STUDY

Requested by the ENVI committee

# Carbon farming

## Making agriculture fit for 2030


Policy Department for Economic, Scientific and Quality of Life Policies
Directorate-General for Internal Policies
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PE 695.482 – November 2021


EN

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## Making agriculture fit for 2030

**Abstract**

Carbon farming refers to sequestering and storing carbon and/or reducing greenhouse gas emissions at farm level. It offers significant but uncertain mitigation potential in the EU, can deliver co-benefits to farmers and society, but also carries risks that need to be managed. The report identifies opportunities and constraints for carbon farming, options for financing, and open questions that need to be resolved to scale up carbon farming in a way that delivers robust climate mitigation and European Union Green Deal objectives.

This document was provided by the Policy Department for Economic, Scientific and Quality of Life Policies at the request of the committee on Committee on Environment, Public Health and Food Safety (ENVI).

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Original: EN



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Manuscript completed: November 2021
Date of publication: November 2021



This document is available at: http://www.europarl.europa.eu/supporting-analyses

Acknowledgments: the authors wish to thank Antonia RIEDEL, Benjamin GÖRLACH (Ecologic institute) and Clunie KEENLEYSIDE, Gabrielle AUBERT, Nora HILLER (IEEP) for their help.



For citation purposes, the study should be referenced as: McDonald, H., Frelih-Larsen, A., Lóránt, A., Duin, L., Pyndt Andersen, S., Costa, G., and Bradley, H. 2021, *Carbon farming – Making agriculture fit for 2030*, Study for the committee on Environment, Public Health and Food Safety (ENVI), Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg,.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| **AFOLU** | Agriculture, forestry, and other land use |
| **BDS** | Biodiversity Strategy to 2030 |
| **BECCS** | Bioenergy with carbon capture and storage |
| **CAP** | Common Agricultural Policy |
| **CDM** | Clean Development Mechanism |
| **CH4** | Methane |
| **CO2** | Carbon dioxide |
| **CSP** | CAP Strategic Plan |
| **EAFRD** | European Agricultural Fund for Rural Development, also known as 'Pillar 2' of the CAP |
| **EAGF** | European Agricultural Guarantee Fund, also known as 'Pillar 1' of the CAP |
| **EIP-AGRI** | European Innovation Partnership for agriculture |
| **ESR** | Effort sharing regulation |
| **ETS** | Emissions trading scheme |
| **GAEC** | Good agricultural and environmental conditions |
| **GHG** | Greenhouse gas |
| **ha** | Hectare |
| **LULUCF** | Land use, land use change, and forestry |
| **MRV** | Monitoring, reporting, and verification |
| **Mt** | Megatonnes |
| **N20** | Nitrous oxide |
| **R&D** | Research and development |
| **SOC** | Soil organic carbon |
| **t CO2-e** | Tonnes of carbon dioxide equivalents |
| **yr** | year |

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# EXECUTIVE SUMMARY

**Carbon farming refers to farm management practices that aim to deliver climate mitigation in agriculture**. This involves the management of both land and livestock, all pools of carbon in soils, materials, and vegetation, plus fluxes of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). It includes carbon removal (sequestration and permanent storage of carbon in soils and biomass), avoided emissions (preventing the loss of already stored carbon), and emissions reductions (i.e., reductions of GHGs below current levels of farm emissions). All farming systems can mitigate, although the level of mitigation potential differs across farm types and different geographies.

**Carbon farming also refers to the business model that aims to upscale climate mitigation by paying farmers to implement climate-friendly farm management practices**. Funding can come from public funds such as the Common Agricultural Policy, or private sources via supply chains or carbon markets. These different funding sources offer different opportunities and risks for farmers and for delivering on climate objectives.

**Carbon farming has received increasing attention in recent years, reflecting the need for agriculture to both contribute to meeting EU climate objectives and to adapt to climate impacts**. In December 2021, the European Commission intends to publish a 'Carbon Farming Initiative' and in 2022, it will develop a regulatory framework for certifying carbon removals, both aiming to offer incentives to farmers to upscale carbon farming within the EU. This study identifies opportunities and constraints for carbon farming, as well as open questions that need to be resolved to scale up carbon farming in a way that delivers robust climate mitigation and other EU Green Deal objectives.

### *Carbon farming: options, mitigation potential, and key challenges*

**Carbon farming in Europe offers significant climate mitigation potential, however, there is considerable scientific uncertainty around the scale of the potential**. This calls for careful policy design. An improved scientific basis for policymaking is needed. Research should be funded that takes an integrated, system-wide approach, considering interactions between different carbon farming options, barriers to uptake, interactions with changes in consumption patterns, and impacts on other environmental and socio-economic objectives.

**Carbon farming can deliver co-benefits to farmers and society, but it also poses risks that need to be carefully managed**. Farming practices that work with natural processes can have benefits for biodiversity, water, soil health, and animal welfare. Farmers can also benefit from productivity improvements, reduced costs, and improved farm resilience. Some carbon farming practices, however, can have negative impacts and lead to trade-offs (e.g., for soil health, biodiversity, or animal welfare). To maximise win-wins and avoid trade-offs, carbon farming must be designed with safeguards and incentives that favour actions with multiple benefits.

**Two key issues pose challenges to scaling up carbon farming: 1) Monitoring, reporting and verification (MRV) cost and accuracy**: accurate MRV is important to ensure that carbon farming delivers real mitigation, but it is expensive and therefore seen as a key barrier for funders and farmers. **2**) **Impermanence**: carbon sequestered and stored in soils and biomass can be intentionally or unintentionally released back into the atmosphere, undoing any positive climate benefit of carbon farming.

**Using carbon farming to offset carbon mitigation in other sectors poses significant risks**, due to carbon farming's relatively high risk of impermanence, uncertainty, and non-additionality. Carbon farming mitigation should be additional and must not reduce climate ambition in other sectors.

### *Carbon farming as a business model*

**There are a number of different ways that farmers can be paid to implement carbon farming practices**. These different payment types and mechanisms offer different opportunities and have different strengths and weaknesses:

- Public funding through the Common Agricultural Policy (CAP) is the largest current source of carbon farming funding: increasing the CAP's climate effectiveness should be a priority.
- Payments through supply chains and voluntary carbon markets can bring in private financing. However, these must be matched by robust and transparent MRV.

### *Costs, funding options and incentives*

**Carbon farming can be costly: carbon farming incentives need to exceed set-up, ongoing, and other costs for carbon farming to make economic sense to farmers**. Farmers face upfront and ongoing costs of implementing carbon farming actions, including lost income, e.g., linked to potentially losing access to certain types of support payments. Key financial costs for administrators include design and research costs, setting of baselines, and ongoing administration costs (including verification). Transaction costs such as administrative and costs of learning can be significant barriers for both farmers and administrators.

**In addition to funding, the following actions are required to realise the potential of carbon farming**: investment in research and development, especially cost-effective MRV, piloting, and research on socio-economic aspects and barriers to uptake; advisory and technical support; capacity building; and removing policy barriers.

**As a public source of finance, the new CAP offers multiple ways to support carbon farming**. This includes direct land management practice payments to farmers for implementing carbon farming actions including direct payments for meeting good agricultural and environmental conditions (GAEC), eco-scheme payments for specific carbon farming-aligned activities, and a variety of CAP Pillar 2 options including multi-annual contracts, innovative approaches, and Natura 2000 payments). CAP, along with EU research funding, can also support the fundamentals of carbon farming through research, networking, and training.

**Voluntary carbon market and supply chain financing can potentially increase the private financing of carbon farming; however, they come with risks and face some challenges**. Transparent, robust MRV are essential to ensure that carbon farming delivers real mitigation. Given concerns regarding the impermanence, non-additionality, and uncertain measurement of carbon farming mitigation, relying on it to offset emissions reductions in other sectors poses significant risks to climate objectives.

### *Carbon farming and its links to EU climate, agriculture, and biodiversity policies*

**The development of carbon farming will depend significantly on how the EU climate policy evolves in the next years**. The 2021 European Climate Law and the Fit for 55 package set more ambitious targets for agriculture and land use, pointing to a bigger role for carbon farming going forward. There is still scope to increase ambition for agricultural and related-land use mitigation, including setting sectoral targets and robust and transparent monitoring and verification of agricultural mitigation; the EU Commission's Carbon Farming Initiative and Carbon Removals Certification Mechanism will have important roles to play in that regard.

**Close links between carbon farming and biodiversity mean that carbon farming can help deliver biodiversity policy objectives, and vice versa**. 40% of the Natura 2000 area is farmland, offering potential for the Nature Directives to be used to implement biodiversity-friendly carbon farming actions. Where carbon farming leads to restoration of degraded habitats, it can deliver win-win benefits for climate as well as the EU Biodiversity Strategy and forthcoming EU Nature Restoration Plan. To ensure win-wins, carbon farming must monitor biodiversity impacts, consider local context, and exclude mitigation measures that are harmful to biodiversity.

**The Common Agricultural Policy offers the most significant opportunities and barriers to widescale carbon farming uptake**. The 2023-2027 CAP delivery model is supposed to help CAP to deliver on environmental objectives of the Farm to Fork and Biodiversity Strategies. The key tool to ensure this will be the CAP Strategic Plans, where Member States must identify needs related to CAP objectives (including mitigation) and identify how these will be addressed and monitored. Member States have considerable flexibility in how they distribute CAP funding and must take advantage of the opportunity to support effective carbon farming action, which must be monitored by the European Commission.

***Conclusion – key messages***

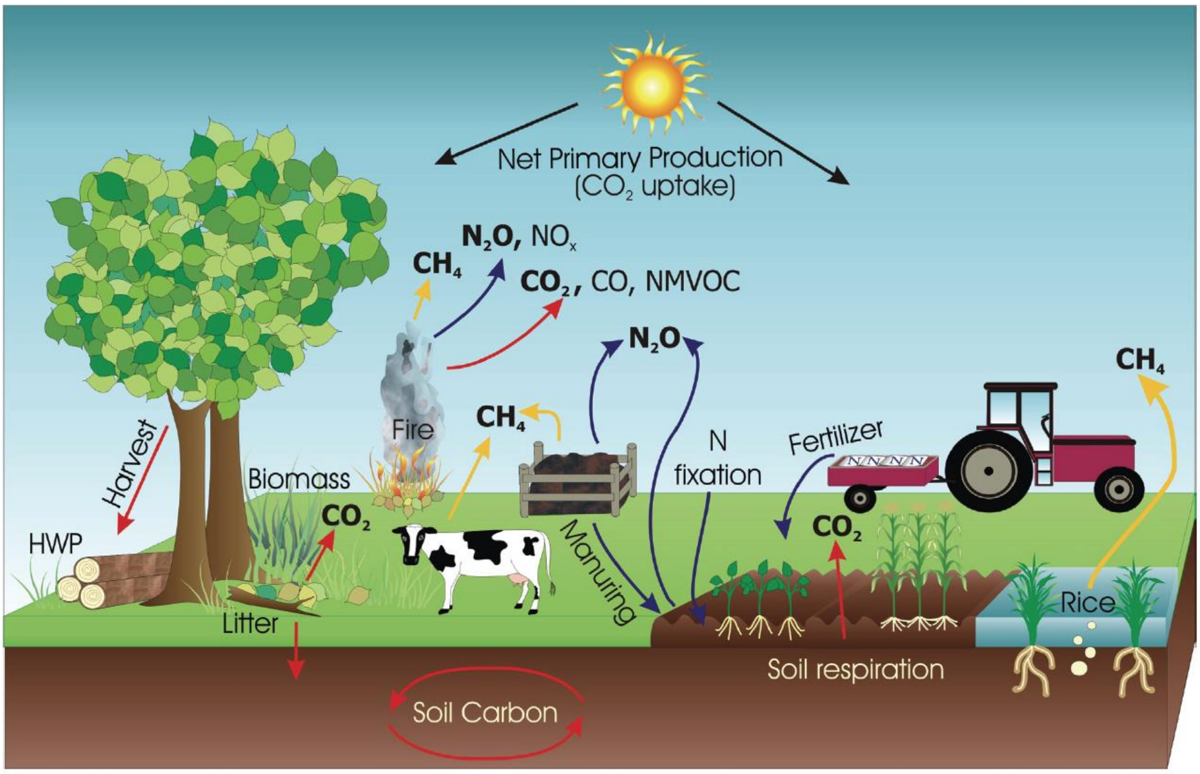
1. As a management practice, carbon farming offers significant potential in Europe to mitigate climate change and deliver other benefits; promoting the widescale implementation of agricultural climate mitigation should be a European priority.
2. Carbon farming should deliver societal co-benefits (including biodiversity, soil health, water quality, and others). There is a risk that poorly implemented carbon farming could negatively impact other societal objectives.
3. Carbon farming mitigation must be permanent.
4. Incentivising carbon farming can be done through different models and payment structures. The different opportunities and risks should be carefully considered when scaling up payments.
5. There is a need for further development of carbon farming monitoring methods, and increased practical experience, and improved assessments of carbon farming potential to increase knowledge and reduce barriers to carbon farming uptake.
6. Through setting dedicated emission reduction and sequestration targets to the agriculture and LULUCF sectors, the EU climate policy could provide clear incentives for carbon farming actions addressing both agricultural CO2 and non-CO2 emissions.

# 1. INTRODUCTION

Carbon farming has received widespread attention in recent years. The European Commission's Carbon Farming Initiative expected in December 2021 and the regulatory framework for certifying carbon removals to follow in 2022 will set out the Commission's proposals for how to advance carbon farming in the EU. The Fit for 55 package also indicates an increasing role for agriculture and land use in delivering on climate mitigation objectives, increasing removals targets for 2026-2030 and aiming for a climate neutral agriculture, land use and forestry sector by 2035, as well as increasing monitoring and compliance requirements.

Carbon farming focuses on the "management of carbon pools, flows and greenhouse gas (GHG) fluxes at farm level, with the purpose of mitigating climate change. This involves the management of both land and livestock, all pools of carbon in soils, materials and vegetation, plus fluxes of carbon dioxide (CO2) and methane (CH4), as well as nitrous oxide (N2O)" (COWI, Ecologic Institute and IEEP, 2021a). For the land managers, this definition means that carbon farming covers farming practices and land use changes that deliver one or more of the following outcomes: 1) carbon removal (sequestration) and subsequent storage in biomass above/below ground and in agricultural soils; 2) the avoidance of future CO2 and other GHG emissions; and/or 3) the reduction of existing CO2 and other GHG emissions.[1]

Figure 1: The main greenhouse gas emission sources/removals and processes in managed farmland




Source: IPCC, 2006.

[1] Although carbon farming is sometimes defined as focused only on carbon removals and sinks rather than the full greenhouse gas balance at farm level, this is problematic because it excludes N20 and CH4 emissions which make up a significant share of the mitigation impact of agriculture. It also creates an artificial separation of activities and processes at farm level which are closely interlinked. As such it may also fail to deliver the needed climate contribution by agriculture and land management.

There is no one-size-fits-all approach to carbon farming, with different mitigation measures available for different types of farming operations. Different farming systems and biogeographical regions vary in how effectively the different types of mitigation measure can be implemented. Carbon farming often delivers public and private co-benefits (such as biodiversity protection or cost savings to farmers). Some mitigation measures, however, may help mitigate climate change but negatively affect other environmental or societal objectives (e.g., soil health, animal welfare).

The term carbon farming is also often used to refer to a new business model for farmers, which consists of incentives for farmers to take up farming practices that deliver a climate benefit at farm level. These incentives can come from public funds, private payments, or a combination of the two. The Common Agricultural Policy (CAP) already funds many actions that can be considered as carbon farming (mainly through co-financing Pillar 2 agri-environment-climate measures and environmental investment measures), although the CAP as a whole has been criticised for failing to meaningfully reduce carbon emission (EU Court of Auditors, 2021). The agreed legislation for the new CAP obliges Member States to identify and prioritise climate needs in their CAP Strategic Plans and gives them a range of opportunities to support more widespread and effective carbon farming practices using EU and national funds and specific interventions from both Pillar 1 and Pillar 2.

In addition to this public funding, in recent years, carbon farming mechanisms have been set up that enable private actors to pay farmers for delivering climate mitigation. Transfers of private funds can either happen via the supply chain for agricultural products (i.e., as a mark-up to product prices) or via carbon markets. In turn, carbon markets can be set up as public or private initiatives.

Carbon farming payments aim to reward farmers for mitigating climate change in order to align farmers' incentives more closely with those of society. In the absence of carbon farming incentives, farmers do not benefit from mitigating climate change, and as a result mitigate less than would be societally optimal. Carbon farming payments aim to reduce this gap by rewarding farmers for the external societal benefit of their mitigation.

In practice, while carbon farming appears promising, existing experience and analytical work on carbon farming mechanisms – be they public or private - point to several challenges and open questions (COWI, Ecologic Institute and IEEP, 2021a). At a fundamental level, there are concerns about whether carbon farming will deliver the promised robust mitigation outcome, societal co-benefits, and socio-economic benefits to farmers. This is due to scientific uncertainties regarding the feasible mitigation potential and the measurement of mitigation outcomes, concerns around permanence of these impacts, barriers to farmer uptake, and risks of negative impacts on other environmental objectives. There are also questions as to how effective carbon farming incentives can be, given the existing complex regulation and subsidy context (e.g., CAP, EU climate and biodiversity policies).

There are also fundamental challenges related to the design of carbon farming incentives. Different approaches to incentivise carbon farming have strengths and weaknesses but share a number of challenges around the rigor and costs of monitoring, reporting, and verification (MRV), ensuring that carbon farming mitigation is additional, and overcoming barriers to scaling up adoption.

This study identifies opportunities and constraints for carbon farming, as well as open questions that need to be resolved to scale up carbon farming in a way that delivers robust mitigation and other EU Green Deal objectives. In this way, the study aims to support the European Parliament's ENVI Committee in critically assessing and responding to the European Commission's proposals for a Carbon Farming Initiative and the Carbon Removal Certification Mechanism.

# 2. CARBON FARMING: OPTIONS AND MITIGATION POTENTIAL

## 2.1. Carbon farming options

Carbon farming includes a range of agronomic practices - land use changes as well as more technological solutions. Practices such as cover crops, improved rotations, peatland restoration or expanding agroforestry systems rely on and work with natural processes in agro-ecosystems. 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 of agriculture. Furthermore, they can increase resilience against climate impacts, thus contributing to improved stability of yields, and benefit the farm business through more efficient use of crop nutrients and livestock feeding regimes, and diversification of crops.

More technological options, such as low-emission livestock housing, biogas digesters, or nitrification inhibitors[2] can also reduce GHG emission intensity per unit of output and improve resource efficiency, especially in livestock farming, but these too can have negative or unintended consequences and do not automatically deliver absolute emission reductions.

This points to the need to have clarity about what is meant by carbon farming, what types of agronomic and technological solutions are supported and promoted under this umbrella term, and the need to simultaneously consider and balance GHG impacts with other environmental co-benefits, risks and safeguards, including resilience of EU agriculture to a changing climate.

To facilitate the discussion, carbon farming can be separated into five main sub-categories of carbon farming interventions: 1) peatland rewetting and restoration, 2) agroforestry system establishment and maintenance, 3) maintenance and enhancement of soil organic carbon (SOC) on mineral soils, 4) livestock and manure management, and 5) nutrient management on croplands and grasslands. These sub-categories vary in their potential to increase carbon removals or reduce GHG emissions. They also pose different opportunities and challenges in terms of co-benefits, risks, costs, incentives, and know-how (COWI, Ecologic Institute and IEEP, 2021a). Table 1 gives a summary of the options and their characteristics.

[2] Nitrification inhibitors are chemicals that can be added to soil to reduce nitrous oxide emissions (and nitrate leaching) by preventing bacteria in the soil from converting nitrogen from fertiliser or animal urine into nitrates.

Table 1: Overview of carbon farming options

| Assessment criterion | Managing peatlands | Agroforestry | Maintain and enhance SOC on mineral soils | Livestock and manure management | Nutrient management on croplands and grasslands |
|---|---|---|---|---|---|
| Carbon farming actions | Peatland rewetting / maintenance / management | Creation, restoration, and management of woody features in the landscape | Cropland and grassland management | Technologies to reduce enteric methane, manure management, increased herd and feed efficiency | Improved nutrient planning, timing and application of fertilisers; reduction in fertilisers |
| Total EU mitigation potential (Mt $CO_2$-e/yr) | 51 - 54 Mt $CO_2$-e/yr | 8 – 235 Mt $CO_2$-e/yr | 9 – 70 Mt $CO_2$-e/yr | 14 – 66 Mt $CO_2$-e/yr | 19 Mt $CO_2$-e/yr |
| Per hectare mitigation potential (t $CO_2$-e/ha/yr) | 3.5 - 29 | 0.03 – 27 | 0.5 - 7 | Not available | Not available |
| Mitigation mechanism | Avoided emissions | Removal | Removal and avoided emissions | Reduced emissions | Reduced emissions |
| Type of change | Land use | Management | Management and land use | Management | Management |
| Co-benefits for farmers | Potential for paludiculture (productive use of wet peatlands) | Diversification of outputs protects against single crop failure | Improved water holding capacity and workability of soils, productivity | Lower input costs (feed, fertiliser, energy), soil health, productivity | Lower input costs |
| Societal co-benefits | Biodiversity, flood regulation, water quality | Improved water retention, microclimate, soil health, biodiversity | Improved water retention, soil health, biodiversity | Decreased nutrient runoff; decreased ammonia emissions | Decreased nutrient runoff; decreased ammonia emissions |
| Risks | CH4 emissions (although net GHG benefit), decrease in production | Non-native species' impact on biodiversity | Biochar and off-farm compost impacting soil health/biodiversity | Animal welfare; water quality impacts of feed additives | Water quality impacts of nitrification inhibitors |

Source: Authors' own elaboration; sources given in section 2.1.1-2.1.4.

### 2.1.1. Managing peatlands

**Definition**: Peatlands are waterlogged land ecosystems that are typified by a high content of organic matter and therefore stored carbon (COWI, Ecologic Institute, and IEEP, 2021b). [3] Drained peatlands release previously stored carbon as well as other GHGs (especially nitrous oxide). Peatlands can be managed to mitigate climate change in three ways: by keeping existing peatlands wet to avoid emissions (either for nature conservation or through paludiculture[4]), by rewetting and restoring previously drained peatlands (to avoid emissions from degrading peatlands), or by adapting the management of drained peatlands in productive use that cannot be rewetted (Joosten, Tapio-Biström and Tol, 2012).

**Mitigation potential**: In Europe, peatlands store four to five times as much carbon as trees (Swindles et al. 2019), a huge carbon sink that must be maintained. In the EU, drained peatlands emit 220 Mt $CO_2$-e per year, making up 5% of total EU GHG emissions in 2017 (Greifswald Mire Centre et al., 2019). Perez Dominguez et al. (2020) estimated that the maximum annual additional mitigation through retiring and rewetting organic soils in the EU would be 51.7 Mt $CO_2$-e in 2030; in addition, ceasing peat extraction could avoid annual emission of 9 Mt $CO_2$-e (European Commission, 2020a). Roe et al. (2021) estimate that the feasible mitigation from rewetting peatlands would be 54 Mt CO2-e per year (average over 2020-2050).

On a per hectare basis, peatland restoration is a highly effective mitigation action. At the upper end of the range, Günther et al. (2020) estimate the level of avoided emissions achieved by rewetting to be up to 29 t CO2-e per ha per year[5], while the MoorFutures methodology, a German carbon farming mechanism, posits a range of potential impact of 3.5-24 t CO2-e per ha per year, depending on previous land use and final state (Joosten et al., 2015). In addition to avoiding emissions, restoration of peatlands can result in some sequestration, though at a low rate of less than 1 t CO2-e per ha per year (Wilson et al., 2016). Although rewetting can lead to a short-term increase in methane emissions, this is outweighed by CO2 savings and can be reduced by appropriate management (for example, mowing and biomass removal before raising the water table) (Günther et al., 2020).

Mitigation potential differs considerably across countries: most peatlands are in northern Europe, and degradation levels – and therefore the mitigation potential of rewetting – differ significantly between European countries. For example, 85% of Norway' peatlands are in a healthy state, in contrast to only 2% in Germany (Tanneberger et al., 2017).

Peatlands can store carbon permanently provided they are continuously managed for storage (COWI, Ecologic Institute and IEEP, 2021b). Impermanence can be human induced, such as re-draining or failing to maintain the peatlands, but also result from natural disasters or sea level rise (Royal Society and Royal Academy of Engineering 2018).

**Co-benefits and risks**: Healthy peatlands provide numerous co-benefits, including biodiversity conservation, flood protection, water filtration, and others (Joosten et al. 2015). Rewetting and restoring drained peatlands can restore delivery of these co-benefits, but because restoring habitats and ecosystems to their original state is often difficult, restored peatlands may not deliver the same

[3] COWI, Ecologic Institute and IEEP (2021b) define peatland as land with a histic horizon ("a soil layer near the surface which when not subject to drainage consists of poorly aerated organic material which is water saturated (or would be in the absence of drainage) for 30 consecutive days or more in most years").

[4] Paludiculture refers to the productive use of wet peatlands.

[5] This level of avoided emissions would be achieved by rewetting peatland that were previously croplands, in boreal or temperate contexts (see table 2 in Gunther et al (2020), which draws on IPCC emissions factors).

level of biodiversity and other benefits as preserved peatlands (Lamers et al., 2015; Renou-Wilson et al., 2019).

There is a risk that peatland rewetting potentially competes with BECCS (bioenergy with carbon capture and storage), afforestation and agriculture, but competition will be relatively low since the total peatland area is limited (Royal Society and Royal Academy of Engineering, 2018).

**Safeguards needed**: Peatland rewetting must be resilient to climate change impacts to ensure that its carbon storage is permanent. Care should be taken to ensure that rewetting on one farm does not have ecological leakage impacts outside that farm (i.e., in hydrologically connected systems).

### 2.1.2. Agroforestry

**Definition**: Agroforestry systems integrate woody vegetation (trees or shrubs) with crop and/or animal systems, storing carbon in above-ground biomass and in soils. Agroforestry covers approximately 8.8% of the EU's utilised agricultural area and is concentrated in the Mediterranean and southeast Europe (Burgess et al., 2018). Most existing systems in the EU are silvopastoral agroforestry systems, which typically combine animal grazing, foraging or fodder production with trees or other woody perennials with the pasture. Many of these are long-established, locally adapted systems, for example d*ehesa* in Spain, *montado* in Portugal, *bocage* agroforestry in France, meadow orchards in the Alpine regions and wood pastures in Romania and Hungary (Kay et al., 2019; Burgess et al., 2018). Modern silvoarable agroforestry combines the cultivation of arable or horticultural crops with woody perennials, often in the form of alternating strips across a field, known as alley-cropping.

**Mitigation potential**: The Agforward project estimated the carbon storage potential of agroforestry in the EU27 (plus Switzerland) to be between 0.3 – 27 t $CO_2$-e/ha/yr or a total of 7.7 – 234.8 Mt $CO_2$/yr (Kay et al., 2019).[6] This estimate does not include below-ground soil organic carbon (SOC), so the total sequestration potential is most likely underestimated as the SOC stocks under agroforestry are shown to be higher than those under conventional arable croplands (for example, by 13%, in a poplar tree silvo-arable system compared to arable land in England) (Upson and Burgess, 2013). A metastudy of hedgerow potential found the SOC sequestration rate under hedgerows to be between 1.1-3.3 t $CO_2$-e/ha/yr, and hedgerow biomass accumulation to be between 6.2 – 15.8 t $CO_2$-e/ha/yr over 20 and 50 years respectively, comparable to forest sequestration rates (Drexler et al., 2021).

The mitigation potential of agroforestry depends on the type of system implemented, the climate and the previous land use. Silvoarable and silvopastoral systems integrated in fields offer high mitigation potential, especially those with high density of fast-growing trees (Feliciano et al. 2018); increased hedgerow or field boundary tree cover offers lower mitigation potential. Systems with lower mitigation potential may be easier to integrate in the landscape as they would affect a small portion of the agricultural land (Drexler et al., 2021).

In terms of the overall GHG balance, agroforestry could reduce nitrogen-related emissions on land where trees are planted (Garcia de Jalón et al., 2017). At the same time, emissions occurring during tree planting due to soil disturbance need to be accounted for.

The permanence of the carbon removal in agroforestry depends on the type of trees and their end use (e.g., timber for fuel versus construction). Poor management and natural events can lead to losses of sequestered carbon, although the fire risk is likely to be lower than in forest areas because the intervening crops can act as firebreaks.

6 Assuming that agroforestry is implemented on the 8.9% of EU farmland that faces multiple environmental pressures.

The agroforestry approach can be adapted to almost any farming system in Europe, with countries that have high share of arable land and grasslands having particularly high potential for expanding agroforestry. Uptake is constrained by various factors, including the permanent nature of the change, significant shift in the farming systems with legal and economic implications and uncertainty for farmers, as well as the fact that agroforestry is a more complex farming approach requiring specific knowledge. Indeed, uptake of agroforestry measures under the 2014-2020 CAP has been low.

**Co-benefits and risks**: Most agroforestry systems deliver multiple ecosystem services with few to no trade-offs for other ecosystem services. Agroforestry contributes to improved soil health, protects against erosion, nitrate leaching and flooding, and has benefits for biodiversity (improved habitat for wildlife, insects, pollinators) (Kay et al., 2019; Burges et al., 2019; Torralba et al., 2016; Drexler et al., 2021). Diversification of farm outputs also makes farmers less vulnerable to single crop failures.

Agroforestry systems that deliver the highest mitigation potential may decrease output of individual food or feed crops compared to single arable or grassland systems. However, even in the short term, these changes in yield are dependent on how the system is optimised and on the biophysical conditions. For example, data on poplar silvo-arable systems in the UK demonstrated reduced output on growth of arable crops and trees when these were combined (García de Jalón et al., 2017); whereas in the Mediterranean context, silvo pastoral systems may improve arable yields under recurring spring temperature increases (Arenas-Corraliza et al., 2018). The effect of reduced output at plot level may also diminish on a larger scale due to the efficient use of nutrients and light in agroforestry systems linked to presence of both trees and crops (Aertsens et al., 2013). By improving microclimate, agroforestry reduces damage from droughts and increases resilience against climate impacts.

**Safeguards needed**: Agroforestry should not be targeted at peat soils, because of the risk of GHG emissions during tree planting (COWI, Ecologic Institute and IEEP, 2021b). To safeguard biodiversity benefits, the preservation and restoration of long-established agroforestry systems should be a priority and new agroforestry should be locally appropriate (e.g., intensive short-rotation coppicing systems should not be introduced on farmland land with existing high biodiversity value).[7]

### 2.1.3. Maintain and enhance SOC on mineral soils

**Definition**: Maintaining and enhancing SOC requires a positive balance of carbon inputs and carbon losses from soils. It is relevant to any farming system, and a wide range of carbon farming practices. This section focuses on SOC sequestration on croplands and grasslands.

Practices with the highest potential for maintaining and improving SOC levels include: 1) cover cropping; 2) improved crop rotations (e.g., through inclusion of legumes and other nitrogen fixing crops); 3) maintaining grassland without ploughing up; 4) conversion from arable land to grassland; 5) organic farming; and 6) management of grazing land and grassland (for example, by optimising stocking densities or grassland renovation).

**Mitigation potential**: The estimates for additional SOC sequestration in EU croplands range from 9 Mt $CO_2$eq/yr (Frank et al., 2015) to 58Mt $CO_2$eq/yr per year (Lugato et al., 2014) to 70 Mt $CO_2$eq/yr (Roe et al., 2021). In addition, because a large share of cropland soils that are mineral soils would continue losing SOC without changes in management, stopping and reversing the losses is equally important (Wiesmeier et al., 2020). For grasslands, Roe et al. (2021) estimate that grasslands in the EU could feasibly sequester 27 Mt $CO_2$-e per year (at a cost of less than USD100/t). Compared to other carbon farming options, the mitigation potential of SOC sequestration in croplands and grasslands is more

[7] Coppicing is a form of woodland management where trees are cut in such a way that they put out new shoots and regrow.

limited and uncertain, and feasible mitigation potential may be more constrained (Batjes, 2019). At farm and plot level, the sequestration potential can vary substantially due to the heterogeneity of soils, climatic conditions, existing SOC levels and management practices. This also increases the costs of MRV and makes the feasible potential difficult to assess. Clay soils and soils with lower current SOC content have higher mitigation potential.

The mitigation potential is limited by soils reaching saturation levels of SOC. Risk of reversal is also stronger than in the case of agroforestry, for example, as there are no legal protections on soil management, unlike restrictions on felling trees or removing hedges.

A controversial issue is the use of biochar as a strategy to increase SOC in mineral soils. The net effect of biochar is highly uncertain when considering the whole lifecycle and negative effects on soil health and biodiversity due to potential contaminants (Jeffery et al., 2017). Risks also come from the application of municipal compost because quality standards are difficult to control and there is a risk of contamination with micro plastics and other contaminants.

**Co-benefits and risks**: Maintaining and enhancing SOC levels improves soil structure and soil fertility, increasing water holding capacity and overall resilience to climate impacts. It also reduces compaction risk and soil erosion. Some argue that maintaining and improving SOC should be promoted primarily as an adaptation option due to significant benefits for soil health and its uncertain mitigation potential (e.g., Amundson und Biardeau, 2018).

**Safeguards needed**: Restrictions should be set on the use of biochar and municipal compost due to risks to soil health and biodiversity.

### 2.1.4. Livestock and manure management

**Definition**: Livestock and manure management refers to any actions taken by livestock farmers to reduce emissions from their farming operation (COWI, Ecologic Institute, and IEEP, 2021b), covering all types of livestock, including beef, dairy, sheep, pig, and others. Actions include those aimed at: directly reducing enteric methane (including feed additives and improved feed digestibility/efficiency); reducing nitrous oxide emissions through manure management (including manure storage and processing, anaerobic digestion and bio methane, and cover cropping); efficiency improvements including animal management to improve productivity (through herd management and feed management); and animal fertility improvements (Jia et al., 2019). Livestock farmers can also increase soil carbon sequestration on their land through grazing and grassland management (discussed in section 2.1.3.). This section focuses on reducing GHG emissions.

**Mitigation potential**: In 2019, methane from enteric fermentation and emissions from manure management in the EU generated 220 Mt $CO_2$-e per annum (EEA, 2021a). International research and existing livestock carbon farming experience in Europe suggest that livestock farms could reduce their emissions by 12-30% by 2030 (COWI, Ecologic Institute, and IEEP, 2021b); this would imply annual potential mitigation of 26-66 Mt $CO_2$-e. Roe et al. (2021) suggest that annual average (2020-2050) technical mitigation potential for enteric fermentation and manure management is 40 Mt $CO_2$-e, of which only 14 Mt $CO_2$-e is considered feasible at a cost of less than €100/t[8]. Perez Dominguez et al. (2021) conclude similarly, finding that technological options on EU livestock farms could mitigate an absolute maximum of 45 Mt $CO_2$-e/yr.

[8] Note there are some minor differences between the Roe et al. (2021) categorisations and the sub-categories we use in our report. For example, the Roe et al. (2021) potential estimates for livestock and manure management include all enteric fermentation management options and manure management but exclude changes in nitrogen fertiliser application, which cannot be separated from nutrient management related to croplands.

Mitigation potential differs widely across different livestock farm types and locations, with confined systems (such as pig farming) and high-intensity farming (such as dairy) better suited to implementing feed additives/vaccines or manure management options; these options would be less feasible in low-intensity systems, which could however implement efficiency and sequestration options (Jia et al., 2019).

Impermanence is only a challenge for carbon sequestration, whereas livestock mitigation options are focussed on emissions reductions (i.e., below the level of emissions that would otherwise occur, the "baseline"). Care must be taken when considering livestock potential to ensure that the baseline is realistic, as an artificially high baseline would overstate potential.

**Co-benefits and risks**: Different mitigation measures for livestock and manure management pose different co-benefits and risks. For example, efficiency-focussed mitigation measures (such as improved feed efficiency, herd management, breeding) can deliver significant cost savings to farmers (COWI, Ecologic Institute, and IEEP, 2021a). Managing nutrient application to grass or fodder crops can positively affect water quality (and related ecosystems); optimal grazing management can improve soil health, reduce water use, decrease soil erosion and improve soil health and biodiversity (Griscom et al., 2017). Some actions can increase electricity use, while some manure management approaches can increase nutrient pollution and negatively affect soil ecosystems, including through soil compaction (Kumar, Park and Cho, 2013).

Effective carbon farming on livestock farms will be likely to lead to production decreases: indeed, the EU Court of Auditors (2021) found that no effective and approved actions reduced emissions without reducing production (except for animal breeding, feed, and health impacts, which only have relatively small impacts and over long time periods). They also identified the risk of relying on efficiency improvements (i.e., decreases in the amount of emissions per litre of milk or kg of meat), which can lead to rebound effects where lower production costs induce higher levels of production (and hence overall emissions).

**Safeguards needed**: Animal welfare and health must be considered when assessing carbon farming actions. The lifecycle impacts of food production must also be considered, i.e., it is important to guard against carbon leakage (where mitigation measures within the carbon farming system result in increases in emissions outside the system); for example, GHG emissions associated with imported feed should be considered (Pieper, Michalke, and Gaugler, 2020). In addition, to ensure that real climate benefits result, farmers must not be rewarded for efficiency improvements, but only for actual reductions in emissions (i.e., reductions in t $CO_2$-e).

### 2.1.5. Nutrient management on croplands and grasslands

**Definition**: Nutrient management focuses on activities that avoid N2O emissions that result from the application of fertilisers and manure management. For the purpose of this briefing, manure management and application are treated together with livestock management (under section 2.1.4). In this section the focus is on reducing emissions from the use of synthetic fertilisers. Key strategies are improved nutrient planning and improving timing and application of fertilisers to avoid over-fertilisation. Also, some estimates consider the use of nitrification inhibitors. The impact of the nutrient management practices can be more significant when combined with agronomic practices such as legume crops, residue management/incorporation, or inclusion of temporary leys/grasslands in the crop rotation.

**Mitigation potential**: Roe et al. (2021) estimate 19 Mt CO2e/yr cost-effective mitigation potential from improved nutrient management in the EU. Their estimates consider direct and indirect N2O emission reductions and upstream CO2 emissions savings from reduced fertiliser manufacturing, as well as nitrification inhibitors.

Improving fertiliser efficiency by itself does not lead to absolute emission reductions, if applied on only part of the farm. A whole farm approach monitoring total fertiliser use is needed to ensure absolute emission reductions.

**Co-benefits and risks**: Improving fertilisation efficiency reduces total fertiliser applications and over-fertilisation and thus also nitrogen leaching and runoff. This in turn protects surface and ground water and reduces costs associated with reducing nitrate levels in drinking water, as well as negative impacts of eutrophication. Improved efficiency does not lead to reduced yields. The measure is cost-effective for farmers since they save on input costs, however, depending on the type of activities involved, they may also incur investments costs (precision technologies) which can lock farmers into the status quo in terms of production type and scale.

**Safeguards needed**: To maintain soil health and water holding capacity, improving the efficiency of synthetic fertiliser use should be combined with measures that improve soil health, such as improved crop rotations, cover crops, inclusion of temporary grasslands, and preventing soil compaction. Nitrification inhibitors have been detected in dairy products and carry the risk of ecotoxicity for terrestrial and aquatic organisms (Kössler et al., 2019). The precautionary principle should be applied to the use of nitrification inhibitors.

## 2.2. Mitigation potential of carbon farming in the EU and key considerations

### 2.2.1. EU mitigation potential and sources of uncertainty

Our review of studies (reported in section 2.1.) identifies a total, additional EU carbon farming mitigation potential of 101-444 Mt $CO_2$-e per year. This is equivalent to approximately 3-12% of the EU's total annual GHG emissions.[9] It also implies that even at the low end of estimated potential, carbon farming could offset 26% of the EU's annual agricultural emissions (i.e. including nitrous oxide emissions from soils, manure management, and livestock enteric fermentation but excluding carbon sequestration/release).[10] However, as indicated by this wide range, there is considerable uncertainty about the true potential of carbon farming in the EU. There are several reasons for the wide range of estimates, and the need to be cautious in interpreting study results:

**Differing definitions of potential**: some studies report technical potential (what can possibly be achieved using current technologies);[11] others report feasible potential (which consider how much of technical potential is actually likely to be realised, given e.g., costs and other barriers). "Feasibility" is defined differently by different studies, with some studies basing feasibility on cost (e.g., Roe et al. (2021) define mitigation as feasible if its assumed cost per t $CO_2$eq is less than USD100) and others using more in-depth assessments to identify realistic potential.

**Different study types**: EU-scale mitigation potential can be estimated either by upscaling local/regional estimates for individual options (or even specific mitigation measures) or by

9 Total EU emissions in 2019 (excluding land use, land use change and forestry, and excluding the UK) were 3637 Mt Co2 (EEA, 2021b).

10 In 2019, agricultural emissions (covering N2O from soils, manure management, and enteric fermentation but excluding carbon sequestration) were 389 Mt CO2eq/yr (EEA, 2021a).

11 An example is Perez Dominguez et al (2021), which assesses the technical maximum potential of all mitigation options available for EU agriculture.

downscaling from global studies; these different approaches arrive at different values. Individual potential studies focus on specific contexts, making them potentially more detailed and accurate (although transferring or multiplying these results to identify EU numbers can introduce significant uncertainty). Global studies draw on integrated climate assessment models (referred to as "top-down") or scale up individual studies ("bottom-up"). Given the global focus, their estimates for the EU are likely to be coarser and more uncertain than individual, EU-focussed studies. However, they have the advantage of considering all carbon farming sub-categories at once and can therefore capture the potential competition between different carbon farming land uses.

**Leakage and land competition**: Bottom-up studies of carbon farming mitigation potential commonly evaluate potential for one specific carbon farming sub-category or mitigation measure in isolation, assuming that all else remains the same. This ignores the significant potential for leakage. Leakage occurs when implementing a carbon farming action on one farm leads elsewhere to increases (or lower reductions) in emissions. This "waterbed" effect reduces the actual mitigation impact of the carbon farming, as pushing down emissions in one area causes ripple effects elsewhere.[12] Bottom-up studies also fail to consider potential trade-offs and interactions between different carbon farming sub-categories or land use changes. Agricultural land can often transition from one land use to another. As incentives for carbon-friendly farming increase, there will not only be management changes within farm types, but also shifts from high-emissions intensity farming to lower-emissions intensity farms: in the long run, land use should reflect (among other factors) the relative efficiency at which the land can produce human food per carbon emission (van Zanten et al., 2016). Failing to account for these leakage and land-competition aspects significantly affects the reliability of mitigation potential estimates.

**Underlying uncertainties**: The variability of mitigation potential estimates also reflects the underlying uncertainty associated with measuring the impact of carbon farming actions. Taking soil carbon as an example, there is a lack of agreement on soil carbon measurement and monitoring approaches, highly variable biophysical contexts, and lack of data on carbon farming actions in many contexts (Rodrigues et al., 2021). Variable methodologies also result in different results from global studies.[13]

### 2.2.2. Distribution of carbon farming potential

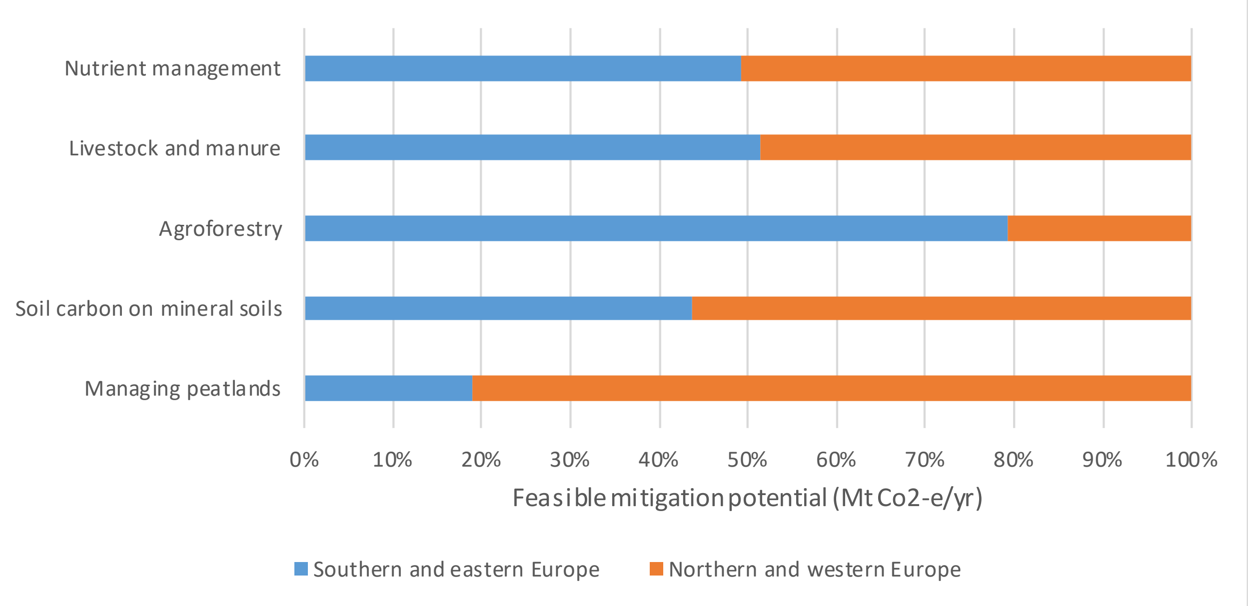
The mitigation potential of different carbon farming options differs widely between and even within EU member states (Perez Dominguez et al., 2021). Figure 2 draws on Roe et al. (2021) data to indicate the relative mitigation potential for different carbon farming sub-categories in southern and eastern Europe relative to northern and western Europe. A clear difference is that mitigation through the restoration and avoided degradation of peatland soils is centred in northern Europe, with only a small total potential in southern Europe; this variability is even greater when looking at country-level statistics, which illustrate the majority of potential lies in northern, western and central Europe: Finland, Germany, Poland, Ireland and Sweden represent 74% of feasible potential. The inverse is true for agroforestry, with cost-effective mitigation potential focused predominantly in southern and eastern Europe; the largest potential can be found in Spain, Italy, Germany, Poland and Romania, who collectively represent 66% of feasible potential. Cost-effective mitigation potential related to livestock

[12] Leakage can take the form of activity shifting, where farmers reduce activity in one area but increase in other areas e.g. by moving stock to another farm. Leakage can also arise due to market effects, where carbon farming actions reduce output and this can lead to price rises that stimulate increased production elsewhere). Ecological leakage can also occur, such as when the rewetting of peatland on one farm results in lower water tables in neighbouring fields and therefore higher emissions).

[13] Section 2.1. features prominently the results from Roe et al (2021), a recent global review study. Global study uncertainty can be seen by comparing different estimates of cost-effective global annual land-based mitigation: Roe et al (2021) estimates 13.8± 3.1 Gt$CO_2$-e/yr of mitigation potential available at costs less than USD100, while Griscom et al (2017) estimates 11.3 Gt$CO_2$-e/yr.

and mineral soils is more evenly spread across the EU regions. Improved understanding of potentials is needed to guide policy design. For example, the expected potential at national and regional scale, as well as an understanding of what specific farming practices have the most significant SOC effects, can facilitate targeting of SOC measures to those areas that have the highest mitigation potential, in particular degraded soils (COWI, Ecologic Institute and IEEP, 2021b).

Figure 2: Distribution of feasible carbon farming mitigation potential across European regions[14]




Source: Authors' own elaboration, based on Roe et al., 2021.

## 2.3. Cross-cutting challenges for carbon farming

Four cross-cutting issues pose challenges for designing policies or other incentives that will translate carbon farming mitigation potential into real actions on Europe's farms: the monitoring, reporting and verification (MRV) of carbon farming mitigation impact, the permanence and the additionality of the impact, and the co-benefits/risks of carbon farming.

### 2.3.1. Monitoring, reporting and verification (MRV)

To ensure that carbon farming actions have a real and positive impact on the climate, one needs to be able to measure them and be confident that they are occurring. This is achieved through monitoring, reporting, and verification: monitoring refers to measuring the decrease in emissions or the increase in sequestration; reporting to the processes for communicating these results; and verification to the ability of administrators or other external parties to ensure the truthfulness and accuracy of the results. Robust MRV is essential to ensure that GHG mitigation and carbon removals have environmental integrity and are real, additional, measurable, permanent, and avoid carbon leakage and double counting.

While robust MRV is essential, it also poses a major challenge as it can be expensive to accurately measure and validate the GHG impact of carbon farming, resulting in a trade-off between MRV accuracy

[14] Southern and eastern European countries: Bulgaria, Croatia, Cyprus, Czech Republic, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain. Northern and western Europe countries: Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Sweden.

and cost. High MRV costs (financial or time) decrease the net-benefit of carbon farming and can act as a significant barrier to farmers voluntarily implementing carbon farming actions or to administrators establishing policies.

The monitoring part of MRV poses a particular challenge for carbon farming. Monitoring can be achieved by direct measurement, modelling, or combined modelling/measurement approaches, each of which has different strengths and weaknesses:

- **Direct measurement**: on-site measurement of carbon stored e.g., in trees or soil and of GHG gases emitted. Direct measurement can monitor GHG impacts with considerable accuracy but can be prohibitively expensive.
- **Modelling**: GHG emissions and removals are estimated based on a combination of measurable proxy data and already-known scientific relationships. Modelling requires previous scientific research to establish relationships between proxies and estimated emissions/sequestration. Modelling has higher uncertainty than direct measurement but lower costs.

It is important that MRV captures all carbon farming impacts on the climate. Given that carbon farming actions have an impact on multiple GHGs and carbon stores, it is important that all are monitored; failing to monitor all GHGs can result in perverse outcomes. For example, there is evidence that planting trees on peatlands can result in net negative carbon storage (as the lost soil carbon from the drained peatland outweighs any increase in above-ground carbon storage (in trees) (Sloan et al., 2018); both of these carbon stores must be monitored, as well as emissions of nitrous oxide, methane, and carbon dioxide.

As shown by Table 2, different monitoring approaches are commonly applied to monitor farm-level carbon farming in the different carbon farming sub-categories. These can monitor GHG impact with different levels of uncertainty and cost, depending on inherent challenges in the different carbon farming sub-categories, and due to different levels of MRV methodology and technology development.

Table 2: Costs and uncertainty of different MRV approaches in carbon farming sub-categories

| Carbon farming sub-category | MRV | | |
|---|---|---|---|
| | **Type of monitoring** | **Uncertainty** | **Costs** |
| **Managing peatlands** | Modelling | Medium | Medium |
| | Measurement | Low-medium | Very high |
| **Soil carbon on mineral soils** | Modelling | High | Medium |
| | Measurement | Medium | Very high |
| **Agroforestry** | Combined (modelling + measurement) | High | High |
| **Livestock + manure management** | Modelling | Medium | Low-Medium |

Source : Based on COWI, Ecologic Institute and IEEP, 2021b; own elaboration.

Note: Nutrient management is not included in the COWI, Ecologic Institute and IEEP (2021b), so excluded from this table.

Given the importance of monitoring as an enabler of carbon farming, research and development should focus on affordable, robust MRV technologies (such as remote sensing, the EU Commission-supported Farm Sustainability tool (FaST)) or data sources. New MRV technologies must be critically assessed to ensure robustness, for example, to ensure they capture the full GHG impacts (rather than capturing only singular GHGs or partial impacts of mitigation measures).

Reporting and verification processes are especially important if carbon farming mitigation is used to generate offset credits that will be used by other sectors in lieu of their own emissions reductions. Without robust reporting and verification - including random and targeted auditing, secure registry systems, and long-term reporting obligations – there is significant risk that carbon farming mitigation could be low-quality.

### 2.3.2. Permanence

For carbon farming to have a positive impact on the climate, mitigation must be permanent (i.e., GHG levels must be lower than they otherwise would have been in the long-term). Given the long-term nature of the climate challenge, there is very little point in storing carbon for short periods of time if it is likely to released again, making it essential that carbon farming mitigation is permanent.

Permanence is a particular challenge for carbon farming mitigation through sequestration and storage (i.e., carbon removed from the atmosphere and stored on agricultural land in biomass (above and below ground and in soils).[15] This sequestered carbon is unstable and can be released intentionally or unintentionally: for example, stored soil carbon can be quickly released through intentional actions, such as changing cropping patterns or reintroducing tillage; carbon can also be unintentionally released e.g., if drought or fire results in the loss of agroforestry trees, releasing their stored carbon (COWI, Ecologic Institute and IEEP, 2021b). The challenge of impermanence is compounded for soil carbon (in peatlands or mineral soils), because monitoring permanence is much harder.

Permanence is not a risk for carbon farming mitigation actions that reduce emissions, such as livestock and manure management or nutrient management actions that reduce methane and nitrous oxide emissions. Once these emission reductions occur, the GHG remain out of the atmosphere and cannot be intentionally or unintentionally released later.

### 2.3.3. Additionality

It can be challenging to identify whether mitigation would have occurred in the absence of a carbon farming incentive scheme, i.e., whether mitigation is additional. Additionality is important when designing mechanisms to incentivise and reward carbon farming for two reasons:

- Cost effectiveness: to avoid rewarding farmers for nothing, carbon farming payments should only pay for mitigation that goes beyond what farmers would have done without the prospect of receiving a financial reward.[16]
- Robust impact on the climate: only carbon farming mitigation that goes beyond what would have happened without carbon farming policies is additional. This is crucial if the carbon farming mitigation is used to generate offsets that other sectors can use as an alternative to mitigating within their own sector. If carbon farming mitigation is not additional (i.e., there are

[15] This type of mitigation is referred to in carbon markets as carbon removals (where new sequestration occurs) or as avoided emissions (where carbon that would have been released instead continues to be stored).

[16] Note this does not imply that farmers should only get paid for taking actions; they could also be rewarded for avoiding actions that would release stored carbon (e.g., not draining wet peatlands if they otherwise would).

no real reductions or sequestration relative to business-as-usual), then using them as offsets instead of reducing emissions elsewhere will make climate change worse.

Additionality is often assessed against a baseline, which aims to describe what would have happened in the absence of policies to incentivise carbon farming. This baseline (often referred to as "business-as-usual") acts as a counterfactual against which actual mitigation is compared. Anything that goes beyond it (i.e., any sequestration in excess of the baseline or emission reductions below the baseline emissions) is considered additional. Baselines can be developed in different ways, which have different strengths and weaknesses.[17] Developing complex baselines can be costly and time-consuming for participants and administrators, in some cases requiring historical data that is not always available (COWI, Ecologic Institute, and IEEP, 2021a). However, simple baseline setting methods are susceptible to being manipulated by participants, resulting in non-additional mitigation (Badgley et al., 2021).[18]

Additionality can be particularly difficult to ascertain within Europe, given that CAP requirements (e.g., Member States' cross-compliance standards) and additional incentives (e.g., agri-environment-climate payments) are diverse, context specific, can have uncertain impacts on mitigation, and change over time. This can make it challenging to set realistic baselines or ascertain additionality at the farm scale, with the potential that farmers are paid multiple times for the same mitigation (e.g., through CAP and through carbon farming mechanisms).

Carbon farming mitigation is only additional if each unit of mitigation is counted no more than once. This issue of double counting can be challenging when voluntary carbon markets exist alongside national requirements for offsetting emissions, and when offset credits can be traded internationally. Carbon farming mechanisms must have strict guidance and transparent registries in place to track carbon credit ownership and to ensure that any mitigation associated with international trade of offset credits is only recorded in one Member State's climate contributions. For example, the UK Peatland Code has implemented a registry system that ensures credits are tracked directly to its owner to prevent double-counting (COWI, Ecologic Institute and IEEP, 2021b).

Additionality is also affected by leakage. If carbon farming actions end up increasing emissions outside of the monitored system (for example, due to animals being moved from monitored farms to unmonitored farms), then the actual additional impact of the carbon farming action on the climate is proportionately reduced.

### 2.3.4. Co-benefits and risks of carbon farming

While carbon farming explicitly targets climate mitigation impacts, often these same actions deliver other environmental, climate adaptation and socio-economic co-benefits. Some of these co-benefits

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[17] For example, baselines can be set backwards looking (i.e., based on historical levels of sequestration, such as average sequestration on the farm over the last three years), forward looking scenarios (e.g. what level of sequestration would we expect on the farm over the next ten years, given current policy and farm characteristics) or benchmark based (e.g. what level of emissions/sequestration would we expect given the type of farm). They can be developed specifically for an individual farm or can be standardised, where the same baseline is applied to all farms (or average standardised rules are used to generate baselines for individual farms) (COWI, Ecologic Institute, and IEEP, 2021b).

[18] This "adverse selection" occurs when farmers only choose to participate when they receive an erroneously generous baseline due to errors in the simple baseline setting method. For example, they are erroneously given a baseline that is below their true current carbon storage level, meaning that if they join the mechanism they do not have to implement actions, they will already appear to have carried out sequestration (or conversely, the baseline estimate of emissions is erroneously above their true current emissions level, meaning that even without taking actions they will appear to have carried out emissions reductions). Farmers who receive an erroneously ungenerous baseline would choose not to participate, biasing the system. Badgley et al (2021) found that adverse selection in the California forest carbon offset program introduced systemic bias and meant that 30% of credits were non-additional.

accrue to farmers (such as cost savings, productivity increase), making carbon farming more attractive; other co-benefits are public goods (such as biodiversity conservation, water quality impacts), which can justify greater public funding for carbon farming. At the same time, there is the risk that some mitigation measures may deliver mitigation but negatively affect other farmer or societal objectives. Examples of these risks include the potential for negative soil health impacts of some soil organic carbon mitigation measures (such as biochar or municipal compost), or negative biodiversity or adaptation impacts associated with implementing agroforestry measures that are not locally appropriate. Carbon farming actions that sustainably take advantage of natural systems such as soils and trees and therefore deliver biodiversity benefits, improve human well-being as well as mitigation can be referred to as nature-based solutions (IUCN, 2016).[19]

To ensure that carbon farming supports the social, environmental, and socio-economic objectives of the European Green Deal, it is important to maximise co-benefits and reduce risks when designing and implementing carbon farming payments and mechanisms. In addition to monitoring the mitigation impacts of carbon farming, the impacts on other objectives should also be monitored (e.g., biodiversity protection and enhancement, water quality/quantity benefits, farm resilience, reduction of flood risk and soil erosion). In addition, carbon farming incentive policies must include sufficient safeguards to avoid negative impacts, e.g., “negative lists” excluding carbon farming actions that will be harmful in particular contexts, regular policy evaluation, and monitoring that covers all GHGs. Given carbon farming’s potential scale and impact, a failure to consider climate and non-mitigation impacts poses significant risk or could fail to capture the multiple benefits that carbon farming financing has to offer.

[19] Not all carbon farming actions are nature-based solutions, for example, technology-based actions such as anaerobic digesters or nitrification inhibitors do not deliver biodiversity benefits and therefore fail to qualify.

# 3. CARBON FARMING AS A BUSINESS MODEL

Chapter 2 discussed carbon farming as a suite of farm management practices aimed at mitigating climate change. The term carbon farming is also used to refer to a business model where farmers are paid to reduce emissions or sequester carbon, in order to incentivise farmers to implement carbon farming practices.[20] The focus of this chapter is on this second interpretation of carbon farming, describing different types of carbon farming payments and different carbon farming mechanism models, and their strengths and weaknesses for farmers and society.

## 3.1. Models for carbon farming payments and mechanisms

### 3.1.1. Carbon farming payment types

How do farmers earn money from carbon farming? And what do farmers have to deliver in return? The answer to these questions depends on the carbon farming payment type, of which there are three, each with its own strengths and weaknesses:

- **Action-based**: farmers receive a set payment for taking a particular action, e.g., complying with a defined farming practice or implementing specific technologies. Action-based payments are commonly applied in CAP (e.g., agri-environmental-climate payments under Pillar 2). Action-based payments are relatively simple, with low monitoring requirements for farmers and administrators. However, the actual mitigation impact of action-based payments is uncertain, as payment depends only on the action, not the result.
- **Result-based**: farmers receive a payment that depends on the actual mitigation outcome that they deliver (typically in t CO2-e that are either sequestered or not emitted), regardless of the specific actions taken. Result-based payments require that the mitigation outcome can be quantified and verified, which requires costly and complex MRV, and if prices and mitigation are uncertain also poses uncertainty for farmers. A strength is that environmental certainty and credibility are high due to the explicit link between the mitigation contribution and payment, also, the flexibility can encourage farmers to innovate and adapt mitigation measures to the local context.
- **Hybrid payments**: Hybrid payments mix action- and result-based payments, combining low-risk, up-front or guaranteed payment for farmers for implementing specific farm management actions, with additional payments based on actual measured mitigation results. Upfront payments can be used to cover implementation costs, or to reduce the financial risk for farmers. Hybrid models can increase farmer uptake by lowering risk and removing upfront financial barriers, whilst still providing flexibility to farmers to implement optimal actions for their farms and guarantee real climate results for society.

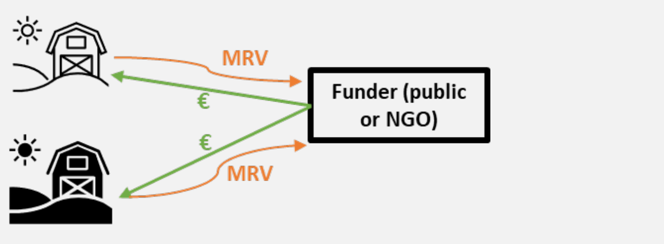
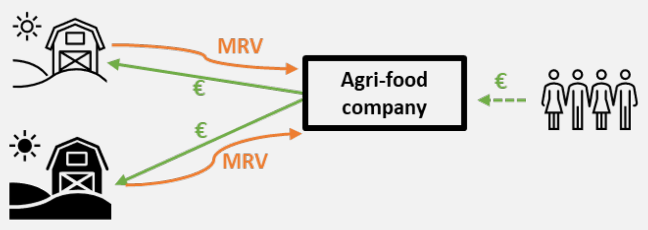
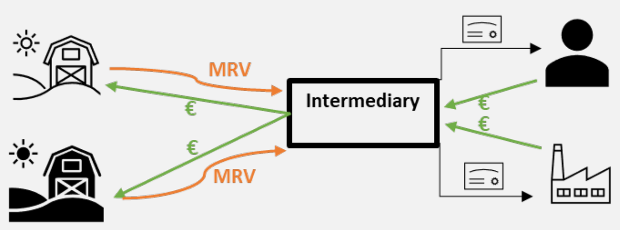
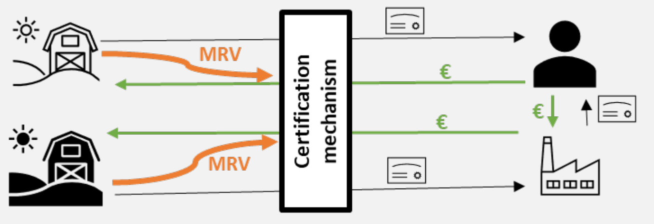
### 3.1.2. Models for carbon farming mechanisms

Carbon farming payments are paid to farmers through a carbon farming mechanism. Table 3 explains four common carbon farming mechanism structures. These differ in terms of who ultimately pays the farmers, what form of payment the farmer receives (i.e., cash or an offset credit tradeable for payment), and, most significantly, the level of monitoring, reporting and verification that is required. The extent and stringency of MRV and the overall complexity of the mechanism determine the cost of participation for farmers, as well as the administrative costs borne by operators of the mechanism. These elements

[20] These incentives are in addition to any co-benefits enjoyed by the farmer, such as efficiency savings, productivity increases, etc.

also determine the environmental certainty of mitigation, with associated risks for farmers and society, which is explored in section 3.2.

Table 3: Models for carbon farming mechanisms

| | | |
|---|---|---|
| **Land-management practice payments** |  | **MRV requirements**: Low -medium<br>**Funder**: Public or NGO<br>**Example**: CAP Greening payments, CAP Pillar 2 payments<br>**Payment:** Cash (generally action-based; hybrid/result-based possible) |
| | A central funder pays farmers a reward for implementing climate carbon farming management actions (related to crops, soil, land use, livestock) | |
| **Corporate supply chain** |  | **MRV requirements**: Low - high<br>**Funder**: Agri-food company<br>**Example**: Arla Climate Check, SPAR Austria Healthy Soils for Healthy Foods<br>**Payment:** Cash (generally action-based; hybrid/result-based possible) |
| | Agri-food companies pay farmers within their own supply chain to reduce their impact on the climate, motivated by the possibility of price premiums from customers, or to meet own company climate objectives. Also known as “insetting” or managing “scope 3 emissions”. | |
| **Voluntary carbon market with intermediary** |  | **MRV requirements**: Medium - high<br>**Funder**: Private companies/individuals<br>**Example**: MoorFutures, Label bas Carbone CarbonAgri, Woodland Carbon Code, Peatland Code<br>**Payment:** Offset certificate - non-fungible, only traded once then retired (result/hybrid/action-based) |
| | A central intermediary pays farmers for implementing mitigation measures, monitors and verifies mitigation impact, and sells offset credits to private buyers. The intermediary can be the private or public mechanism developer or a project developer. They often provide farmer training/support. | |
| **Voluntary carbon market - exchange-based** |  | **MRV requirements**: High<br>**Funder**: Private companies/individuals<br>**Example**: Verra VCS, Gold Standard, puro.earth<br>**Payment:** Freely tradeable offset credit (result-based) |
| | Farmers implement mitigation measures in accordance with approved methodologies to produce offset credits that they trade directly with buyers. A certification mechanism aims to ensure that the offset credits produced are matched by high quality, unique climate mitigation/sequestration (i.e., equivalent to removals/reductions in other sectors and therefore tradable). | |

Source: Authors' own elaboration.

## 3.2. Advantages and disadvantages of different carbon farming mechanism models

In this section we identify the relative strengths of different carbon farming mechanism models and highlight key risks; text boxes provide European examples of existing mechanisms.

**Land-management practice payments**: Up until relatively recently, land-management practice payments were the primary source of carbon farming funding. Europe's Common Agricultural Policy (CAP) has used this model for farm support payments for decades, with an increase in the use of practice-based payments to incentivise improved environmental and climate performance in recent years. Land-management practice payments have the advantage of being simple and therefore low-cost to administer, generally with low MRV requirements. They pose low risk for farmers, who know when they apply what the payment will be. While land-management practice payments can be result-based, generally they are action-based, which further lowers the risk for farmers (COWI, Ecologic Institute, and IEEP, 2021a). [21] However, this type of funding generally depends on public financing, which is a relatively limited funding source. Given that land-management practice payment financing is predominantly action-based with limited MRV, the mitigation impact is commonly uncertain; result-based land-management practice payments would involve higher MRV requirements (and costs) but deliver more certainty about the mitigation outcome.

**EAFRD agri-environment funding for soil management – Medved farm example,** https://enrd.ec.europa.eu/projects-practice/medved-farm-investing-soil-conservation-practices_en

**Structure:** Land-management practice payments **Location**: Slovenia
**Category**: Soil organic carbon on mineral soils **Since:** 2014 **Impact:** Unknown

The Medved family farm is an example of CAP-funded payments for implementing agri-environmental practices that help mitigate climate change. On their 55ha of mixed dairy/cropping farm, they have received payments for implementing specific practices including sowing of green manure crops (i.e. cover crops that are grown then incorporated into the soil for nutrients), no tillage, and direct application of organic fertilisers. This has increased organic content of soils, with mitigation, fertility, and resilience benefits.

**Corporate supply chains**: Growing public concern with climate change has motivated some agri-food companies to commit to corporate climate pledges, or to market products as climate-friendly in the hope of earning price premiums or access to new markets. This model can bring in private sources of funding for carbon farming, where agri-food companies are motivated either by price premiums or for marketing reasons. An additional advantage is that agri-food companies have existing relationships with many farmers, giving them the ability to set minimum standards or effectively communicate and attract voluntary farmer participation. However, one main risk of this model is that the processes are often opaque. To be credible, these mechanisms need to be transparent, which includes application of proven and published methodologies for quantifying and verifying the results of carbon farming (with associated high MRV requirements, costs and complexity). A number of standards have been

[21] Result-based land management practice payments examples were demonstrated for farmland biodiversity in the four-year pilot schemes co-funded by the European Commission (Byrne et al. 2018; Chaplin et al. 2019).

developed to support this transparency (including Science Based Targets,[22] Green House Gas Protocol,[23] ISO Standard 14064,[24] among others). There is also a need to regulate the claims that corporates can make to consumers.

**Arla Foods** https://www.arla.com/sustainability/sustainable-dairy-farming/how-arla-farmers-reduce-dairys-carbon-footprint/

**Structure:** Corporate supply chain **Location**: Northern Europe

**Category**: Livestock **Since:** 2013 **Impact:** Objective 30% reduction by 2030

Arla dairy farmers are visited by a farm consultant who uses an Arla-built farm carbon audit tool to calculate current (baseline) farm emissions. Farmers update this baseline annually. Farmers were paid a bonus 0.01EUR/litre of milk to complete the audit (action-based).

**Voluntary carbon markets**: Since the early 2000s, governments, NGOs, and private companies have developed markets to incentivise mitigation measures (Nogues et al., 2021). These markets link voluntary buyers who want to pay for mitigation measures with projects or individuals willing to implement those actions in return for payment (often in the form of "offset credits" that equate to a removal or reduction of 1 t $CO_2$-e).[25] These voluntary carbon markets are growing quickly, with a global trading volume of 178 Mt $CO_2e$ in 2020, up 80% from 2019, and projected 2021 global market value of over USD1 billion (Forest Trends' Ecosystem Marketplace, 2021). While most voluntary market removals and reductions come from forestry and renewable energy, agricultural methodologies (livestock emissions reductions, peatland rewetting, and soil carbon sequestration) are emerging within Europe (Cevallos, Grimault, and Bellassen, 2019). Voluntary carbon markets could significantly increase private funding for carbon farming, but they also pose risks and face challenges, depending on the type of market:

- **Voluntary carbon markets – exchange-based** are the most scalable, theoretically capable of enticing large scale private financing for carbon farming – provided there is sufficient demand. They are relatively *laissez-faire*, based on methodologies that are applied similarly across different farms, with the quality of the removals/mitigation assessed through relatively stringent MRV. The resulting offset credits are assumed to be "fungible", i.e., equivalent (and tradeable) with those created through other mitigation methods (such as afforestation or even renewable energy reductions). However, there are significant disadvantages: the high MRV costs and the relatively complex, open market structure lower the cost for buyers and other market actors, but raise costs for participating farmers, often excluding smaller farms (who cannot benefit from economies of scale) and reducing the net benefits of farmer participation. In addition, the fact that the price is determined on the market increases uncertainty and risk for market participants. The fungibility of offset credits results in a general feature of offset markets: if all allowances are considered as equivalent, the requirements for credits to enter the market must be sufficiently high and stringent. If this cannot be ensured, it leads to a risk for the market – and ultimately the environment. If carbon farming credits of low quality enter the market (e.g., due to uncertainty, impermanence, or vulnerability to fraud), this can

[22] See: https://sciencebasedtargets.org/

[23] See: https://ghgprotocol.org/

[24] See: https://www.iso.org/standard/66453.html

[25] An important distinction of voluntary markets is that, while offset credits are generated that can be bought and sold on a market, these credits are not used to comply with legal obligations (unlike emission allowances in a compliance ETS. Instead, buyers use these credits to voluntarily offset the emissions for which they are responsible.

undermine and erode trust in the market. If such credits are then still used to offset mitigation in other sectors, this could undermine the achievement of overall climate targets.

- **Voluntary carbon markets with intermediaries**: these markets generally involve closer cooperation between farmers and an intermediary, with the intermediary effectively reducing the risk and complexity of farmer participation. The credits produced in these markets are usually limited to a single type of mitigation measure or carbon farming, and the offset credits are often only allowed to be sold once and then retired (i.e., are not considered fungible). Intermediaries commonly guarantee a set price for farmers. For this reason and because offset credit buyers can rely on the reputation of the intermediary, MRV may not need to be as stringent to be convincing to buyers, relative to an exchange-based voluntary carbon market. This can lower complexity and costs for farmers (and therefore increase farmer uptake) without increasing environmental uncertainty, relative to exchange markets. However, due to the large role of the intermediary (commonly supported by farming consultants), and the cost of the services provided by the intermediary, it is more challenging to scale up these markets.

**Carbon by Indigo, https://www.indigoag.com/carbon**

**Structure:** Exchange-based voluntary carbon market **Location**: USA, Europe
**Category**: Soil carbon sequestration **Since:** 2019 **Impact:** unknown (3.3 million acres)
Carbon by Indigo developed a Verra Voluntary Carbon Standard methodology for quantifying soil carbon increases on croplands. Baselines are set using direct measurement. Sequestration over the ten-year project duration is then estimated either by direct measurement or modelling using data on farm characteristics/management. There is some uncertainty concerning the environmental robustness of the methodology, due to leakage, permanence, and model/measurement uncertainty. Credits are sold to corporate buyers (current prices USD15).

**MoorFutures https://www.moorfutures.de/**

**Structure:** Voluntary market with intermediary **Location**: Germany
**Category**: Peatland rewetting **Since:** 2010 **Impact:** 69,000 t CO2-e (by 2060)
MoorFutures works with landowners to establish a baseline scenario and then estimate the expected avoided emissions of rewetting peatlands. Farmers sign 50+ year contracts and receive result-based payments (of €40-80/t). MoorFutures funds these by selling offset certificates to corporates (e.g., McDonalds, banks) and individuals.

# 4. COSTS, FUNDING OPTIONS AND INCENTIVES

## 4.1. Carbon farming costs and barriers

### 4.1.1. Financial costs

From a business point of view, carbon farming only makes sense for farmers if the benefits (reward payments plus the co-benefits that they enjoy) outweigh the costs that they face.[26] From a societal perspective, decision makers must ensure that the benefits of carbon farming (including climate mitigation, biodiversity, and other external benefits) exceed the costs (including costs faced by both the farmers and administrators). Table 4 identifies the types of costs to set-up and run a carbon farming mechanism faced by farmers and administrators, and what these depend on.

Costs vary widely depending on the mechanism type, carbon farming sub-category, specific mitigation measures implemented, and the local context. Few studies evaluate administrator costs, with most studies focused on a narrow definition of farmer costs. An illustrative example is the LIFE CarbonFarmingScheme (2021), which evaluated seven potential carbon farming actions, all result-based voluntary carbon market models with stringent MRV. They considered farmer baseline setting, implementation, and transaction costs, finding that the total cost per t $CO_2$-e range from €20 (for afforestation) to €84 (for peatland actions).

MRV costs can make some carbon farming mechanisms uneconomic for farmers. In mechanisms with high MRV requirements, the costs of quantifying emissions/removals and proving this to administrators can be prohibitively expensive, outweighing the potential carbon farming payments and therefore reducing farmer uptake (COWI, Ecologic Institute, and IEEP, 2021b). This is a particular issue where mechanisms require on-site visits and sampling to measure baselines and changes in e.g., soil carbon stocks. This varies considerably by carbon farming mechanism model: Label bas Carbone CarbonAgri estimates that cost of consultant site visits is €2000 per farm every 5 years; GoldStandard projects face USD67,500-87,500 of verification, validation, and registry costs in the first 5 years (COWI, Ecologic Institute, and IEEP, 2021b); the LIFE CarbonFarmingScheme (2021) estimates project validation, verification, and market registration costs of €110,000-240,000 within the first five years. In addition to reducing net benefits, these high MRV costs can mean that only large farms or farmers can participate in high-MRV mechanisms. Accordingly, carbon farming MRV should only be as stringent as it needs to be.[27] However, the trade-off – lower MRV and lower environmental certainty – may not be acceptable in many cases.

[26] Farmer costs can include lost income, including subsidies. From a societal perspective, any reduction in subsidy payments would not be a cost.

[27] The level of necessary stringency depends on the importance of accuracy; if carbon farming will be used to create offset credits (see section 3.), then stringency must be very high. COWI, Ecologic Institute and IEEP (2021a) identify a number of ways to minimise the trade-off between overall MRV accuracy and cost: MRV should be looser on smaller farms and on farms where regulators have greater certainty about results (e.g. farms that have been recently audited); mitigation measures that are easy to monitor should be favoured while mitigation measures with expensive monitoring or high uncertainty can be excluded; existing data and science should be utilised to decrease farmer costs.

Table 4: Administrator and farmer costs associated with carbon farming

| | Cost types | Determinants |
|---|---|---|
| **Administrator** Set-up costs | **Mechanism design:** Development of the methodology (i.e., how to quantify mitigation, how to monitor, report and verify mitigation measures); developing all governance and operating rules.<br>**Scientific research/data collection:** Calculating mitigation depends on locally appropriate research and data.<br>**Baseline setting* and validation**: Administrators may bear the cost of setting participant baselines (e.g., sampling, consultant visits) and validating new participants/projects.<br>**Outreach, training:** Costs of attracting farmer participants. | Set-up costs are generally fixed costs, so will be lower per t/$CO_2$-e or per participant in larger mechanisms. They will be higher for more complex mechanisms.<br>Research and baseline costs will be lower when there is existing data and research to support implementation, and where scheme design builds on existing examples. |
| **Administrator**: Ongoing costs | **Monitoring and verification**: Assessment of farmer mitigation measures to ensure they comply with the methodology and verify results, any auditing costs.<br>**Mechanism administration**: Administrative costs e.g., contracting, registry management, governance, system evaluation etc.<br>**Funding*:** Costs associated with getting funding e.g., marketing and selling offset credits to buyers. | Ongoing costs are variable, i.e., higher the more participants are involved (though with some economies of scale).<br>More complex mechanisms will have higher MRV costs and administrative costs. |
| **Farmer** Set-up costs | **Learning costs:** Carbon farming requires additional knowledge and potentially training. Farmers must also learn how to operate within the carbon farming mechanism.<br>**Baseline setting*:** Farmers may bear baseline-setting costs.<br>**Implementation costs:** Farmer costs of implementing carbon farming action (e.g. technology purchase costs, tree planting, rewetting). | To maximise farmer uptake, administrators can support farmers to reduce these set-up costs (e.g., through training, consultant support).<br>Set-up costs are fixed costs, so larger participants have lower average costs. |
| **Farmer** Ongoing costs | **Implementation costs:** Direct ongoing costs of implementing the mitigation measure (including time costs, additional equipment, running costs).<br>**Opportunity costs:** Income foregone due to implementing mitigation measures.<br>**Transaction costs*:** Farmer MRV and administrative costs. | Transaction costs depend principally on MRV requirements: complex schemes and high MRV pose significant costs for farmers. |

* Costs can be borne by farmers or by administrators, depending on scheme design.

Source: Authors' own elaboration.

### 4.1.2. Non-financial barriers to carbon farming uptake

In addition to costs, non-financial barriers can also pose a significant challenge to upscaling carbon farming. Previous studies have identified the following priority issues, which must also be addressed to upscale carbon farming (European Commission, 2021a; Nogues et al., 2021).

Farmer barriers include:

- **Learning costs** – Carbon farming and interacting with new mechanisms requires new knowledge and skills, requiring training, support, outreach, and practical examples (and potentially up-front payments).
- **Risks** – Result-based mechanisms and the price uncertainty of exchange-based markets pose risks for farmers.

Administrator barriers include:

- **MRV cost and uncertainty** – Carbon farming MRV is often relatively uncertain or expensive (or both).
- **Other design challenges** – As explored in Chapter 2, issues of permanence and defining additionality (especially with leakage and land-competition) and interactions with existing agricultural and environmental regulations make carbon farming challenging for administrators.
- **Administrator knowledge** – Carbon farming requires administrator knowledge, ability, and a baseline of data and scientific understanding.

## 4.2. Funding availability for carbon farming: public and private options

The different kinds of costs identified in section 4.1. can be covered by private or public funds, and in some cases by a mixture of the two.

### 4.2.1. Private sources of finance for carbon farming - market-based and corporate supply chain mechanisms

Private and corporate sources of finance predominate in carbon-farming mechanisms linked to voluntary carbon markets or to companies in the farm sector supply chain. These private sector payments offer the potential to increase funding available for carbon farming though they do face some challenges and issues.

There are an increasing number of voluntary carbon markets, where private actors pay for offset credits generated by carbon farming (Cevallos, Grimault and Bellassen, 2019). These mechanisms are typified by result-based payments and either intermediary or exchange-based carbon markets. Label bas Carbone CarbonAgri is one example of such a market: it sells emissions reduction certificates to corporate and private buyers, which are matched by emissions reductions on French livestock farms. The revenue from the sales of emissions reduction certificates is used to pay farmers per t CO2-e emissions reduced, as well as cover training and administrative costs (COWI, Ecologic Institute, and IEEP, 2021b).

Administrators' up-front development costs are significant and private finance may not be available to fully cover these costs, especially in the early years when income from credit sales is small. Public support may therefore have a role to play in getting projects off the ground. Such projects that are jointly funded by both public and private actors are increasingly common, but require safeguards to avoid double-funding of the same action, double-counting of carbon credits, or public funding crowding out private capital. The peatland restoration max.moor scheme in Switzerland is a public-private partnership, with public start-up financing to cover establishment costs, which are not directly recouped from the sale of offset credits. To avoid the double-counting issues, the Swiss authorities retire one CDM credit for each credit issued by the max.moor initiative (COWI, Ecologic Institute, and IEEP, 2021b). The Label bas Carbone CarbonAgri mechanism was also developed and established using public funding: in addition to being administered by the French Ministry for Ecological Transition, the methodology was developed in part through an EU LIFE research project and utilises tools and research developed by public agencies (COWI, Ecologic Institute, and IEEP, 2021b).

As a different type of funding mechanism, corporate supply chain finance for carbon farming comes from companies wanting to reduce the carbon footprint of their products. They do so by offering farmers in their supply chain a small financial incentive to implement action-based carbon farming, with MRV costs lower than they would be in a carbon market. For example, Arla Food's Climate Check sustainable dairy project uses data from a publicly available digital reporting tool, verified by an external auditor. Supply chain support can be in kind or in cash. The Swiss food retailer Coop encourages farmers to plant timber and wild fruit trees in combination with standard fruit trees, in return for a payment of CHF 75 per tree plus free advice on the choice, location and regular care of the trees. The payment is additional to any other form of agricultural support (COWI, Ecologic Institute and IEEP, 2021a).

Several factors will influence the amount of private finance available. A key limit for the growth of private offset markets is the potential perception of carbon farming offset credits as having relatively low environmental robustness due to concerns about permanence and non-additionality, and uncertainty in measuring mitigation impact (as discussed in section 2.3.). Until these concerns are adequately addressed, there is significant risk of using carbon farming credits to offset mitigation in other sectors, which should reduce demand within voluntary carbon markets. While this challenge could in the future be addressed through more stringent MRV, the current cost of such MRV is a significant barrier to farmer voluntary uptake, as is risk faced by farmers (COWI, Ecologic Institute, and IEEP, 2021a).

### 4.2.2. Public sources of finance for carbon-farming

In considering public funding for carbon farming, by far the most significant source is the wide range of opportunities Member States will have to use their CAP funds from 2023 onwards to support carbon farming. A large amount of the overall EU budget contribution to climate objective is expected to come from the CAP, which is 'expected to contribute' 40% of its budget, almost EUR 155 billion, towards climate spending between 2023 to 2027. This is an expectation, not an obligation, and crucially its effectiveness will depend on how Member States choose to meet their climate and other environmental needs (which will be wider than just carbon farming) in their draft CAP Strategic Plans (CSPs); the extent to which these choices are modified during the Commission approval process; and the response of farmers to the CAP carbon farming standards and payments in their Member State.

This section discusses, from the point of view of a farmer or landowner, the carbon farming baseline requirements and the types of funding that could be available under both Pillars of the CAP 2023-27. Whether or not these payments will actually be available to individual farmers is down to Member States decisions, which are discussed in section 5.3.

CAP finance could support carbon farming in a number of ways: by setting baseline standards of land management; through a suite of practice-based land management contracts for specific carbon farming actions at several levels of climate ambition, which in combination could make a considerable contribution to funding on-going costs of carbon farming; upfront investment support for farm-level land use changes to enable carbon farming; advisory and capacity building support that could help to cover farmers' costs of learning; finally, the EAFRD could contribute to R&D costs for farmers and administrators setting up new carbon farming mechanisms locally, and also at national and EU level (the latter through the CAP Network and the agricultural European Innovation Partnership (EIP-AGRI)). The farm-level CAP measures available from 2023 are detailed below.

**Potential for farm-level CAP funding for carbon farming from 2023**

Significantly, the agreement on the new CAP extends the underlying eligibility for CAP Pillar 1 direct payments, to include the carbon farming practices of paludiculture and agroforestry (European Parliament, 2021b). This change could remove significant barriers for farmers rewetting peatlands, for example, because they might no longer stand to lose their direct payments. The new GAEC conditionality standards set the baseline land management requirements for all farmers receiving direct payments under Pillar 1 and land management payments under Pillar 2. Several are directly relevant to the management of peatlands and wetlands, retention of grassland, and retention of SOC, as shown in Table 5. Failure to comply with GAEC standards can lead to quite high financial penalties which act as a deterrent for farmers.

Eco-schemes are new, area-based payments fully funded under Pillar 1. The Commission's proposed list of examples includes: conservation agriculture; rewetting wetlands/peatlands, paludiculture; minimum water table level during winter; appropriate management of residues (i.e., burying them), seeding on residues; establishment and maintenance of permanent grassland and extensive use of permanent grassland; agroforestry (European Commission, 2021c). Eco-schemes can be paid per hectare either on a cost incurred or income forgone basis or, in some cases, a top up income payment which farmers enter under an annual contract. Groups of farmers are also eligible.

Using their EAFRD co-funding under Pillar 2 of the CAP, Member States have a wider choice of interventions they could make available to farmers to support carbon farming. These include multi-annual environmental management contracts for carbon farming, which can be tailored to suit the national or regional need and farming context, as well as the opportunity for innovative approaches like result-based environmental management contracts and pilot schemes. Area-based annual Natura 2000 compensation payments (for the requirements farmers have to fulfil under the EU's nature laws) could underpin appropriate carbon farming within Natura 2000 sites, e.g., for permanent grassland, peatland and wetland habitats.

Table 5: CAP standards from 2023 for good agricultural and environmental condition of land relevant to carbon farming

| Main Issue | Requirements and standards | | Main objective of the standard |
|---|---|---|---|
| Climate change (mitigation of and adaptation to) | GAEC 1 | Maintenance of permanent grassland based on a ratio of permanent grassland in relation to agricultural area at national, regional, sub- regional, group-of-holdings or holding level in comparison to the reference year 2018; Maximum decrease of 5% compared to the reference year. | General safeguard against conversion to other agricultural uses to preserve carbon stock |
| | GAEC 2 | Protection of wetland and peatland[28] | Protection of carbon-rich soils |
| | GAEC 3 | Ban on burning arable stubble, except for plant health reasons | Maintenance of soil organic matter |
| Soil (protection and quality) | GAEC 6 | Tillage management, reducing the risk of soil degradation and erosion, including consideration of the slope gradient. | Minimum land management reflecting site specific conditions to limit erosion |
| | GAEC 7 | Minimum soil cover to avoid bare soil in periods that are most sensitive[29] | Protection of soils in periods that are most sensitive |
| | GAEC 8 | Crop rotation in arable land, except for crops growing under water[30] | Preserve the soil potential |
| Biodiversity and landscape (protection and quality) | GAEC 9 | [partial extract] Minimum share of agricultural area devoted to non-productive areas or features; Minimum share of at least 4% of arable land at farm level devoted to non-productive areas and features, including land lying fallow; …; Retention of landscape features; Ban on cutting hedges and trees during the bird breeding and rearing season | Maintenance of non- productive features and area to improve on-farm biodiversity |
| | GAEC 10 | Ban on converting or ploughing permanent grassland designated as environmentally-sensitive permanent grasslands in Natural 2000 sites | Protection of habitats and species |

Source: European Parliament (2021b).

[28] Member States may provide in their CAP strategic plans that this GAEC will only be applicable as from claim year 2024 or 2025. In such cases, Member States shall demonstrate that the delay is necessary for the establishment of the management system in accordance with a detailed planning. Member States, when establishing the standard for GAEC 2, shall ensure that on the land concerned an agricultural activity suitable for qualifying the land as agricultural area may be maintained.

[29] In duly justified cases, Member States may adapt the minimum standards to take into account the short vegetation period resulting from the length and severity of the winter period.

[30] There is a more detailed definition of the requirements and exemptions in the agreed text of the legislation.

### 4.2.3. Contribution of EU research funding to carbon farming

EU funds under the LIFE, Horizon Europe and INTERREG programmes could make a significant contribution to innovation and R&D in carbon faming (see box text for examples of recent relevant projects). Examples of EU research and project funding related to carbon farming include:

- **LIFE**: The LIFE Carbon Farming Scheme, which started in 2020, aims: to develop guidance for policymakers on implementation of a carbon farming incentive scheme; to identify characteristics of efficient markets by studying demand from sectors mandated to GHG reductions, and supply from the agricultural and forest sectors: and to demonstrate the rules in 10 test farms and 10 forests, two of each from five different soil-climatic regions in Europe. The project has already released four reports.
  The five-year LIFE PEAT RESTORE[31] project in Germany, Poland and the three Baltic Member States has rewetted about 5,300 ha of degraded peatlands, created guidelines for peatland restoration and management, tested techniques for Sphagnum farming on bare peat and creating floating islands in a former peat extraction area. It has also estimated the climate effect of the restoration measures and tried to raise public awareness with events, booklets, panel discussions, photography exhibitions and short films. The results of the project were presented at a final conference in October 2021 and are available at https://life-peat-restore.eu/en/welcome-to-life-peat-restores-online-conference/

- **Horizon 2020**: The recently completed H2020 project CIRCASA[32] aims to strengthen the coordination and synergies in European and global research on SOC sequestration in agricultural soils, leading to an improved understanding and scientific basis to target ambitious practices required to preserve and enhance SOC. A new Horizon Europe call[33] for projects on the topic International Research Consortium on (agricultural) soil carbon (HORIZON-CL6-2021-CLIMATE-01-07) closed in October 2021, with the grant award expected in early 2022.

- **INTERREG**: The INTERREG North Sea Region's Carbon Farming[34] project focuses on the implementation of carbon farming techniques that will improve soil structure, increase soil biodiversity and offer better water holding capacity and nutrient availability. The seven partners, from The Netherlands, Belgium, Germany and Norway, including farmers' associations and research centres. have been working to promote and showcase uptake of carbon farming techniques. One of the outputs of the project are policy recommendations on how to incentivise carbon farming. The main recommendation is to develop a holistic framework in which the climate, biodiversity and water-related objectives do not conflict with each other at the farm level and provide a clear and motivating framework (Nijman, 2021). Peatland restoration and paludiculture have been the focus of the DESIRE project supported by the INTERREG Baltic Sea Region Programme of the European Regional Development Fund).

## 4.3. Additional requirements for carbon farming uptake and effectiveness

In addition to monetary reward, a number of additional actions will be needed to address the non-financial barriers to carbon farming (4.1.2) if carbon farming is to be adopted by administrators and

[31] See : https://life-peat-restore.eu/en/

[32] See : https://cordis.europa.eu/project/id/774378

[33] See : https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl6-2021-climate-01-07;callCode=HORIZON-CL6-2021-CLIMATE-01

[34] See : https://northsearegion.eu/carbon-farming/

farmers at the scale required to make an effective contribution to EU environmental policy in the next 10 years:

**Removing policy barriers** by adjusting implementation of existing policies and/or development of new policies could strengthen carbon farming uptake and effectiveness. Here, it is particularly important to identify and redress existing, counterproductive incentives for farming under the CAP, some of which discourage carbon farming or encourage farming that increase rather than decrease agricultural GHG emissions. To realise this opportunity, it will be important for the Commission to ensure that the approved CAP Strategic Plans from 2023 encourage uptake of targeted carbon farming actions where they will have greatest mitigation benefit. This requires designing GAEC requirements and practice-based payments for carbon farming that take full account of the variability within each Member State in soils, climatic conditions, farming systems structures, current land uses and the real costs/benefits to the farmer of carbon farming, rather than a "one size fits all" approach. Member States could further leverage uptake of carbon farming by differentiating payment rates and targeting eco-schemes and environmental/climate land management contracts where they will achieve greatest mitigation benefit and positively impact other societal goals such as biodiversity conservation. This would give a clear signal to farmers that level of payment is linked to both the scale of change required and the resulting GHG benefits to society.

A related policy barrier is that CAP payments are subject to a seven-year policy cycle with funding levels, regulations, and priorities all liable to change between cycles. This 7-year CAP cycle is a significant barrier for the permanence and additionality of CAP carbon farming support for carbon sequestration/storage and long-term actions to avoid GHG emissions (e.g., for agroforestry management, peatland restoration/rewetting, converting arable land to permanent grassland, raising water tables). Longer environmental and climate management contracts under CAP Pillar 2 would address this problem, enable long-term business planning by farmers and encourage uptake of action-based carbon farming mechanisms. There is a CAP precedent for 20-year contracts 'for environmental reasons and for the protection of natural resources'.[35]

**Investment in R&D** could strengthen carbon farming uptake and effectiveness by addressing the accuracy and cost of MRV methods, as well as potential synergies and conflicts with other EU objectives. There is currently an MRV trade-off between the affordability (i.e., low-cost) and certainty of the results achieved. If levels of uncertainty are high, it may be an obstacle to market-based funding carbon farming scheme, for both administrators and farmers, who typically share both the MRV costs and the financial risk. Therefore, priority should be given for R&D investment towards developing cost-effective and accurate MRV systems (and the data and models that underpin them). These investments should be complemented by continuing practical experience that can identify new barriers, catalyse new solutions, and develop lessons that can be applied in subsequent schemes (COWI, Ecologic Institute and IEEP, 2021a).

A second priority should be research and demonstration of cost-effective carbon farming methods in different pedo-climatic conditions, ideally with co-benefits for the farmer and society, but at a minimum ensuring the principle of 'do no harm'. Existing carbon farming schemes have shown evidence of significant co-benefits but also potential trade-offs between environmental objectives. Factoring these into the delivery of the scheme and rewarding farmers for delivering specific co-

[35] For CAP payments 'to set aside farmland for at least 20 years with a view to its use for purposes connected with the environment, in particular for the establishment of biotope reserves or natural parks or for the protection of hydrological systems' (Council of the EU, 1992; Article 2(1)f).

benefits will be an important contribution to increasing farmer participation and delivering other EU environmental priorities.

The third priority for R&D should be to understand the sociological aspects of farmers' attitudes to carbon farming, their awareness of the opportunities and barriers for their business and the key influences on their decision making. Investment in enhancing farmers' knowledge and perceptions of carbon- and non-carbon benefits, attitudes towards climate change and farming practices and financial uncertainty could help overcome current social-cultural barriers to uptake of carbon farming practices and funding opportunities (COWI, Ecologic Institute and IEEP, 2021a, b).

**Advisory and technical support** for potential funders (public and private), scheme operators, and farmers will support setting up new market-based initiatives or expanding or endorsing existing schemes and initiatives**.** Any effective scheme and effective MRV system will need to be informed and run by people with appropriate knowledge and technical expertise to understand the results that the scheme is intended to produce. Further, providing the necessary advisory and technical support to farmers builds trust between farmers and advisers. This trust and adequate provision of advice to farmers is important for the functioning and success of any environmental land management, but especially for results-based carbon farming mechanisms. Scaling up training and advisory services for farmers, funders and schemes operators could further incentivise the uptake of carbon farming schemes (COWI, Ecologic Institute and IEEP, 2021a).

**Capacity building** and information and awareness raising support to increase institutional capacity in scheme funders, and skills and knowledge capacity among farmers and their advisers and workers are crucial elements for scheme development and operation, whether market-based or action-based. Member States currently have opportunities to strengthen carbon farming skills and capacity using CAP and other public funding (as discussed in 4.2.2).

# 5. CARBON FARMING AND ITS LINKS TO KEY EU POLICY AREAS

In addition to the issues discussed in the previous chapters, the success of the EU carbon farming initiative will inevitably depend on whether there are sufficient policy incentives in place to drive the demand for carbon farming actions/schemes, whether that is from Member States or private actors. In addition to the Common Agricultural Policy (CAP), which remains the main driver of actions in the EU farming sector, other EU policies, the EU policy framework for climate and biodiversity are also important here and described and assessed in this section.

## 5.1. EU climate policy

The EU climate and energy policy framework plays a crucial role as it sets the overall climate ambition and prescribes obligations to certain sectors of the economy. Over the past decade, EU climate mitigation targets became more ambitious, increasing from 20% reduction from 1990 levels by 2020 (EU 2020 climate and energy package) to 55% by 2030 and economy-wide climate neutrality by mid-century (European Climate Law under the European Green Deal). At the same time, the scope of the relevant legislation has also changed with implications for climate action in the agriculture and land use sectors. The following section provides an overview of how carbon farming has been promoted by EU climate policy, including a brief assessment of the implications of the recently proposed Fit for 55 package.

### 5.1.1. Agriculture in the EU 2030 climate and energy policy framework

The EU 2030 climate and energy policy framework was adopted in 2018 to deliver an EU-wide emission cut of at least 40% by 2030. Agricultural activities emit and remove both CO2 and non-CO2 greenhouse gases (GHGs). These emissions are addressed under different pillars of the framework. Agricultural non-CO2 GHGs, together with emissions from other sectors outside the scope of the EU's Emission Trading System (EU ETS), are covered by the Effort Sharing Regulation (ESR). The ESR sets binding targets for Member States but with flexibility on the potential contribution of individual ESR sectors. Targets range from 0% to 40% reduction by 2030 (compared to 2005 levels), reflecting the relative wealth of Member States, and they are meant to collectively deliver a 30% emissions cut in those sectors by 2030.

Agricultural CO2 emissions (or removals) linked to changes in carbon stored in soils and biomass due to cropland and grassland management practices are on the other hand covered by the Land use, land use change and forestry (LULUCF) Regulation. The Regulation sets a "no-debit" rule, requiring Member States to ensure that accounted emissions (debits) from all land-use categories within the LULUCF sector are less than accounted removals (credits) in the period of 2021 - 2030. There are several flexibilities integrated into the legislation to help Member States comply with the no-debit rule; including banking credits for later periods, transferring credits between different land use categories and Member States as well as a compensation mechanism in the managed forest land category that is only available under certain conditions. While the LULUCF sector does not count towards the 2030 emission reduction target, Member States are allowed to use the LULUCF sink to offset 280 Mt of emissions from their ESR sectors in 2021-2030. This flexibility has been criticised claiming that it disincentivises the reduction of GHG emissions in the ESR sector (Fern, 2018).

From a carbon farming point of view, the following observations can be made about the current (2030) EU climate and energy policy framework:

- The ESR and LULUCF Regulation set targets and requirements for Member States and therefore they provide no direct incentives for individual farmers. As such, it does not alone provide sufficient incentives for the reduction of non-CO2 GHGs from the agriculture sector. Across all effort sharing sectors, agricultural emissions decreased the least in the period of 2005-2018. Agriculture remains the sector where projections foresee only limited changes in emissions in the period up to 2030 (EEA, 2020).

- Existing rules do not prevent the decrease of the EU's carbon sink. Between 2010 and 2019, the LULUCF sink in the EU decreased by 21% from -315 Mt CO2-e to -249 Mt CO2-e. While this is in part due to age structure of forests, a Commission impact assessment from 2020 concluded that "*left without a revised policy framework, the net removal of CO2 from the atmosphere by the LULUCF sector in the EU will at best remain stable – or even decrease*" (European Commission, 2020a).

### 5.1.2. The Fit for 55 package

To set Europe on a responsible path towards becoming climate neutral by mid-century, the European Climate Law, which was adopted in June 2021, increased the 2030 EU-wide emission reduction target to at least 55% compared to 1990 levels. The contribution of the LULUCF sector to this target is capped at 225 Mt CO2e[36]. In July 2021, the European Commission proposed a set of revisions (Fit for 55 package) to the current 2030 climate and energy policy framework to meet the higher ambition set out in the European Climate Law.

Key elements of the Fit for 55 package include the revision of the Effort Sharing and LULUCF Regulations. Amongst the most relevant changes are:

- The ambition level in the ESR sectors is proposed to increase from the current 30% to 40% by 2030 (compared to 2005 levels). Flexibilities remain, but with a number of changes that will likely restrict offsetting until 2030, although after this it is then expected to increase again (Fern, 2021).
- An overall target of 310 Mt CO2-e of removals is proposed in the land use and forestry sector for the period from 2026 to 2030, which will be divided between Member States as annual national targets based on the verified emissions and removals from years 2021, 2022 and 2023. This has been proposed to encourage Member States to increase the size of carbon sinks beyond 225 Mt CO2-e, i.e., the maximum contribution of the LULUCF sector to the 55% target. This will de facto increase the 2030 net target to 57% (European Parliament, 2021a).
- An integrated policy framework covering agriculture, forestry and land use (AFOLU) is proposed from 2030 with the view of achieving carbon neutrality in the AFOLU sector by 2035. The transition to this integrated framework is foreseen to happen through several stages:
    - 2021-2025: No major changes in the LULUCF regulatory framework.
    - 2026-2030: An overall EU removal target of 310 Mt CO2-e will apply as described above.
    - From 2031 onwards the LULUCF sector will include the non-CO2 GHG emissions from agriculture with the objective of reaching a climate neutral EU land sector by 2035 at the latest.
    - From 2036 onwards the EU land sector will be expected to become net sink. These removals from the land sector are foreseen to be used to balance remaining emissions in other sectors that have exhausted their emissions reduction possibilities, or that have achieved for instance over 90% emission reductions.

[36] i.e. maximum contribution of net removals from LULUCF are 225Mt; any additional will not count for 55% reduction.

In addition to these changes in the Effort Sharing and LULUCF Regulations, two other relevant policy initiatives should be highlighted:

- The Commission's Carbon Farming Initiative, which is expected to be launched before the end of 2021, will promote a new business model in the EU farming sector that rewards climate-friendly management practices by land managers. Whilst the exact scope of the initiative is yet to be seen, the Commission's focus seems to be on carbon removal and storage (as opposed to non-CO2 emissions).

- A new regulatory framework for carbon removal certification, for which the Commission's proposal is expected at the end of 2022, will lay out detailed rules for monitoring, verifying and accounting carbon removals in the EU to ensure robustness and transparency.

These changes, if approved as proposed, may have a number of implications for carbon farming. First and foremost, the launch of a sequestration-focused EU carbon farming initiative and the foreseen target on removals will most likely encourage Member States to take action to increase the absorption of CO2 in agricultural and forest land. At the same time, the proposed target of 310 Mt CO2e remain well below the potential identified in recent scientific literature that indicates that annual removals of up to 600 Mt CO2e can be achieved in the EU LULUCF sector by 2030 (Böttcher et al., 2021)[37]. Secondly, the incentives provided through the EU climate policy to implement carbon farming actions targeting agricultural non-CO2 emissions remain weak. This is the case, even though there is widespread evidence that agricultural GHG emissions can be reduced cost-efficiently. The proposed integration of agriculture into the LULUCF sector may further delay action in the farming sector to reduce non-CO2 emissions. Thirdly, the environmental integrity of the EU carbon farming initiative will depend upon the forthcoming regulatory framework to monitor and verify carbon removals in agriculture and forestry.

In order to overcome these challenges and ensure that carbon farming makes a significant and lasting contribution to the EU's climate mitigation efforts, the following policy recommendations can be made:

- Avoiding and reducing GHG emissions should be the first and main priority of climate mitigation efforts in the land use sectors. This avoidance and reduction of emissions first principle should be reflected in the carbon farming initiative. In particular, this requires that non-CO2 emissions are within the scope of the initiative.

- Setting a quantified GHG emission reduction target for agriculture could help reduce the risk that Member States rely extensively on removals to meet net targets (see e.g., in Germany). This is especially important in the context of a combined agriculture and LULUCF sector (AFOLU) foreseen after 2030.

- The development of a robust, transparent and science-based certification system for carbon removals is essential to ensure the environmental integrity of the EU carbon farming initiative and the wider climate policy regime.

[37] The mitigation potentials in section 2. are for additional mitigation; these here refer to total net mitigation.

**National climate policies addressing agriculture – Germany's Federal Climate Change Act**

In 2019, Germany's government implemented a climate law which provides sectoral climate targets, including for agriculture. Through combining annual emission budgets, annual mitigation targets and climate protection measures, the overall target of net zero greenhouse gas emission has been set for 2045. The steps towards climate neutrality are reduction of GHG emissions in comparison to 1990 of at least 65% by 2030 and of 88% by 2040. For agriculture in particular the aim is to reduce emissions to 56 million tonnes of CO2-e by 2030. The contribution of the LULUCF sector is set to at least 25Mt CO2-e by 2030 and 40 Mt CO2-e by 2045.

The climate protection measures and monitoring are in the hand of the responsible ministries. Ministries are also responsible for compliance in their sectors. For agriculture, the foreseen measures address both CO2 and non-CO2 emissions and removals. For non-CO2 emissions, measures include the reduction of nitrogen surpluses (ammonia emissions, nitrous oxide emissions and targeted measures to reduce nitrogen emissions from agricultural soils) and the improvement of nitrogen efficiency (together 1.9 to 7.5 million tonnes of $CO_2$ equivalents annually) and management of livestock manure and agricultural residues (2.0 to 2.4 million tonnes of CO2-e annually). Carbon sequestration and storage will be encouraged through humus build up in agriculturally used soils, by conserving and rewetting peatlands, and by rewarding ecosystem services in forests (reduction potential is estimated to 1.0-3.0 million tonnes of CO2-e annually).

The emission reduction targets reflect the recent changes to the law, which the government implemented after a ruling by the Federal Constitutional Court. The Court concluded that missing interim targets after 2030 are not compatible with the principle of intergenerational justice by referring to Article 20 of the 'Grundgesetz' – the protection of the natural foundations of life in responsibility for future generations. Based on the ruling, the government was ordered define further reduction paths for 2030 to 2050 and amend the Climate Protection Act in order to reach climate neutrality, with CO2 budgets used as a basis for the climate targets. In response, in June 2020, the government passed an Emergency Climate Protection Programme, with an additional EUR 8 billion funding for climate measures, including EUR 480 million for agriculture and land use, land use change and forestry sectors.

## 5.2. EU biodiversity policy

As agricultural landscapes are of great importance to biodiversity protection, carbon farming measures have significant potential to deliver biodiversity co-benefits (as well as some potential disbenefits or trade-offs). Carbon farming policy initiatives and implementation should therefore be carefully aligned with current and developing EU biodiversity policy commitments, at both EU and Member State/regional level.

The EU Biodiversity Strategy (BDS) sets out the EU's planned actions to put nature on a path to recovery by 2030. It replaces the previous Biodiversity Strategy to 2020 which, despite some success, failed to halt the decline of biodiversity in Europe. The new BDS aims to address these gaps both by strengthening the implementation of existing biodiversity policies, such as the EU Nature Directives, and by introducing new initiatives, such as an EU Nature Restoration Plan. This section will outline the key overlaps between carbon farming and biodiversity policy objectives including how biodiversity policies can support carbon farming, and how carbon farming can in turn help to achieve biodiversity goals.

Although the focus will be on contributing to the protection and restoration of farmland biodiversity, carbon farming initiatives can also help achieve other BDS headline targets. For example, reducing the use of pesticides by 50%, bringing back 10% of agricultural area under high diversity landscape features, and contributing to the goal for zero pollution by reducing the use of fertilisers by at least 20%. Moreover, depending on the way in which they are implemented, some carbon farming actions may indirectly help to achieve other biodiversity targets such as reversing the loss of pollinators.

### 5.2.1. Legal obligations of Member States/regions for the conservation of farmland habitats and species under the EU Nature Directives

The Nature Directives set out obligations for Member States for protecting habitats and species both inside and outside designated Natura sites. They also apply to farmland and can overlap with carbon farming, since around 40% of the Natura 2000 total area is farmland (EASME, 2020). There are over 50 habitat types and 260 protected species under the Habitats Directive which are closely associated with agriculture (European Commission, 2017).

Article 6(1) of the Habitats Directive requires Member States to establish the necessary conservation measures for Special Areas of Conservation (designated Natura sites). Article 6(2) requires them to take the appropriate steps to avoid the deterioration of natural habitats and the habitats of species. Both Articles include requirements which can include restoration measures (Coalition, 2020). Article 6(2) has been interpreted by the EU Court of Justice to include an obligation to “ensure that damaged habitats are allowed to recover”.

Carbon farming can have implications for the Nature Directives. There are around 200 habitat types that are defined and protected at the EU level under Annex I of the Habitats Directive.[38] Some of these habitats contain significant amounts of carbon, but the degradation of ecosystems by human activities adversely affects their carbon sink capacity. The carbon stored is then released, having negative and dangerous consequences for the climate and for the ecosystems (IUCN, 2017). Restoring these habitats through carbon farming practices could help achieve favourable conservation status of the habitat types protected under the Directives.

- **Peatland ecosystems** are covered by thirteen different habitat types in the Habitats Directive. In total, 33 000 km2 of these habitat types are protected in more than 8,700 Natura 2000 sites (European Commission, 2020b). The Natura 2000 network has a positive impact on biodiversity and habitat protection of peatland in the EU (Peters and Unger, 2017) and therefore, restoring these habitat types and maintaining them in a favourable conservation status under the obligations of the Directive will have positive consequences for biodiversity and for the climate.
- **Agroforestry systems** have the potential to be deployed across a large area of farmland across the EU. 85 forest habitat types are listed in Annex I of the Habitats Directive, including long established silvo-pastoral systems. New agroforestry systems have the potential to deliver carbon sequestration and can provide wider benefits for ecosystem services and biodiversity, such as a greater diversity of landscapes and habitat connectivity (COWI, Ecologic Institute and IEEP, 2021a).

[38] The Habitats Directive Annex I lists 58 habitat types which are considered to be dependent on or associated with extensive agricultural practices, and Annex II lists 197 species or subspecies of plants or animals (other than birds) associated with agro-ecosystems or grassland ecosystems. Additionally, 62 of the 195 birds listed in Annex I of the Birds Directive are considered to be key farmland species (European Commission, 2014).

Despite the importance of this legislation, Member States' lack of implementation by of their obligations under the Nature Directives is preventing many protected habitat types from reaching favourable conservation status.

- **Peatland ecosystems**: their overall conservation status remains unsatisfactory, despite the protection and restoring obligations set out in the Nature Directives. According to the reporting assessment made under Article 17 of the Habitats Directive for the 2013-2018 period, only 11% of the assessments of peatland habitat types currently show a favourable conservation status at the EU level (European Commission, 2020b).[39]
- **Agroforestry systems**: the overall conservation status of forest habitats under the Habitats Directive also remains largely unsatisfactory. According to the same assessment under Article 17, none of the agroforestry habitat assessments showed a favourable conservation status[40]. The Montado agroforestry project in Portugal is an experimental approach demonstrating how payments to farmers based on indicators of habitat quality such as carbon farming practices could help to achieve the obligations of the Nature Directives while delivering positive climate benefits (see box text).

**Payment for environmental results in the Portuguese Montado,** https://www.rbpnetwork.eu/country-infos/portugal/montado-produzir-e-conservar-payment-for-environmental-results-in-the-portuguese-montado-43/

*Montado* is a traditional agroforestry system combining oak trees with natural or semi-natural pasture and extensive grazing, which represents approximately 4 million hectares of farmland. Some of these habitats are protected under Natura 2000 legislation but are threatened by inappropriate management.

In the Central Alentejo region of southern Portugal an innovative pilot project is under development that aims to reward farmers for improvements in the conservation of the ecosystem through result-based payments for a set of 11 verifiable indicators of healthy and functional soils; oak tree regeneration; and Mediterranean biodiverse pasture. The indicators are being field tested.

Finally, the Nature Directives can have implications for carbon farming in terms of research funding. The LIFE programme, has supported thousands of exemplary biodiversity restoration projects for conservation of Natura habitats and species across Member States, supporting carbon farming (EASME, 2020).

### 5.2.2. Implementation of the EU Nature Restoration Plan

The BDS announced the creation an EU Nature Restoration Plan aiming to restore degraded ecosystems by 2030. This plan will include a proposal for legally binding nature restoration targets which should prioritise the restoration of ecosystems with the highest potential to capture carbon, as well to deliver further benefits, such as hazard risk mitigation, soil health and pollination. The European Commission is planning to publish its proposal for the EU nature restoration targets on December 14th, 2021.

[39] Based on the total number of habitat assessments (56 assessments of bog, mire and fen habitat types).

[40] Habitat types 6310 dehesa (and montado) (in Mediterranean biogeographical region), 6530 Fennoscandian wooded meadows (in boreal and continental biogeographical regions), 9070 wooded pastures (in alpine, boreal and continental biogeographical regions).

Carbon farming and habitat restoration should address the climate and biodiversity crises in an integrated way as these are intrinsically linked (COWI, Ecologic Institute and IEEP, 2021). Indeed, carbon farming schemes can achieve win-win solutions for climate and biodiversity through the restoration of habitats because restoration re-establishes the natural carbon storage and long-term sequestration capacities of degraded habitats.

Several key carbon farming practices can achieve benefits for both climate and biodiversity through ecosystem restoration:

- **Carbon farming on peatlands** includes actions to rewet and restore drained peatlands, and to improve their management. Healthy, wet peatlands are some the most important ecosystems in terms of climate benefits due to their exceptionally high carbon storage capacities. Their restoration is therefore closely aligned with the EU Nature Restoration Plan's aim to restore significant areas of degraded and carbon-rich ecosystems by 2030. In addition, the rewetting and restoration of peatlands can contribute to hazard risk mitigation through increased water retention and reduced run-off. Nature restoration targets also aim to restore habitats and species showing a deterioration in conservation trends and status (European Commission, 2020b). Peatlands are home to several unique and specialised plant, animal, and microbial species many of which are currently threatened. EU peatlands have been historically drained for agriculture and continue to face important pressures, especially ploughing. Around 30% of Annex 1 peatland area in the EU is probably degraded and in need of restoration and, according to the European Red List of Habitats, 85% of peatland habitat types are threatened (Janssen et al., 2016). [41]

- **Carbon farming on mineral soils** includes measures to enhance SOC on mineral soils under cropland and grassland. Increasing SOC can directly contribute to biodiversity restoration as healthy SOC levels are needed for the biochemical processes which underpin life both underground and above ground. Moreover, high agricultural biodiversity can in turn enhance SOC accumulation. Soil health and biodiversity are clearly tightly linked, as reflected in the BDS, which announced the proposal in 2021 for a new soil strategy to address soil degradation in Europe. In fact, the EU Nature Restoration Plan will be a key part of this strategy as it is expected to include soil restoration targets to protect soil fertility, reduce soil erosion and increase SOC (European Commission, 2020b). Carbon farming can therefore directly contribute to this and could be used to implement national restoration plans, which Member States will be expected to draft by 2023. In addition, co-benefits of carbon farming measures can indirectly contribute to farmland biodiversity restoration. For example, cover cropping, improved crop rotations, and landscape features can restore cropland biodiversity, and the restoration of permanent grassland can provide valuable habitats for endangered species. Finally, carbon farming can reduce pressures on biodiversity. SOC enhances nutrient availability, soil structure and water retention leading to higher productivity and, as a result, decreased need for fertilisers. In addition, carbon farming on mineral soil can achieve the hazard risk mitigation objectives of the EU nature restoration law through increased water retention and reduced run-off and decreased erosion risk.

- **Agroforestry**: In drier EU climates, the restoration of long-established agroforestry carbon farming systems (e.g., the *dehesa* and m*ontado* of the Iberian Peninsula) would help to achieve the Nature Restoration Plan's aim of restoring degraded ecosystems with high potential to

[41] This calculation is based on Member State habitat condition reporting under Article 17 of the Habitats Directive, applying the methodology in Romao et al (2020).

capture and store carbon. New agroforestry systems can create important farmland habitat which can support key species. In fact, the EU BDS highlights the potential of agroforestry to deliver for biodiversity.

**Risks of carbon farming for Nature Restoration Plan**

While carbon farming actions can deliver huge win-wins for biodiversity, they can also pose significant risks to biodiversity if impacts are not carefully considered at the planning stage. Carbon farming measures must be designed, targeted and implemented in a way that ensures they also achieve biodiversity outcomes. This includes:

- **Monitoring biodiversity impacts**: To ensure biodiversity objectives are achieved alongside carbon removal and avoidance of or reduction in GHG emissions, biodiversity outcomes should be monitored and reported, as well as climate outcomes.
- **Considering local context**: Biodiversity conservation needs are highly location-specific (no one-size-fits-all), so carbon farming initiatives should be tailored to local contexts. For example, landscape features such as wildflower strips and hedges can increase carbon sequestration no matter where they are, yet their spatial location can lead to very different outcomes for small invertebrates which need well-connected habitats. Similarly, considering the location of restored sites within the broader ecological landscape can enhance their biodiversity value if they increase connectivity. In some cases, ecosystems adjacent to restoration sites can also determine biodiversity outcomes. For example, carbon farming on grassland may achieve better biodiversity outcomes if adjacent to an existing species-rich grassland that can act as a seed source.
- **Excluding mitigation measures harmful to biodiversity**: Some practices which enhance carbon in ecosystems can lead to poor biodiversity outcomes. For example, adding external organic material, such as biochar and municipal waste, can increase soil carbon, but can lead to habitat contamination. Planting trees can also lead to negative biodiversity impacts if they are not in the 'right place', e.g., on peatland or on species-rich grassland. Choices of tree species for agroforestry, or of wildflower and shrub species for landscape features can also have adverse biodiversity impacts if these are non-native species which can threaten native ones. Similarly, intensification of species-rich grasslands to increase biomass/SOC can damage both the habitat and the species that depend on it.

## 5.3. EU Common Agricultural Policy

In section 4.2., we discussed the carbon farming baseline requirements and the types of funding that could be available to farmers and landowners under both Pillars of the CAP 2023-27, pointing out that whether or not these payments will actually be available to farmers is down to individual Member States' decisions. Here we focus on the key points in decision-making and progress-tracking of the Member States' 28 CAP Strategic Plans 2023-27[42] (now being drafted) that will determine the specific carbon-farming requirements and payments for farmers in each EU country.

[42] 26 national CAP Strategic Plans and 2 regional plans for Belgium.

### 5.3.1. The new CAP delivery model for 2023-27

One of the main features of the post-2020 CAP is the shift to a 'new delivery model', which is supposed to move the entire CAP towards a performance-based approach. This reflects the existing approach to the EARFD rural development co-financing under 'Pillar 2', where Member States had to programme different measures according to EU-set objectives. In the new CAP, Pillar 1 is also brought into this 'programming', meaning that Member States will also have to justify, and receive the European Commission's approval on, their EAGF-funded interventions. Each Member State will submit their proposals for EAGF and EAFRD spending and choice of interventions in a single 'CAP Strategic Plan' (CSP).

**Carbon farming in the Farm to Fork Strategy**

Launched in May 2020, the Farm to Fork Strategy aims to accelerate the transition to a fair, healthy and environmental-friendly EU food system. It proposes quantitative but non-legally binding targets for 2030 in some key areas, including pesticide and fertiliser use, sales of antimicrobials as well as organic farming. 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 ecoschemes under the 2023-2027 CAP as a key source of funding for carbon farming and other sustainable land use and management practices.

Whilst there is no legally binding reference in the CAP to delivering on the quantitative targets of the Farm to Fork and Biodiversity Strategies, the environmental objectives of the CAP are supposed to ensure delivery on these Strategies. Well-designed support for carbon farming provides Member States with opportunities to leverage CAP finance to do this, for example helping to achieve both favourable conservation status and long-lasting carbon benefits on peatlands, wetlands, and agroforestry systems.

Each Member State must include a 'needs assessment' as part of their CSP, and the European Commission has already made recommendations to Member States on the issues that they should address in this assessment, with a focus on those linked to the Strategies' targets. The needs assessments (and the CSP as a whole) will be subject to approval by the European Commission.

The CAP has an explicit objective to deliver on climate: '*contribute to climate change mitigation and adaptation, including by reducing greenhouse gas emissions and enhancing carbon sequestration…"* (European Parliament, 2021c) However, Member States also have to decide how to deploy CAP interventions and allocate budgets relative to the eight other specific CAP objectives.

Under the new CAP's Performance Framework, each CSP must include uptake targets set by the Member State according to a suite of 'result indicators' that relate to the delivery of the nine EU level objectives, of which three objectives relate to the climate and environment (it is important to note that in this CAP context the term 'result indicators' has a different meaning from the term used in market-based or action-based payments to farmers discussed in section 3.1.1.). Each Member State will be assessed over the course of the CAP cycle on their delivery on these uptake targets. If Member States fall short of their targets by more than a certain amount it can trigger a process that can culminate in an action plan, and, ultimately, affect their EAGF or EAFRD payments.

The 'result indicators' that relate to the CAP climate objective include: the share of total livestock under support to reduce emissions; the agricultural area under commitments to reduce emissions from soils or enhance carbon storage in soils and biomass; the agricultural area under commitments to improve adaptation, supported investments in renewable energy production, including bio-based; share of farms benefitting from climate-related investment support; the area under CAP support for afforestation, agroforestry and restoration and total investment to improve the performance of the forestry sector (European Parliament, 2021c). Targets will also need to be set under some of the other eight objectives that may indirectly support carbon farming, for example area under commitments to improve soils (such as reduced tillage), or area under commitments to improve nutrient management.

Finally, in the CAP's performance framework there are also impact indicators that relate to carbon farming, including the level of soil organic carbon in agricultural land and GHG emissions from agriculture. Data to measure these are expected to come from established data sources, such as the Farm Accountancy Data Network and Eurostat. Whilst there is no direct link between impact indicators and the penalties for Member States, they will play a role in the approval process as Member States will have to justify how their plans provide increased ambition in relation to the climate and environment with reference to the impact indicators.

### 5.3.2. Member States' choices on how to support carbon farming in their CSPs

There is no specific minimum amount (ringfencing) that Member States must put towards climate or carbon farming schemes, given that the ringfencing for eco-schemes in the EAGF and environmental payments in the EAFRD cover both environment and climate spending. It is also unclear if the expected contribution of 40% of the CAP budget will in practice lead to Member States funding climate schemes or propose adequate conditionality GAEC standards for climate, because there is an automatic 40% marker on Pillar 1 direct payments. There is a risk Member States CSPs will not be strong enough to secure adequate climate action to justify this 40% climate label for the CAP. Indeed, this has been the experience with the current CAP, where various analyses have concluded that the European Commission's claim that 20% of the CAP constitutes climate spending is not justified due to requirements being too weak[43]. Moreover, the European Commission has doubled the amount that the CAP is claimed to contribute to climate action, from 20% to 40%. This was based on the 'enhanced conditionality' requirements (see Table 5 for details), however, given that the requirements are still to be set by Member States, who also arguably introduced potential loopholes in the co-decision process, this has also been questioned, including in analyses by the IEEP.[44]

On the other hand, the flexibility afforded to Member States, and the Commission's role in the approval of their CSPs, means that significant support could be given to farmers and other land managers for carbon farming through the CAP – provided the Member States choose to do so. Therefore, to justify the 40% marker, Member States should include stronger requirements in their farm-level standards for conditionality and the voluntary measures listed in section 4.2.2., corresponding to each Member States' needs regarding protecting carbon rich soils, existing agroforestry and woody features and avoiding or reducing farming GHG emissions. Of these by far the most important to achieve EU climate targets in the 2023-27 CAP and beyond will be farm-level obligations and payments for climate-effective actions land and livestock management that also contribute to other CAP objectives, notably on biodiversity and water policy. In Table 6, we illustrate the best practice choices that MSs could make in their CSPs for the carbon farming actions that are the focus of this report (references are to the text of the CAP Strategic Plan regulation as adopted on 23 November 2021 in European Parliament (2021c).

[43] See for example the European Court of Auditors report on climate spending in the CAP (European Court of Auditors 2021).

[44] See for example Bas-Defossez, Hart and Mottershead (2020).

Table 6: Best practice carbon farming choices for Member States' CSPs 2023-27

| CSP decision point | Best practice choices for effective carbon farming support |
|---|---|
| Needs and Strength, Weakness, Opportunity, Threat (SWOT) assessment | Identify specific carbon farming needs and opportunities to achieve the CAP climate objectives in the Member State's different farming systems, soil types and land cover (including drained peatland and existing agroforestry systems).<br><br>Identify, for each of these different contexts and farming systems a 'long-list' of the most effective, evidence-based, carbon farming practices and where these should be targeted.<br><br>Refine the list by identifying the other environmental co-benefits (and risks) of each these practices and target locations (e.g., for biodiversity, soil quality, water quality, flood risk management), and rejecting any which lack co-benefits or pose a risk. |
| Intervention strategy | Detail how the short-list of carbon farming practices are to be addressed through four integrated 'packages' of CAP interventions for peatland restoration and rewetting, agroforestry, managing SOC on mineral soils and livestock and manure management. Each package should make coherent financial sense for individual farmers and be built up from the following elements, each underpinning or complementing the next:<br><br>• eligibility definitions for EAGF payments for 'agricultural activity' and 'agricultural area' to include paludiculture agroforestry, and pastures which form part of established local practices and/or where grasses and other herbaceous forage are traditionally not predominant or absent in grazing areas.<br>• clearly specified GAEC conditionality requirements aimed at raising baseline standards for carbon farming (see section 4.2.2. for relevant GAEC standards). Conditionality standards must 'take into account, where relevant, the specific characteristics of the areas concerned, including soil and climatic condition, existing farming systems, farming practices…'. In effect, these standards set the baseline requirements for further CAP-funded carbon farming actions but, as experience of previous CAP implementation has shown, the level at which Member States set these requirements may not be optimum for an effective baseline.<br>• EAGF eco-schemes in the form of an annual top-up to basic income support for: existing agroforestry systems, for other farming systems proportional to the average density/ha of woody or wetland landscape features on the farm (above a minimum threshold); for paludiculture and other restored peatlands/wetlands; for permanent grasslands which are never ploughed or cultivated outside Natura 2000 sites.<br>• EAGF sectoral support for paludiculture on rewetted peatland, as a 'non-food crop used for the production of products that have the potential to substitute fossil fuels.'<br>• EAFRD investment aid to cover the initial costs of the switch to carbon farming (e.g., blocking drains to rewet peatland, restoration of low-intensity traditional agroforestry systems under threat and creation of new agroforestry systems, converting arable land to permanent grassland).<br>• EAFRD compensation payments/ha for Natura 2000 disadvantages on peatland and wetland, and action-based environmental land management contracts for implementation of relevant carbon farming practices.<br>• EAFRD funded up-to-date technical advice on needs/benefits of carbon farming and also more specialised advice and training services (public and private). |

| CSP decision point | Best practice choices for effective carbon farming support |
|---|---|
| | • EAFRD support for innovative and pilot projects for carbon farming, bringing together farmers, advisors, researchers, enterprises or non-governmental organisations in European Innovation Partnership Operational Groups and/or LEADER initiatives. |
| Increased ambition for climate | Set ambitious targets and milestones for climate result indicators to be achieved by the end of the CSP implementation period. |

Source: Own compilation based on COWI, Ecologic Institute and IEEP (2021a).

### 5.3.3. Other CAP support for trans-national sharing of best practices and innovation in carbon farming

At EU level the EAFRD supports two important 'umbrella' networks that could assist the transition to the widespread uptake of CAP support for carbon farming that is needed to deliver EU climate objectives for the AFOLU sector. These are the new ENRD Contact Point (which will change its name to CAP Network under the 2023-2027 CAP), and EIP-AGRI. Both work on the basis annual thematic programmes approved by DG AGRI, and these could offer clear opportunities to support and encourage Member States to upscale carbon farming.

# 6. CONCLUSIONS AND RECOMMENDATIONS

1. **As a management practice, carbon farming offers significant potential in Europe to mitigate climate change and deliver other benefits. Promoting the widescale implementation of agricultural climate mitigation should be a European priority.**

   - There is some uncertainty about the EU-wide potential of agricultural climate mitigation; it is important that the realistic feasible potential of carbon farming is not overstated so as not to stifle ambition in other sectors. More regionally specific research into mitigation potential that addresses sources of uncertainty in these estimates would allow development of more targeted, and ultimately more effective, policy responses.

   - All farming operations have some ability to mitigate climate change, though the potential differs widely across farm types and regions. In addition to classical on-farm mitigation activities (e.g., more efficient fertiliser use), carbon farming involves more systemic shifts, including land-use change and shifts in type and location of production. Carbon farming should be accompanied by demand-side changes, including dietary shifts away from emissions intensive foods such as meat and dairy, and reduced food waste.

2. **Carbon farming has the potential to deliver significant societal co-benefits (including biodiversity, soil health, water quality, and others). Poorly implemented carbon farming, however, runs the risk of negatively impacting other societal objectives.**

   - Carbon farming can deliver co-benefits for farmers and society. For example, actions that increase soil carbon storage provide adaptation and productivity benefits for farmers, as well as biodiversity conservation and water storage and quality benefits to society. However, this is not true of all carbon farming actions, some of which pose risks other societal objectives such as biodiversity conservation or water availability.

   - Any carbon farming policies or mechanisms must develop sufficient safeguards to protect against negative impacts, monitor the impact of carbon farming on climate and other objectives, and design incentives to encourage carbon farming actions that maximise multiple societal benefits.

   - To facilitate this, it is important that monitoring and certification capture and reward non-mitigation impacts.

   - Co-benefits such as decreased costs, increased productivity or higher revenues can be a significant selling point for farmers.

3. **Carbon farming mitigation must be permanent. Impermanent mitigation offers little benefit for the climate.**

   - Existing carbon stocks (in soil carbon, agroforestry, non-degraded peatlands) must be protected. These non-degraded ecosystems also provide high biodiversity benefits. Regulations to protect existing carbon stocks and increased CAP cross-compliance requirements could be effective.

   - Mitigation through sequestration (in soil, trees and other biomass) is at significant risk of being either reversed, either intentionally through management change or unintentionally e.g., due to climate change impacts. Carbon farming mechanisms must carefully manage this risk.

4. **Incentivising carbon farming can be done through many different models and payment structures. The different opportunities and risks should be carefully considered when designing and scaling up payments.**
   - The Common Agricultural Policy is the most significant source of funding for climate action in the EU agriculture, however, research shows that it has had limited impact on agricultural emissions (European Court of Auditors, 2021; Alliance Environnement, 2019). The 2023-2027 CAP offers a number of options to help increase carbon farming uptake but impacts on the ground will largely depend on how Member States use the high degree of flexibility given to them throughout the design and implementation of the relevant interventions. In addition to new carbon farming incentives, there is a need to identify and reduce counterproductive CAP subsidies that increase agricultural emissions.
   - Payments within agricultural supply chains offer some potential to implement carbon farming. However, to guard against the potential for "greenwashing" it is crucial to ensure high levels of transparency, use of proven methodologies, and regulating of corporate claims.
   - Voluntary carbon markets could facilitate private financing for carbon farming, though their relatively high MRV costs pose a significant barrier to widespread uptake and needs careful assessment of risks and effectiveness and robust certification before scaling up.
   - Using carbon farming to offset mitigation in other sectors poses significant risks. This is due to relatively high MRV uncertainty, impermanence concerns, and difficulty ensuring that removals are additional.
5. **There is a need for further development of carbon farming monitoring methods, and increased practical experience, and improved assessments of carbon farming potential to increase knowledge and reduce barriers to carbon farming uptake.**
   - A key cross-cutting challenge for carbon farming is measuring the mitigation impact of carbon farming actions at low-cost. The development of new methods and tools should be a priority to enable widescale uptake of carbon farming.
   - Carbon farming MRV must capture the full impact on the climate by considering all relevant GHGs and carbon stores, and by monitoring carbon leakage impacts. Failing to monitor whole-farm and system impacts of carbon farming poses the risk of perverse outcomes. Monitoring must also consider non-mitigation impacts.
   - Carbon farming often involves new skills and knowledge. Farmers and administrators should be supported to develop and exchange these skills.
   - Piloting and gathering and sharing practical experience with carbon farming will be essential to develop robust, cost-effective policies with high farmer uptake.
   - To improve policy design, integrated assessments of carbon farming mitigation potential at regional scale should be developed that consider together all carbon farming mitigation options and interactions, while also considering how to optimise climate and other co-benefits.
6. **The EU climate policy, including the Fit for 55 package, should provide clear incentives for carbon farming actions addressing agricultural non-CO2 emissions. Specifically:**
   - Avoiding and reducing GHG emissions should be the first and main priority of climate mitigation efforts in the land use sectors. This avoidance and reduction of emissions first

principle should be reflected in the carbon farming initiative. In particular, this requires that non-CO2 emissions are in the scope of the initiative.

- Setting a quantified GHG emission reduction target for agriculture could help reduce the risk that Member States rely extensively on removals to meet net targets. This is especially important in the context of a combined agriculture and LULUCF sector (AFOLU) foreseen after 2030.
- The development of a robust, transparent and science-based certification system for carbon removals is essential to ensure the environmental integrity of the EU carbon farming initiative and the wider climate policy regime.

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Carbon farming refers to sequestering and storing carbon and/or reducing greenhouse gas emissions at farm level. It offers significant but uncertain mitigation potential in the EU, can deliver co-benefits to farmers and society, but also carries risks that need to be managed. The report identifies opportunities and constraints for carbon farming, options for financing, and open questions that need to be resolved to scale up carbon farming in a way that delivers robust climate mitigation and European Union Green Deal objectives.

This document was provided by the Policy Department for Economic, Scientific and Quality of Life Policies at the request of the committee on at the request of the committee on Committee on Environment, Public Health and Food Safety (ENVI)

PE 695.482
IP/A/ENVI/2021-11

Print ISBN 978-92-846-8750-3 | doi: 10.2861/78289 | QA-07-21-096-EN-C
PDF ISBN 978-92-846-8751-0 | doi: 10.2861/099822 | QA-07-21-096-EN-N