas budget for 2030-2050 to be published by the Commission.
- A commitment to negative emissions after 2050.
- the establishment of European Scientific Advisory Board on Climate Change, which will provide independent scientific advice.
- Stronger provisions on adaptation to climate change.
- Strong coherence across Union policies with the climate neutrality objective.
- A commitment to engage with sectors to prepare sector-specific roadmaps charting the path to climate neutrality in different areas of the economy.
- The European Climate Law was published in the Official Journal on 9 July 2021 and entered into force on 29 July 2021.

In 2023, for the first time, the Commission assessed progress towards the climate neutrality and adaptation objectives, as required under the European Climate Law. The findings were published as part of the 2023 Climate Action Progress Report and in a separate Staff Working Document on national progress with implementing adaptation.

Although greenhouse gas emissions continue to fall and there are encouraging signs of action on the ground, the Commission's assessment is that current progress towards the EU's climate neutrality objective appears to be insufficient. Action is most needed in areas which still require significant reductions in emissions (e.g. buildings, transport), where progress is too slow (e.g. agriculture), or where, in recent years, there has been a deteriorating trend, as is the case for the carbon sink (e.g. land use, land-use change, and forestry).

The European Union has made broad progress on adaptation to climate change, in particular through the ongoing implementation of the EU Adaptation Strategy. However, progress has been uneven across areas.

The assessment of progress on adaptation at the national level shows that Member States need to take significantly more action to adapt to climate change – for instance, on governance, funding, risk assessments, nature-based solutions, as well as monitoring, reporting and evaluation in order to reduce their social and economic vulnerabilities to the intensifying climate-related risks.

Based on the assessment, the Commission issued recommendations to Member States under the European Climate Law in December 2023. Member States that submitted draft updated National Energy and Climate Plans (NECPs) in time for the Commission's EU-wide assessment of the draft NECPs receive recommendations on:

- The draft updated NECPs
- The consistency of their measures with the EU's climate -neutrality objective
- The consistency of their measures with ensuring progress on adaptation under the European Climate Law.
- Member States which did not submit a draft updated NECP or submitted one several months after the deadline only receive recommendations under the European Climate Law.

8.2.1 Carbon removal and carbon farming in the Climate Law

Carbon removal and carbon farming are integral components of the European Climate Law and the broader EU strategy to achieve climate neutrality by 2050. These approaches focus on removing carbon dioxide (CO2) from the atmosphere, either through natural processes or technological solutions, and are essential for offsetting emissions that are difficult to eliminate.

Here's how carbon removal and carbon farming are included in the framework:

- *Emphasis on Carbon Removal:* The European Climate Law acknowledges the importance of carbon removal methods, including carbon farming, as a means to achieve negative emissions. Since reaching climate neutrality involves balancing emitted and absorbed CO2, carbon removal plays a critical role in offsetting residual emissions that are hard to reduce, such as those from agriculture, aviation, and certain industrial processes.
- *Support for Nature-Based Solutions:* The law supports nature-based solutions, which include practices like reforestation, afforestation, soil carbon sequestration, and wetland restoration. These activities fall under the broader category of carbon farming, where land management practices are optimized to increase the amount of carbon stored in soil, vegetation, and ecosystems.
- *Incentives for Carbon Farming:* The EU provides incentives for farmers and landowners to adopt carbon farming practices through various mechanisms, such as the Common Agricultural Policy (CAP). These incentives encourage sustainable land management practices that increase carbon sequestration while also providing co-benefits like improved biodiversity and soil health.
- *Integration into National Climate Plans:* Member states are required to include carbon removal strategies in their national climate action plans, which are part of the overall framework set by the European Climate Law. These plans outline how each country intends to contribute to the EU's climate targets, including the use of carbon farming and other removal techniques.
- *Monitoring and Verification:* The European Climate Law includes provisions for the monitoring and verification of carbon removal activities to ensure they are effective and contribute to the EU's climate goals. This includes developing reliable accounting methods for measuring carbon sequestration and ensuring that practices lead to genuine, long-term carbon removal.
- *Research and Innovation:* The EU invests in research and innovation to improve carbon removal technologies and practices, including carbon farming. This support helps develop more efficient methods of capturing and storing carbon, making these practices more accessible and scalable.

8.3 EU Biodiversity Strategy 2030

The European Union (EU) Biodiversity Strategy for 2030 responds to an alarming loss of nature that undermines our wellbeing and prosperity. It is a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The Strategy aims to put Europe's biodiversity on a path to recovery by 2030 and contains over 100 specific actions and commitments ranging across several policy areas. It is the proposal for the EU's contribution to the upcoming international negotiations on the global post-2020 biodiversity framework. It will benefit everyone, as nature delivers services to all people.

The aim is to adopt a whole of the society approach to implementation and mainstream biodiversity across all European Union's (EU) policies and funds. The European Commission will put in place a new European biodiversity governance framework. This will help map obligations and commitments and set out a roadmap to guide their implementation. As part of this new framework, the European Commission will put in place a monitoring and review mechanism. This will include a clear set of agreed indicators and will enable regular progress assessment and set out corrective action if necessary. This mechanism will feed the Environmental Implementation Review and contribute to the European Semester. The new governance framework will ensure co-responsibility and co-ownership by all relevant actors in meeting the EU's biodiversity commitments. It will support administrative capacity building, transparency, stakeholder dialogue, and participatory governance at different levels. The Commission will assess the progress and suitability of this approach in 2023, and consider whether a legally binding approach to governance is needed. To meet the needs of this strategy, at least €20 billion a year should be unlocked for spending on nature, including private and public funding at national and EU level, through a range of different programmes in the long-term EU budget. As nature restoration will make a major contribution to climate objectives, a significant proportion of the 25% of the EU budget dedicated to climate action will be invested on biodiversity and nature-based solutions. In addition, the Commission will boost the engagement of business, improve knowledge, education and skills, and work on measuring and integrating the value of nature.

The measures presented in this strategy will demonstrate that the European Union is ready to lead by example to address the global biodiversity crisis. This will be used in particular when working towards the successful adoption of an ambitious global biodiversity framework under the Convention on Biological Diversity.

8.3.1 Carbon Farming within the 2030 Biodiversity Strategy

Carbon plays a crucial role in the EU Biodiversity Strategy for 2030, as it is closely linked to both climate change and ecosystem health. The strategy recognizes that healthy ecosystems, such as forests, wetlands, grasslands, and peatlands, are vital carbon sinks that help mitigate climate change by absorbing and storing carbon dioxide (CO2) from the atmosphere. Here's how carbon is integrated into the strategy:

- **Protection and Restoration of Carbon-Rich Ecosystems**

Peatlands and Wetlands: These ecosystems are significant carbon sinks, storing large amounts of carbon in their soils. The strategy emphasizes the importance of protecting and restoring these areas to prevent carbon release and enhance their carbon sequestration capacity.

Forests: Forests are another key component, as they absorb CO2 during photosynthesis. The strategy includes measures to protect old-growth forests, promote sustainable forest management, and restore degraded forest areas, thereby enhancing their role in carbon storage.

- **Nature-Based Solutions**

The strategy promotes the use of nature-based solutions (NBS) to combat climate change. This includes practices such as reforestation, afforestation, and agroforestry, which not only sequester carbon but also enhance biodiversity, improve soil health, and provide other ecosystem services.

- **Carbon Farming**

The strategy supports the development of carbon farming practices, which involve managing land in ways that increase carbon sequestration in soils and vegetation. This could include techniques like cover cropping, reduced tillage, and the restoration of natural habitats on agricultural lands. These practices are intended to align with the broader goal of making agriculture more sustainable and biodiversity-friendly.

- **Linking Biodiversity and Climate Policies**

The strategy underscores the interconnectedness of biodiversity and climate change, advocating for policies that address both issues simultaneously. This includes aligning the EU Biodiversity Strategy with other EU policies, such as the Climate Law and the Climate Adaptation Strategy, to ensure that actions taken to reduce carbon emissions also benefit biodiversity.

- **Monitoring and Reporting**

The strategy includes provisions for monitoring carbon stocks in ecosystems and reporting on progress. This helps track the effectiveness of conservation and restoration efforts in sequestering carbon and contributing to climate mitigation.[17]

8.4 The EU's Digital Strategy and Its Connection to Carbon Farming

The EU's Digital Strategy[18] aims to drive Europe's digital transformation while ensuring technological sovereignty and a human-centric approach. It focuses on strengthening digital infrastructure, fostering innovation, and supporting sustainable development. By establishing a foundation for a fair, resilient, and competitive digital economy, the strategy promotes long-term growth and digital leadership across the EU.

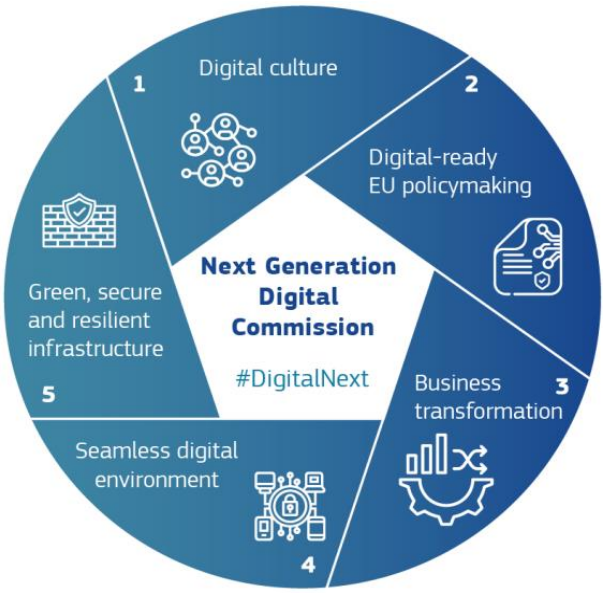


Figure 8.2 Strategic objectives of EU`s Digital Strategy

https://commission.europa.eu/system/files/2022-06/c_2022_4388_1_en_act.pdf

[17] *EU Biodiversity Strategy for 2030.* (2020). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0380

[18] *EU's Digital Strategy.* European Commission. (2022). https://commission.europa.eu/system/files/2022-06/c_2022_4388_1_en_act.pdf

The Commission will focus on five strategic objectives to drive its digital transformation, addressing current needs while preparing for future challenges.

It is driven by a set of principles applied by the European Commission based on shared European values: Digital partnerships; Digital interaction first; Digital empowerment; Digital sovereignty and autonomy and Data security and resilience.

The EU's Digital Strategy is linked to carbon farming and GHG emissions reduction in agriculture through its focus on digital innovation and supporting the green transition. By encouraging the adoption of technologies like digital agriculture, precision agriculture, and other data-driven solutions, the strategy helps optimize resource use, minimize waste, and improve land management. These technologies enable farmers to reduce GHG emissions, enhance carbon sequestration, and boost crop productivity with less environmental impact. Additionally, the strategy promotes the adoption of sustainable farming practices by providing access to data, tools, and policies that support greener agricultural methods.

8.5 Smart Specialization Strategies and their Connection to Carbon Farming

Research and innovation are essential for sustainable and smart economic transformation, forming the backbone of the EU's green and digital transitions. In 2010, the European Commission urged national and regional governments to develop Smart Specialization Strategies (S3)[19] for research and innovation (R&I), enabling European regions to identify and leverage their competitive advantages. By mainstreaming R&I as tools for regional development, Smart Specialization marked a significant shift in EU regional policy. Over a decade later, the concept has become deeply integrated, with its pillars—participation, prioritization, and localization—fully embedded in regional development practices. This approach has transformed how European regions design their innovation strategies, fostering enhanced cooperation at all levels.

The S3 strategies are founded on three pillars:

- Localization - Smart specialization is a place-based approach that utilizes the resources in close proximities.
- Prioritization - S3s identify and focus resources on a small number of areas which are known as S3 investment priorities.
- Participation - S3s require stakeholders from the quadruple helix—public sector, research, private sector, and civil society—to actively engage in defining, reviewing, monitoring, and implementing S3 investment priorities throughout the strategic development.

Smart Specialization Strategies (S3) are closely related to carbon farming and the reduction of GHG emissions from agriculture by focusing on localized exploitation of state-of-the-art agricultural practices. These technologies have the capacity to reduce GHG emissions and promote carbon sequestration. This approach accelerates the transition towards sustainable agricultural systems, supporting EU objectives like the European Green Deal and the Farm to Fork Strategy, and contributing to the broader goal of carbon neutrality in agriculture.

The national S3 strategies of Greece, Cyprus and North Macedonia and their priorities related to carbon farming will be further analyzed in the next policy white paper developed in the CARBONICA project.

[19] *Smart specialization.* (2021). European Commission. https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice/about_en

9 Policy Considerations to Support Carbon Farming

Based on insights drawn from the policy analysis and a review of relevant literature, the current European policy landscape—anchored in the Common Agricultural Policy (CAP), the European Green Deal, and complementary initiatives—offers a foundational platform for advancing carbon farming practices. Nonetheless, evidence suggests that more nuanced policy alignment at the national level, especially in terms of harmonizing with EU-wide objectives, is essential. Additionally, targeted measures to support smallholder farmers and facilitate the adoption of enabling technologies are identified as key levers for broader uptake and long-term viability.

The literature emphasizes the importance of inclusive governance and multi-stakeholder collaboration in the design and implementation of carbon farming initiatives. By fostering coordination among policymakers, farmers, and other actors, the EU can enhance the effectiveness of carbon farming strategies, ensuring they contribute meaningfully to climate mitigation while maintaining agricultural productivity.

These policy options suggest potential avenues for cultivating a more enabling environment for carbon farming, with the aim of positioning the agricultural sector as a pivotal contributor to the transition toward climate-resilient and sustainable development.

- **Enhance Financial Incentives and Support**
  - Expand funding mechanisms under the CAP to include hybrid approaches that combine practice-based and results-based payments.
  - Increase targeted subsidies and grants to lower the financial barriers for smallholder farmers.
- **Develop a Robust Carbon Certification Framework**
  - Establish standardized and cost-effective methods for monitoring, reporting, and verifying carbon sequestration to build trust and transparency in carbon markets.
  - Prioritize public funding over voluntary carbon markets to ensure equitable access to incentives.
- **Foster Innovation and Technology Adoption**
  - Invest in precision agriculture and Earth Observation technologies to improve the scalability and efficiency of carbon farming practices.
  - Promote the development of accessible tools to assist farmers in adopting and tracking carbon sequestration methods.
- **Increase Awareness and Knowledge Sharing**
  - Develop education and training programs to equip farmers with the skills needed to implement carbon farming techniques effectively.
  - Establish platforms to facilitate collaboration and knowledge exchange among stakeholders.
- **Strengthen Policy Integration**
  - Align national policies with EU climate and biodiversity strategies to ensure consistent adoption of carbon farming practices across member states.
  - Include specific measures in strategic plans to address regional agricultural challenges and leverage local opportunities.
- **Address Barriers to Adoption**
  - Simplify the design of carbon farming schemes to make them more accessible to farmers.
  - Provide long-term support to mitigate the impact of fluctuating carbon prices and market uncertainties.
- **Encourage Public-Private Collaboration, Regional and Global Partnerships**
  - Foster partnerships between policymakers, technology providers, academia, and farmers to accelerate the development and implementation of scalable solutions.
  - Promote cross-border initiatives to share best practices and create synergies between EU member states and global counterparts.
  - Integrate carbon farming into broader international climate and sustainable development frameworks.

10 Conclusion

Carbon farming represents a transformative approach to addressing the dual challenges of climate change and agricultural sustainability. By integrating practices that sequester carbon in soils and vegetation, such as cover cropping, agroforestry, and reduced tillage, carbon farming simultaneously mitigates greenhouse gas (GHG) emissions and promotes biodiversity, soil health, and farm resilience. These regenerative practices align with global climate goals, supporting both mitigation and adaptation in the face of growing environmental challenges.

The European Union (EU) plays a pivotal role in advancing carbon farming through policies like the Common Agricultural Policy (CAP), the European Green Deal, and the Farm to Fork Strategy. These initiatives incentivize sustainable practices, promote ecosystem restoration, and set ambitious targets for reducing GHG emissions. Also, they encourage farmers to embrace sustainable practices, ensuring agricultural activities are harmonized with broader climate and environmental goals. However, achieving widespread adoption of carbon farming requires addressing significant challenges, including high initial costs, lack of technical knowledge, and the need for standardized carbon measurement and verification systems.

To overcome these barriers, a collaborative approach is essential. Scaling up carbon farming practices requires not only strong policy frameworks but also active participation from farmers, researchers, and the private sector. The successful implementation of carbon farming technologies and policies relies on the active engagement of diverse stakeholders through the Quadruple Helix (QH) model, which underpins the CARBONICA Excellence Hub—a cornerstone initiative of the CARBONICA project. This model fosters dynamic collaboration between academia, farmers, policymakers, and technology providers, creating a holistic and integrated framework for advancing carbon farming practices. Collaborative platforms can play a vital role in fostering stakeholder engagement, facilitating knowledge exchange, and integrating advanced practices into carbon farming initiatives. This collaborative framework ensures that policies are informed by cutting-edge science, adapted to the realities of farming, and supported by technological innovation. The result is an accelerated adoption of sustainable farming practices, enhanced carbon sequestration, and a more resilient agricultural sector that contributes meaningfully to global climate goals.

Policymakers must provide financial incentives. Simultaneously, advancements in digital agriculture and Earth Observation technologies can facilitate the monitoring and verification of carbon sequestration efforts, ensuring transparency and accountability. Targeted policy is also crucial, with key recommendations including the enhancement of financial incentives, technical support, and clear guidelines for carbon farming practices. By fostering innovation and development of robust carbon certification frameworks, carbon farming can play a pivotal role in creating a sustainable agricultural system that supports climate mitigation, enhances food security, and promotes ecological balance. Through such efforts, the agricultural sector can transition from being a significant source of emissions to a key contributor to climate solutions, building a sustainable future for generations to come.

Carbon farming offers a transformative pathway for agriculture to become a net-positive force in addressing climate change. By aligning the needs of farmers with ambitious climate objectives and bolstered by strong policy support, carbon farming paves the way for a sustainable agricultural future that enhances environmental health, strengthens economies, and supports resilient communities.

11 References

1. Acharya, B. S., Rasmussen, J., & Eriksen, J. (2012). Grassland carbon sequestration and emissions following cultivation in a mixed crop rotation. *Agriculture, Ecosystems & Environment*, *153*, 33–39. https://doi.org/10.1016/j.agee.2012.03.001
2. Bureau, J.-C., & Mahé, L.-P. (2015). CAP reform beyond 2020: Challenges in defining a new agricultural and food policy. *International Agricultural Policy*, 22(2), 5-16. Retrieved from https://www.oecd.org
3. Busari, M. A., Kukal, S. S., Kaur, A., Bhatt, R., & Dulazi, A. A. (2015). Conservation tillage impacts on soil, crop and the environment. *International Soil and Water Conservation Research*, *3*(2), 119–129. https://doi.org/10.1016/j.iswcr.2015.05.002
4. California Department of Food and Agriculture - Office of Environmental Framing and Innovation. (n.d.). *Healthy Soils Program*. https://www.cdfa.ca.gov/oefi/healthysoils/; https://www.cdfa.ca.gov/oefi/healthysoils/docs/2024/list_of_new_practices_received_2024.pdf
5. *Carbon Sequestration techniques, Interreg VB North Sea Region Programme*. (2019). Northsearegion.eu. https://northsearegion.eu/carbon-farming/what-is-carbon-farming/carbon-sequestration-techniques
6. Cool Effect Carbon Offset Program. (n.d). https://www.cooleffect.org/
7. Demeyer, A., Roels, J., Krol, M., Paulsen, H. M., Klinkert, H., Lambrecht, E., et al. (2021). *Incentivising Carbon Farming: Policy Recommendations from the Carbon Farming Project*. White paper. Interreg North Sea Region Programme. https://northsearegion.eu/media/18284/whitepaper-carbon-farming-digital.pdf
8. Dinis, I. (2024). Examining disparities in common agriculture policy direct payments among farming systems: evidence from Portugal. *Agric Econ* 12, 7. https://doi.org/10.1186/s40100-024-00299-6
9. Economic Times. (2023, July). *Malaysian carbon exchange to host first local carbon credit auction in July*. Retrieved October 25, 2024. Available at: https://energy.economictimes.indiatimes.com/news/renewable/malaysian-carbon-exchange-to-host-first-local-carbon-credit-auction-in-july/110083162
10. European Commission. (2019). *The European Green Deal*. European Commission; European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en; Eur-Lex.europa.eu. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640
11. European Commission. (2020). *Biodiversity Strategy for 2030*. Environment.ec.europa.eu. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
12. European Commission. (2020). *EU Biodiversity Strategy for 2030*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0380
13. European Commission. (2020). *Farm to Fork Strategy.* Food.ec.europa.eu. https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
14. European Commission. (2021). *COMMISSION STAFF WORKING DOCUMENT Sustainable carbon cycles - Carbon farming.* https://climate.ec.europa.eu/document/download/d3529f84-0f18-40ee-ab72-124ba786fb5a_en
15. European Commission. (2021). *European Climate Law*. Climate.ec.europa.eu. https://climate.ec.europa.eu/eu-action/european-climate-law_en.
16. European Commission. (2021). *Smart specialization.* https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice/about_en
17. European Commission. (2022). *EU's Digital Strategy.* https://commission.europa.eu/system/files/2022-06/c_2022_4388_1_en_act.pdf
18. European Commission. (2023). *Approved 28 CAP Strategic Plans (2023-2027)*. Retrieved from EUR-Lex.https://agriculture.ec.europa.eu/document/download/7b3a0485-c335-4e1b-a53a-9fe3733ca48f_en?filename=approved-28-cap-strategic-plans-2023-27.pdf
19. European Commission. (2023). *Common agricultural policy*. Agriculture.ec.europa.eu. https://agriculture.ec.europa.eu/common-agricultural-policy_en

20. European Commission. (2023). *Eco-Schemes.* https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/eco-schemes_en
21. European Commission. (2024). *CAP and the Environment.* Agriculture.ec.europa.eu. https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/cap-and-environment_en
22. European Commission. (2024, July 4). *New reports highlight CAP's role in strengthening rural areas*. Agriculture and Rural Development. https://agriculture.ec.europa.eu/news/new-reports-highlight-caps-role-strengthening-rural-areas-2024-07-04_en
23. European Environment Agency. (2022). *Greenhouse gas emissions from agriculture in Europe*. www.eea.europa.eu. https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-agriculture
24. European Environment Agency. (2024). *Greenhouse gas emissions from agriculture in Europe*. www.eea.europa.eu. https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-agriculture
25. European Parliament. (2022). *Topics: Green Deal: Key to a Climate-Neutral and Sustainable EU.* https://www.europarl.europa.eu/topics/en/article/20200618STO81513/green-deal-key-to-a-climate-neutral-and-sustainable-eu#the-european-green-deal-goals-and-benefits-8.
26. Eurostat. (2024). *Crop rotation*. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Crop_rotation
27. Eurostat. *Crop rotation*. (n.d.). Ec.europa.eu. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Crop_rotation
28. *Global CO2 emissions by year 1940-2023 | Statista*. (2023). Statista. https://www.statista.com/statistics/276629/global-co2
29. *Greenhouse gas emission statistics - carbon footprints*. (2024). Ec. europa.eu. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_carbon_footprints#Global_CO.E2.82.82-emissions_.E2.80.93_EU_vis-.C3.A0-vis_the_rest_of_the_world
30. Institute for European Environmental Policy. (2023). *Environment and climate assessment of Poland's CAP Strategic Plan Institute for European Environmental Policy February 2023 Report*. https://ieep.eu/wp-content/uploads/2023/02/Environment-and-climate-assessment-of-Polands-CAP-Strategic-Plan_IEEP-2023.pdf
31. Institute for European Environmental Policy. (2023). *Environment and climate assessment of Spain's CAP Strategic Plan Institute for European Environmental Policy February 2023 Report*. https://ieep.eu/wp-content/uploads/2023/02/Environment-and-climate-assessment-of-Spains-CAP-Strategic-Plan_IEEP-2023.pdf
32. Institute for European Environmental Policy. (2023). *Environment and climate assessment of France's CAP Strategic Plan Institute for European Environmental Policy February 2023 Report*. https://ieep.eu/wp-content/uploads/2023/02/Environment-and-climate-assessment-of-Frances-CAP-Strategic-Plan_IEEP-2023.pdf
33. Institute for European Environmental Policy. (2023). *Environment and climate assessment of Germany's CAP Strategic Plan Institute for European Environmental Policy April 2023 Report*. https://ieep.eu/wp-content/uploads/2023/02/Environment-and-climate-assessment-of-Germanys-CAP-Strategic-Plan_IEEP-and-Ecologic-Institute-2023-1.pdf
34. Kragt, M., Blackmore, L., Capon, T., Robinson, C. J., & Wilson, K. A. (2014). *What are the barriers to adopting carbon farming practices?* https://www.researchgate.net/publication/270573098_What_are_the_barriers_to_adopting_carbon_farming_practices.
35. Mcdonald, H., Frelih-Larsen, A., Lóránt, A., Duin, L., Andersen, S., Costa, G., & Bradley, H. (2021). *Carbon farming Making agriculture fit for 2030*. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695482/IPOL_STU(2021)695482_EN.pdf
36. Mcdonald, H., Frelih-Larsen, A., Lóránt, A., Duin, L., Andersen, S., Costa, G., & Bradley, H. (n.d.). *Carbon farming Making agriculture fit for 2030*. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/695482/IPOL_STU(2021)695482_EN.pdf

37. Nyssens, C. (2021). *Carbon Farming for Climate, Nature and Farmers* . European Environmental Bureau. https://eeb.org/wp-content/uploads/2021/10/Carbon-Farming-Report-FINAL-WEB.pdf
38. Paulsen, H. M. (2020). *Inventory of techniques for carbon sequestration in agricultural soils*. Iterreg North Sea Region Programme. https://vb.northsearegion.eu/public/files/repository/20200602061009_20200312CFRapportInventoryoftechniquesforcsinagriculturalsoils.pdf
39. Pragati Pramanik, Mandal, N., Mukherjee, A., Aniruddha Maity, & Sarkar, A. (2022). *Carbon Farming: Practices, Benefits and Challenges*. https://www.researchgate.net/publication/372556020_Carbon_Farming_Practices_Benefits_and_Challenges.
40. Schön, J., Gentsch, N., & Breunig, P. (2024). Cover crops support the climate change mitigation potential of agroecosystems. *PloS One*, 19(5). https://doi.org/10.1371/journal.pone.0302139
41. Sharma, M., Kaushal, R., Kaushik, P., & Ramakrishna, S. (2021). Carbon Farming: Prospects and Challenges. *Sustainability*, *13*(19), 11122. https://doi.org/10.3390/su131911122
42. Statista. (2024). *Greenhouse gas emissions worldwide - statistics & facts*. https://www.statista.com/topics/5770/global-greenhouse-gas-emissions/#topicOverview
43. *Strategy for Mainstreaming Carbon Farming in Central Europe,* Interreg Central Europe. (2024). https://www.interreg-central.eu/wp-content/uploads/2024/10/CARBON-FARMING-D.3.1.1-1.pdf
44. Thapa, R., Mirsky, S. B., & Tully, K. L. (2018). Cover Crops Reduce Nitrate Leaching in Agroecosystems:A Global Meta-Analysis. *Journal of Environmental Quality*, *47*(6), 1400–1411. https://doi.org/10.2134/jeq2018.03.0107
45. Turmel, M.-S., Speratti, A., Baudron, F., Verhulst, N., & Govaerts, B. (2015). Crop residue management and soil health: A systems analysis. *Agricultural Systems*, *134*, 6–16. https://doi.org/10.1016/j.agsy.2014.05.009
46. U.S. Department of Agriculture. (2023). *General Assessment of the Role of Agriculture and Forestry in U.S. Carbon Markets.* https://www.usda.gov/sites/default/files/documents/USDA-General-Assessment-of-the-Role-of-Agriculture-and-Forestry-in-US-Carbon-Markets.pdf; https://www.usda.gov/oce/energy-and-environment/markets/carbon
47. U.S. Department of Agriculture. (2021). *Climate-Smart Agriculture and Forestry Strategy.* https://www.usda.gov/sites/default/files/documents/climate-smart-ag-forestry-strategy-90-day-progress-report.pdf
48. U.S. Department of Agriculture. (2024). *Conservation Reserve Program.* https://www.fsa.usda.gov/resources/programs/conservation-reserve-program
49. U.S. Department of Agriculture. (2024). *Environmental Quality Incentives Program (EQIP).* https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives
50. Washington State Department of Ecology. Halter, C. (n.d.). *Climate Commitment Act*. Ecology.wa.gov. https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act
51. World Resources Institute. (2020). Overview of Carbon Offset Programs: *The Bottom Line on… What are greenhouse gas offsets?* http://pdf.wri.org/bottom_line_offsets.pdf