CARBON FARMING SCHEME

LIFE Preparatory Project

Incentive scheme to encourage foresters and farmers to adopt agricultural practices enforcing removal of CO_2 from the atmosphere

LIFE19 PRE FI001 – SI2.828588
The Life Carbon Farming project has received funding from the LIFE Programme of the European Union

Expanding carbon sequestration activities by providing best practices and guidance for future farming schemes

The goal of the project is to identify and accelerate the development and adoption of novel incentives for carbon sequestration and the increase and maintenance of the organic carbon stock in soil and biomass in Europe. With the aim of promoting a well-functioning voluntary carbon market the project will uncover the key factors in supply and demand measures to invite the private sector to accelerate climate action. The results of the project will be fed into the development of the EU agricultural and climate policies.

Read more: www.st1.com/st1-life

Coordinator: st1

Partners: BSAG Baltic Sea Action Group, Tyynelän tila, Luke Natural Resources Institute Finland, puro·earth, NEOT North European Oil Trade

Financed by:

LIFE19 PRE FI001 – SI2.828588
The Life Carbon Farming project has received funding from the LIFE Programme of the European Union

Incentive scheme to encourage foresters and farmers to adopt agricultural practices enforcing removal of CO2 from the atmosphere by North European Oil Trade (NEOT).

Published 1.10.2021.

LIFE CarbonFarmingScheme 30/06/2021

Project Data

Project number: LIFE19 PRE FI/001 – SI2.828588
Project start date: 14/05/2020
Project end date: 13/05/2022
Total Project duration: 24 months
Project Website: https://www.st1.com/st1-life

Beneficiary Data

Beneficiary: North European Oil Trade Oy
Contact person: Aino Siirala
Postal address: PL 55, 00088 S Group
E-mail aino.siirala@neot.fi

Contents

Definitions

Carbon farming and carbon forestry

Nature-based practices performed in agriculture or forestry in order to sequester greenhouse gases from the atmosphere.

Compliance carbon market

System where a company can use carbon credits as mechanism that contributes to reaching legally binding climate targets

CRC

Carbon removal credit. A credit covering one ton of CO2e removed from the atmosphere and stored.

Voluntary carbon market

Market where parties such as companies and private persons can voluntarily offset their emissions by buying carbon credits. In a voluntary market carbon credits cannot be used to fulfil legally binding climate targets.

1. Introduction

The current climate change mitigation actions are insufficient to achieve the 1.5-degree target. According to European Commission's Strategy on Adaptation to Climate Change "Even stopping all greenhouse gas emissions would not prevent the climate impacts that are already occurring, which are likely to continue for decades" (EC 2021).

As the current climate commitments and targets cannot be achieved by only focusing on emission reductions, the potential of negative emissions must be tapped (IPCC 2018 & EC 2020a). Unlike many of the currently used means to reduce emissions, negative emissions are scalable solutions. Emission reductions will be of utmost importance also in the future but reaching ambitious climate targets requires also taking full advantage of negative emissions from both nature-based solutions and carbon capture and utilization (CCU).

To be able to create carbon sinks in the future, we need to start investing to their development and creation already now. Adequate funding is needed to incentivize the initial investment farmers and foresters need to make to undertake carbon farming and carbon forestry practices.

With a carbon removal credit market, we are able to create demand for carbon sinks and flow private money to the agriculture and forestry sectors. A compliance market where companies can use carbon removal credits to fulfil some of their climate targets assures stable demand and investment flow for carbon sinks.

This report outlines an approach for building an incentive scheme for nature-based carbon removals to rapidly scale up nature-based carbon sequestration.

We use biofuel sector as an example in few occasions in this report to show how issues such as sustainability, monitoring, reporting and verification is ensured in the biofuel legislation and markets. We chose biofuels in road transport as the case example as we operate in the road transport sector and know well the sectors' current climate regulation, practices, and market.

This report is produced as a part of LIFE preparatory project LIFE CarbonFarmingScheme "Expanding carbon sequestration activities by providing best practices and guidance for future carbon farming schemes" -project. The project aims to identify factors and incentives that can direct private sectors' investments to carbon sequestration actions, where the project focuses on the demand from sectors mandated to GHG reductions. Also, the project conducts a pilot on actual carbon farming activities to gain understanding of onboarding of farmers and foresters and of incentives needed for carbon sequestration activities. As a final report of the project, we present guidance of regulatory and policy aspects towards implementation of an incentive scheme.

2. Carbon removal credit value chain

In this section the value chain of carbon removal credits (CRC) is introduced as we understand it. Each part of the value chain presented in Figure 1 are explained in more detail, and references to sections with more discussion on the topic are made.

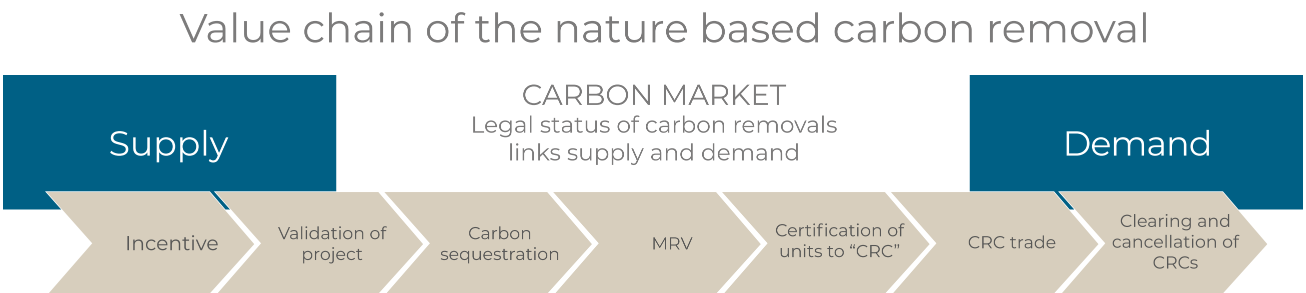


Figure 1 Value chain of nature-based carbon removal credits

Incentive

A key factor for both the farmer and forest owner is the availability of adequate funding for carbon sequestration activities. Funding can come either from public or private sources. It can be based either on actions taken or the amount of carbon sequestrated. It is also possible to implement different combinations in terms of both funding sources and funding criteria. Funding for both different sources and methods is presented in section 5. It is also essential that operators have sufficient reliable information on the various carbon sequestration methods and sources and forms of funding.

Validation of project

If CRCs are used to substitute emission reductions, we should ensure that the climate impact resulting from the CRCs is at minimum equivalent to the actual emission reductions in order not to increase the overall net emissions. However, if the aim is to support the increase of carbon sinks and not substitute emission reductions, the requirements for CRCs do not necessarily need to be as high regarding all criteria. To ensure set criteria are met, projects need to be validated. Carbon related criteria are for example additionality of the project (financial, environmental, and legal), permanence of the sink and carbon leakage. Carbon farming and forestry may also have other indirect favourable or inconvenient effects. Therefore, other ecological impacts such as biodiversity and social impacts (such as economic development and human rights) must be validated. These aspects are addressed in section 7.

Carbon sequestration

The range of methods of carbon sequestration to both soil and forests is very wide. The cost of biological carbon sequestration also varies on a large scale. In addition, the difference between project duration of carbon sequestration actions varies from measure to measure. Different methods costs and duration are outlined in sections 3 and 4.

MRV

Monitoring, reporting and verification (MRV) is an important part of the value chain of CRC especially when carbon farming projects receive result-based funding and CRCs are sold in a marketplace. Monitoring of carbon sinks refers to measuring or modelling the amount of carbon sequestered. Reporting of carbon sinks refers to reporting of the values related to the quantity and quality of the carbon sink, obtained in the monitoring phase. Verification of carbon sinks refers to verifying the validity of the values to be reported. MRV is discussed in section 8.

Certification of units to CRC

After MRV examination, the approved carbon sink units are entered in the CRC register, which is used to take care of e.g., holding, transferring, cancelling, and deleting CRCs. The register also minimizes the possibility of double counting. In the voluntary market often each market place has its own registry system. If compliance CRC market is introduced in the EU, a public CRC register must be set up, like the one already exists in EU ETS. The EU ETS has previously addressed emission reduction units from CDM and JI projects, and the best practices obtained from this can be used to create a CRC register.

CRC trade

CRC-trading can take place in voluntary market or in compliance market. In a voluntary market, the buyer's motive may be, for example, the company's efforts to reduce its carbon footprint. Some companies have set themselves a carbon neutrality target, in the implementation of which CRCs are also used. In this report, a compliance market is defined as a system where a company can use carbon credits as mechanism that contributes to reaching legally binding climate targets. Examples of such systems can be found, although compliance CRC market is not yet in use on an EU-wide basis. Section 6 provides examples of how the system could be introduced in the EU.

Clearing and cancellation of CRCs

Once the CRCs have been exploited by the purchaser, they are cancelled and removed from the register.

3. Carbon Farming and Carbon Forestry

The range of methods of carbon sequestration to both soil and forests are wide. These methods are outlined in general in this section. The cost of biological carbon sequestration also varies on a large scale. In addition, the difference between project duration of carbon sequestration actions varies from measure to measure. In section 3.1 biochar is presented as an example of relatively rapid carbon sequestration. Similarly, in section 3.2 afforestation is given as an example of carbon sequestration over several decades.

The time difference between the realization of the costs of carbon capture measures and the actual carbon sequestration, and the revenue from it, is a significant factor for the investor, especially in the situations where a carbon sink is realized over the years and even decades. If the income takes place slowly after the investments, this may weaken the conditions to carry out the method. Therefore, financial systems should be designed to reduce and minimize this risk.

3.1. Carbon sinks and agriculture

According to World Bank (2012): "A range of practices has been suggested as important to soil carbon sequestration and thus of potential relevance to increasing crop yield, increasing the resilience of agroecosystems, and mitigating GHG emissions. Mitigation of GHG in agriculture can involve several practices such as avoiding the conversion of native forests and grasslands to croplands; enhancing removal of carbon from the atmosphere through a range of soil and water management practices including crop diversification; restoration of barren, abandoned, or seriously degraded agricultural lands; and livestock and manure management. The impacts of changes in agricultural practices on soil carbon stocks such as changes to crop rotation or reduced grazing are usually more subtle than those brought about by more dramatic changes in land use such as conversion of cropland to forest or grassland to tree crops."

World Bank (2012) has identified, for example, the following methods for carbon sequestration to grassland and cropland soils:

- Application of fertilizers and manure to stimulate biomass production

Grassland:

- Improved grassland management
- Introduction of improved pasture species and legumes
- Establishment of pasture on degraded land

Cropland:

- No or reduced tillage
- Mulching/residue management
- Use of cover crops/green manure
- Use of improved crop varieties
- Agroforestry/tree-crop farming
- Application of biochar and other soil amendments

Biochar can be considered as an example of a fast way to accumulate carbon in soil. According to Government of Western Australia (2021), ''Biochar is a stable, carbon-rich form of charcoal that can be added to soil to increase water and nutrient retention. It is produced by pyrolysis, a process where biomass (plant or animal waste) is heated at temperatures greater than 250°C with little or no oxygen. Biochar can reduce carbon dioxide (CO2) released to the atmosphere because pyrolysis traps the carbon in the biochar, which otherwise would be released through decomposition or burning of plant material. Biochar is stable in soils and, depending on the type of source material, can remain in soils for hundreds to thousands of years''. If only the action of adding biochar to the soil is considered, biochar is a relatively fast way to sequester carbon compared to, for example, the growth rate of sinks in afforestation (Section 3.2).

3.2. Carbon sinks and forests

The main categories regarding forest biological sinks are afforestation, reforestation, and deforestation. According to IPCC (2000) "There are several approaches to define these terms. One approach involves the concept of land-use change. Deforestation can be defined as the conversion of forest land to non-forest land. Reforestation and afforestation can be defined as the conversion of non-forested lands to forests with the only difference being the length of time during which the land was without forests''.

World Bank (2021) has defined different categories of forest biological sinks increasing in the following way:

Afforestation/Reforestation (A/R):
Activities to establish forest on land that has been under another land use for some period, through plantation, seeding, assisted natural revegetation, etc. This includes commercial plantations for timber or other products, smaller-scale activities such as community forestry projects and agro-forestry, and A/R on degraded lands as part of soil, water and ecosystem restoration and improved management. Broadly speaking, afforestation refers to the conversion to forest of land that has not been forested for a relatively long period of time (e.g., 50 years under the Kyoto Protocol) while Reforestation refers to the establishment of forest on

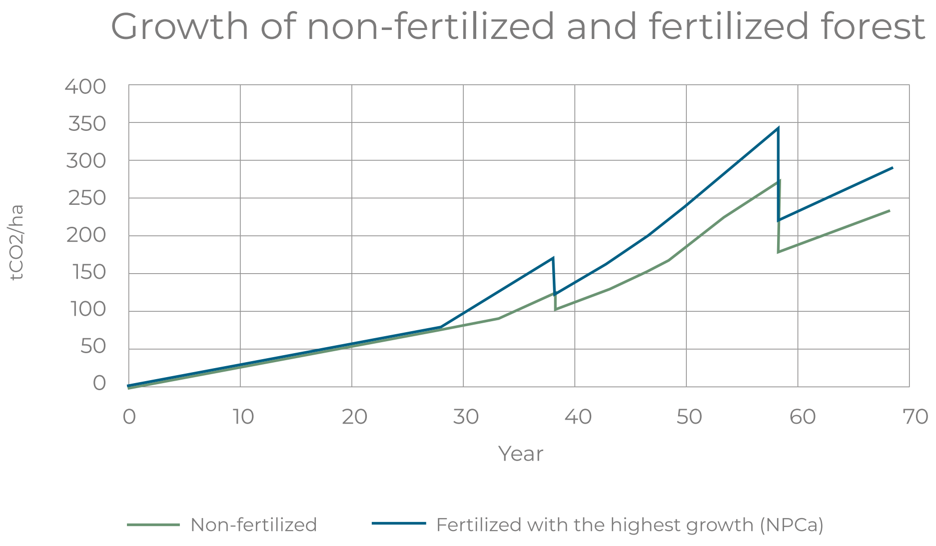
land that was forested but that has been converted to non-forested land (e.g., on lands that did not contain forest on 31 December 1989 under the Kyoto Protocol).

Sustainable Forest Management:
Activities aiming at increasing carbon stocks within the forest perimeter and reduce the impact of forestry activities through improved forestry practices, such as Reduced Impact Logging (RIL), extension of rotation length, forest enrichment or forest protection (for forest being exploited for timber, fuelwood, or pulpwood extraction).

Forest Conservation:
Activities that relate to protection and restoration of natural areas (possibly larger that the forest area itself), including improve, maintain, and enforce protection of natural areas and prevent their conversion through measures providing alternative livelihoods to communities at risk (intensification of agriculture, diversification of agroforestry, reforestation, etc.).

Growing biological carbon sinks through afforestation is a long-term project. Its costs consist largely of planting trees and ensuring the conditions for their growth through the care of seedlings. The growth of trees and, with it, carbon sequestration, takes place slowly over decades (Figure 2). Forest growth can be accelerated by fertilizing. The effect time of fertilization is 8-10 years. In this case example, fertilization is carried out every fifth year.

Figure 2 Growth of non-fertilized and fertilized forest in Finland. The stands were thinned at the age of 37 and 58 years. (Natural resources Institute Finland).



3.3. Duration of carbon farming and carbon forestry projects

Duration in the agricultural sector is usually shorter than in the forest sector. In some cases, the carbon content of soil is increased almost immediately once the action has taken place. On the other hand, especially in the forestry sector, the carbon content of the trees and also soil increases year by year, and the total growing time of the trees can be several decades, even over 100 years. In the forest cases, the investments are mainly done in the beginning of the project, while the outcome, e.g., carbon sinks, are increased over a very long period.

According to I4CE (2019) ''duration of projects varies from 5 to 100 years depending on the activities implemented. For forestry projects, minimum duration is 30 years (Label Bas Carbone and Registro Huella de Carbono) and goes up to 100 years (Woodland Carbon Code). Duration for peatlands projects varies between 20 years and 50 years (Peatland Code, MoorFutures, EC 2020b) with the possibility of a 10-year duration if the peatland is used for agriculture in line with peatlands conservation.

Projects in the agricultural sector are shorter: sequestration in agricultural soils projects with the Kaindorg eco-region range from 7 to 10 years, while carbon farming projects under the Label Bas Carbone will last for a renewable 5-year term''.

3.4. Co-effects in carbon farming

COWI et al. (2021) describes the potential co-effects of carbon farming in the following way: ''The main target of Carbon farming is to increase biological carbon sinks, but it also can have co-effects. The positive co-benefits can be, for example, reduced soil erosion and nutrient leaching, improved soil functionality and water infiltration, diversified income streams for farm businesses, improved animal welfare (shade and shelter), pollination services and, in the case of long-established features and systems, the conservation of biodiversity and landscape character.

One example of a potentially negative impact is the potential to displace food production and disrupt food processing enterprises that could be associated with large-scale rewetting of highly productive drained peatlands''.

In nature based carbon sinks increasing in the forests one important question is the permanence of the sink. For the forest owners, the money from the timber sales is, in many cases, a major source of income. If carbon sequestration decreases possibilities for felling, the income from carbon forestry must cover the losses to make it sensible for the forest owners. On the other hand, if the carbon forestry hinders loggings in one place, and the timber-demand in bio-based industry does not change due to actions in one place, felling may increase in other places (carbon leakage, more details in section 7.1.4)

More on criteria such as biodiversity and social impacts in section 7.

4. Costs of carbon farming and carbon forestry

In this section we measure the cost structure of three different set of instruments to enhance carbon sequestration. The selected instruments fall under four different categories: soil improvements, forest fertilization and afforestation and reforestation. Cost structure of biochar is calculated and presented separately.

Calculation methodology is based on transaction cost theory and draws from the literature on transactions costs in agri-environmental support scheme (OECD 2007, Ollikainen et. al. 2008, Vatn et al. 2002). More detailed description of the theory and calculations can be found from Appendix 1. Based on the literature we estimate the design, implementation and monitoring costs of a particular instrument as a percentage of total instrument cost.

In addition, based on the data collected from different collaborators (Natural Resources Institute, Tyynelä farm) and operators (Green Carbon, South Pole, Puro, Soilfood), we estimate the system cost, and system cost range for each category of instruments analysed.

The costs incurred in similar policy schemes are often categorised as set-up costs, implementation costs and participation costs (OECD 2007, Ollikainen et al. 2008). These costs include research and information costs, design, enactment and evaluation, distribution and monitoring as well as participation costs, among others. Sub-categories of policy related transactions costs are described in Figure 3.

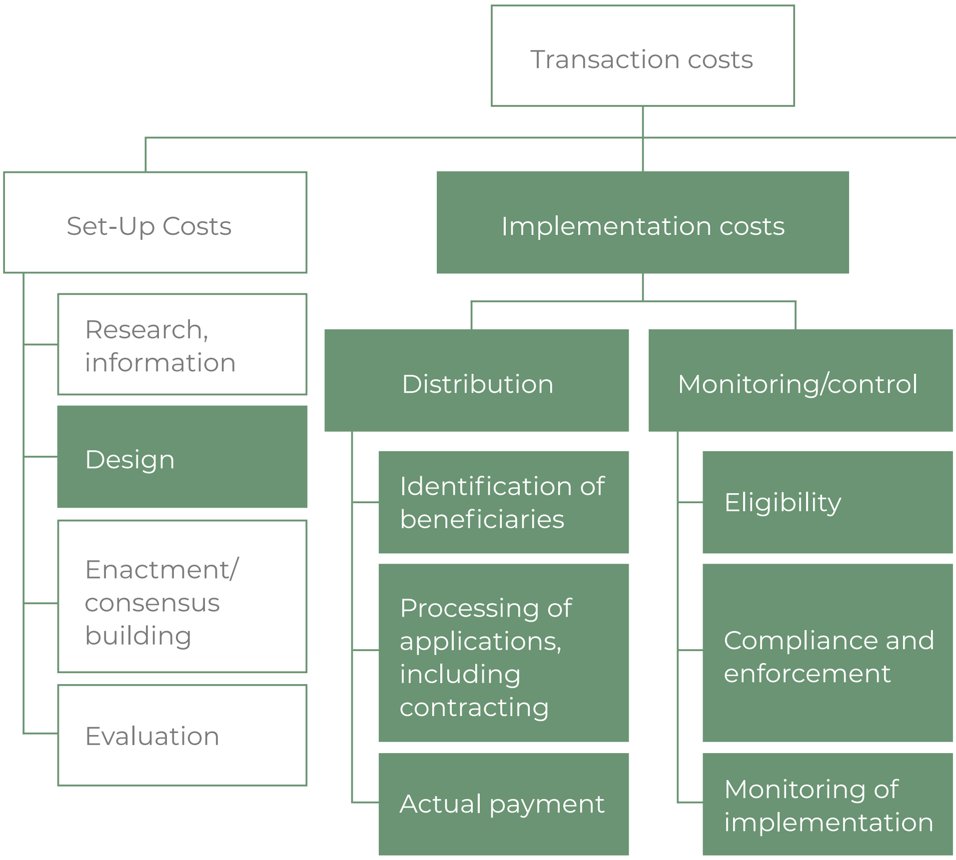


Figure 1. Policy related transaction cost in agri-environmental policies (Ollikainen et al. 2008, 197).

In carbon schemes also costs of trading, registering and clearance are often included. In our analysis we define the costs as instruments costs, per hectare costs and system costs:

1. Per hectare instruments cost – cost incurred on the implementation of the policy instruments. These costs are mainly paid by actor (farmer, forest owner) and they cover the costs of all raw materials, logistics, operation etc.

2. Per hectare transaction costs (TC) – the per hectare transaction costs are estimated design, implementation and monitoring costs as a proportion of instrument costs.

3. System costs – program-based costs stemming from validation, verification, register and trading. These costs occur regardless of the size of the project, and are assumed constant within the project period (20 years)

Table 1 Definition of the system costs

System costs

Validation	project validation
Verification	verification of credits
Register	registration fees (per estimated annual credits), annual registry fees, issuance fees
Trading	trading service fees

Table 2 Definition of the calculated transaction costs

Transaction costs

Design	Costs incurring from design and planning of the policy instrument, compensation scheme, monitoring and the overall operating system. Mainly research and administrative cost, and partly indirect.
Implementation	Costs incurring from targeting, instrument selection, defining beneficiaries and compensation mechanisms, contracting, among others.
Monitoring	Costs incurring from measuring eligibility, compliance, monitoring of implementation, reporting, and auditing

4.1. Results of the cost analysis

Our results show that the costs of different carbon sequestration instrument categories are high, and within the same annual cost range for a twenty-year program period. Annual total costs range from 10 000 € to 19 600 € and total costs 199 000 € to 393 000 €.

The relation between investment costs and running costs depend on the instrument. Differences stem mainly from investment costs, relating to the type of an instrument and especially on instrument cycle. For afforestation, costs incur mainly as a set-up cost, while forest fertilization incurs costs categorized as annual running cost. For zerofiber, cost incur every five years.

All system costs are project based. Thus, the costs of small projects are relatively higher. The increasing number of projects is unlikely to reduce costs, since all projects need to be validated and verified separately. Trading and registering may be linked to project size, but in our calculation assumed constant for all projects.

Estimated break-even CO_2 per tonne prices for each instrument at different transaction cost percentages are presented in Figure 4. Break-even price is defined as the minimum price of CO_2 tonne that covers the total per hectare instrument costs, given the estimated carbon sequestration per hectare.

Total instrument cost includes instrument cost and per hectare transaction costs as defined in the above section. With a 6 per cent transaction costs, the lowest break-even price is 19 €/ tCO_2 for afforestation and the highest 84 €/tCO_2 for peat land forest ash fertilization.

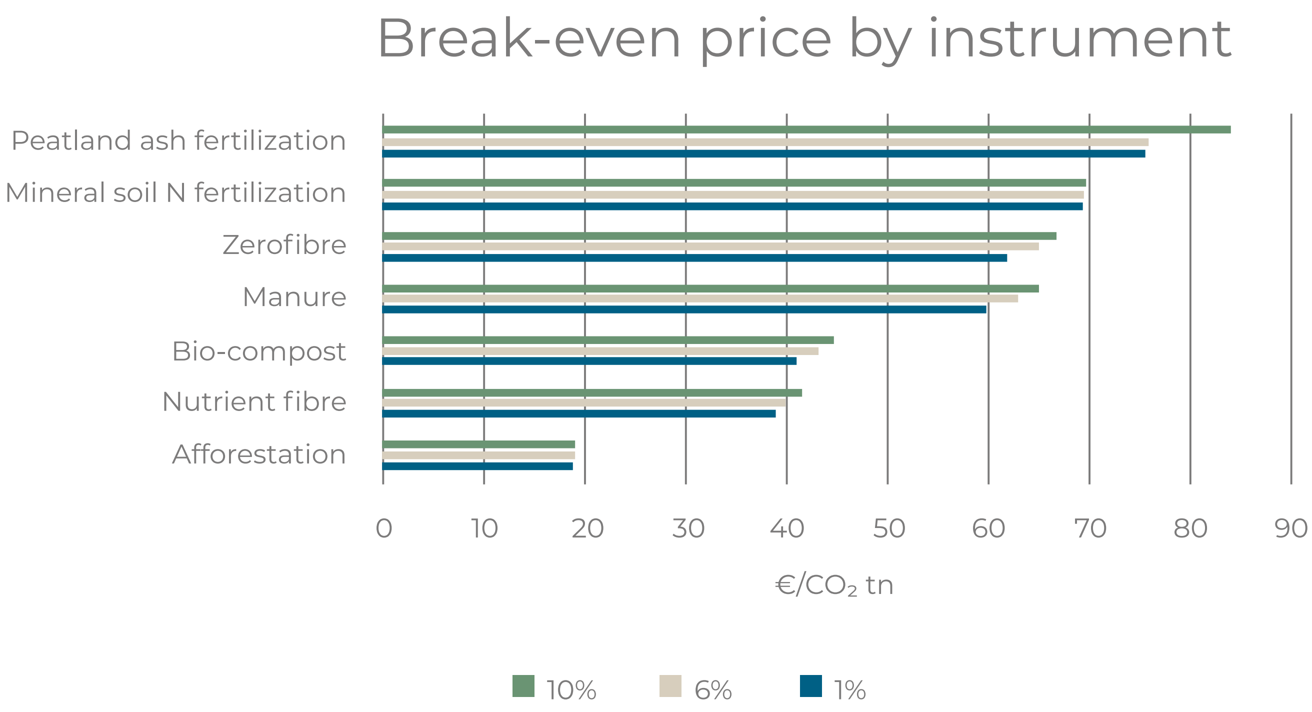


Figure 4 Break-even CO_2 price with different transaction cost percentages

While the system costs are relatively higher compared to instrument costs, economic incentives to enhance system investments are needed. For CO_2 prices per tonne to make return of investment with respect to system costs, requires relatively large initial hectares in the program. Even CO_2 per tonne price premiums have very limited role in returns to investment.

Threshold area is defined as the number of hectares per instrument, when the estimated value of carbon sequestration at break-even price plus a premium on 10 € is higher than the total costs of an instrument. Threshold areas are presented in Table 3.

For soil improvements, threshold area ranges from 149 hectares to 389 hectares, depending on the instrument. For forest fertilization similar range is from 106 hectares to 171 and for afforestation from 401 to 660 hectares, given the defined break-even prices for all instruments. This result indicates that the initial size of a project needs to be large enough to form any return of investment. In addition, the price of CO_2 per tonne is required to maintain at least its current ETS levels around 50 €/tCO_2 in order to make at least half of the analysed instruments profitable.

Table 3 Threshold areas required to cover system costs, with estimated break-even prices

Break-even price (€/tCO2)	Premium (€/ha)	Threshold area ha (min)	Threshold area ha (max)
Soil improvements			
39	10	235	389
45	10	209	347
53	10	183	303
67	10	149	248
Forest fertilization			
69	10	126	171
84	10	106	144
Afforestation			
19	10	401	660

Table 4 Summary table of system, total and annual costs, and lower and upper limits, of carbon sequestration scheme by category

	Validation of project	Cost of actions to enhance carbon sequestration	TC	System verification	Register	CRC trade	Total costs	Average annual cost
Organic soil improvement materials in agriculture	Simple: 60 000 € Complex: 120 000 €	192 €/ha - 887 €/ha	16 €/ha - 267 €/ha	40 000 € - 120 000 €	10 000 € - 20 000 €	120 000 €	230 208 € - 381 153 €	11 510 € - 19 058 €
Forest fertili-zation	Simple: 60 000 € Complex: 120 000 €	9 000 €/ha - 10 000 €/ha	90 €/ha - 1 000 €/ha	2 €/ha - 40 €/ha	10 000 € - 20 000€	120 000 €	199 092 € - 271 040 €	9 955 € - 13 552 €
Afforestation/ reforestation	Simple: 60 000 € Complex: 120 000 €	2 350 €/ha	23,5 €/ha - 235 €/ha	40 000 € - 120 000 €	10 000 € - 20 000 €	120 000 €	232 374 € - 382 585 €	11 619 € - 19 129 €

4.2. Policy implications

Our results indicate that building infrastructure to market-based carbon sequestration may require public investments. All support instruments should be based on the following guidelines to minimise market distortions and form an effective policy regime:

- fixed term with phase-out
- targeted on infrastructure and investments
- support levels defined on the cost-benefit basis
- result-based, not action based

The system costs of analysed instruments are relatively high compared to estimated returns. In addition, given the estimated break-even price levels and the current ETS CO2 price level, the instrument costs might be covered and yet form profit in the program period.

Research and innovation on validation and verification as well as design, implementation and monitoring, are required for infrastructure building. New innovations and measures could contribute to decreasing system costs and thus, to smaller initial set-up costs.

Investment support and grants targeted to setting up supply chains, especially outside the farm gate (e.g. machinery required, but not utilised in current operations), and to adaptation of required technology in verification and monitoring are needed.

Table 5 Recommended policy measures targeted to system costs

	R&D	Financial instruments (ERI, EIB)	Investment support (as a % of costs), e.g. CAP	Investment grants (fixed amount) e.g. CAP, Cohesion funds	Current direct payments (CAP)	Current agri-environmental support scheme (CAP)
System costs						
Validation	x	x	x			
Verification	x	x				
Register	x			x		
Trading	x					
Transaction costs						
design	x					
implementation	x		x	x		
monitoring	x		x	x		
Other						
Collaborating/ pooling						x

The estimated break-even CO_2 prices are partly within the current ETS price range. A floor or a guarantee price of CO_2 per tonne with price adjustment to reduce windfall would form an incentive to implement policy instruments and reduce price risks of both farmers and operators. The costs of the regime would depend on the carbon price development, and thus uncertain and unexpectable. This risk could be reduced with fixed term and fixed size of the program.

While the focus of the public support should be in infrastructure building and investments, there are some well justified reasons to target support directly on the instruments. Research and development are required to improve the understanding on the impact of different instruments, to find most effective solutions for cardon sequestration in different natural conditions and operational circumstances, among others. Also, new materials and methods need to be designed and analysed.

Investment support is justified when the instrument costs incur mainly on setting-up the instrument. In our analysis, this applies to afforestation. In addition, this is in line e.g. with the current agri-environmental support scheme, where selected environmental investments in general, and e.g. afforestation, are supported with lump-sum payments.

Table 6 Recommended policy measures targeted to instrument costs

	R&D	Financial instruments (ERI, EIB)	Investment support (as a % of costs), e.g. CAP	Investment grants (fixed amount) e.g. CAP, Cohesion funds	Current direct payments (CAP)	Current agri-environ-mental support scheme (CAP)
Instrument costs						
Organic soil improvement materials in agriculture	x					x
Forest fertilization	x					
Afforestation/ reforestation	x	x	x			x
Spreading of industrial bio-coal	x	x	x			x

4.3. Biochar costs

The costs of biochar as a carbon farming method were estimated in the similar way as for other carbon farming and carbon forestry methods in the above sections. However, the data for biochar was not comparable to other instruments. Biochar instrument costs are based on the costs of CO2 per tonne utilizing biochar in carbon sequestration, not on the actual spreading costs of biochar.

According to the calculations on the costs of biochar, the systems costs are high since most of the costs stem from investment costs. Over a 20-year period, the average hectare costs are mainly within the same range as in other instruments. There is low return to investment, but long-term impact.

Utilizable policy instruments for biochar could be investment support and research and innovation.

More detailed calculations and results on costs of biochar can be found in Appendix 2.

Table 7 System and total costs of biochar with a program period of 20 years

	Lower limit	Upper limit
Instrument cost (€/ha)	85 840	85 840
Validation cost (€)	60 000	120 000
System verification (€) (every 5-years)	40 000	120 000
Register (€)/annual	10 000	20 000
Trading (€)	120 000	120 000
Transaction cost (€/ha)	858	8 584
Total cost (€)	316 698	474 424
Average annual cost (€)	15 835	23 721

5. Funding

5.1. Funding sources

In this report we divide carbon farming and carbon forestry funding into two categories: public funding and private funding. With public funding we refer to funding or aid from the EU or state e.g., through Common Agricultural Policy (CAP), innovation funds, or other types of state aid for innovation. Private funding can mean any type of funding from the private sector (companies, private organisations, and consumers), and here we are assuming that money from private sector would flow to carbon farming and carbon forestry practises through a CRC market. In this report we are assessing both the public and private funding options as well as a combination of both.

5.1.1 Public funding in agriculture, CAP

The Common Agricultural Policy of the European Union is major sectoral policy having an impact on agricultural production and thus, on land use and the use of natural resources in the EU. In addition, it has major social impacts in remote and rural areas of the EU, especially in the relatively poorer regions. The CAP is still the only sector policy within the EU which is implemented in all the EU member countries under both the common regulation and common financing. The CAP covers around 32 per cent of the total budget spending in the Multiannual Financial Framework for the years 2021-2027.

The increasing emphasis on climate change mitigation and adaptation has fostered several policy processes in the EU. The EU Green Deal aims to form an umbrella to connect all sector policies towards a common target. Given the significant role of the CAP both in the use of natural resources and in the budget expenditures, it is evident that the Green Deal will increase pressure towards fundamental CAP reform in the future.

Expected changes in the future CAP

The European Commission presented legislative proposals on the common agricultural policy for the period 2021-2027 in 2018. The Commission seeks to improve justification for agricultural policies via improved effectiveness especially in the environmental dimension of the policies. Several factors were identified and later summarized to nine different targets. The focus of the CAP in 2021-2027 is on environment, climate change, sustainable development, investments, new farmers, small-scale farming, and poorer regions within the EU.

The defined objectives present three different categories: income-related objectives, climate and environmental objectives, and societal objectives. The climate and environmental objectives tighten the current agri-environmental measures, greening, and cross-compliance with a regime focusing on preserving carbon-rich soils through protecting wetlands and peatlands, obligatory nutrient management tools to improve water quality, reduce ammonia and nitrous oxide levels, crop rotation instead of crop diversification. Farmers are rewarded for going beyond mandatory requirements. EU member countries will develop voluntary eco-schemes to support and incentivise farmers to observe agricultural practises for the climate and the environment.

Carbon farming within the CAP

The current and future CAP has several possibilities to enhance carbon farming, and thus, carbon sinks in agriculture. In the current CAP structure, land use and farming decisions can be directed by the terms of mandatory cross-compliance and voluntary greening in the I Pillar, and voluntary agri-environmental support scheme in the II Pillar. The current structure, funding, and the policy instruments in use are not designed to enhance carbon farming as such. However, the agri-environmental support scheme has had indirect enhancing impacts, especially in terms of land use changes, traditional biotypes preservation, among others.

In the CAP, farmers are compensated of fulfilling the requirements of the policy. Policy performance can be improved if compensation is based on measured benefit. This shift is possible within the proposed CAP but requires the development of a solid measurement system and clearly defined compensation schedule. The benefit-based policy instrument for carbon farming could be piloted during the policy period 2021-2027.

The most effective role of the CAP is to form infrastructure for carbon farming. Good agricultural farming practises defined in the CAP include several requirements that serve the objective of increasing carbon sinks in agriculture. Enhanced conditionality requirements and eco-scheme measures will include:

- Permanent grassland
- Protection of wetland and peatlands
- All year vegetative cover
- Crop rotation
- Landscapes

These requirements will comply in the enhanced conditionality, eco-scheme, and agri-environmental support scheme. The role of these practises depends on the overall structure of the climate and environmental support instruments defined in the national CAP strategic plans. The implementation of the selected new instruments will start in 2023.

Farmers' incentives to participate on voluntary carbon farming enhancing practises depend on compensation levels.

In the future CAP

- Basic support requires fulfilling the mandatory enhanced conditionality requirements. Due to income support element, compensation is, by design, greater than the costs and income losses incurred.
- In the voluntary eco-scheme, farmers will participate, if the compensation is higher than or equal to the incurred costs or income losses.
- In the voluntary agri-environmental support scheme, farmers will select the instruments with the biggest difference between payments and costs and/or income losses, and will participate in the system, if the overall support is higher than the costs and/or income losses due to the selected policy instruments.

The relatively higher support levels for carbon farming activities would form an incentive for agricultural producers to adapt new production practises and implement policy instruments with most effective impact on carbon sinks.

CAP and carbon farming: Key findings

The CAP is not alone able to respond to the increasing climate and environmental demands for agriculture. The Green Deal's climate and environmental related objectives are three out of nine policy objectives in the future CAP. Mandatory enhanced conditionality and voluntary eco-scheme are designed to improve the justification of the I Pillar direct payments.

The effectiveness of this green architecture of the CAP is reduced due to the lack of result-based payments. The level of direct income payments is not based on the costs, income losses or benefits of the enhanced conditionality or eco-schemes.

The agri-environmental payments in the II Pillar are based on the implementation of the instruments. The support is aimed to compensate the costs incurred, or the revenue lost, but neither cost nor revenue losses are measured at the farm level.

The future CAP includes several instruments that helps to create infrastructure for carbon farming. This infrastructure does not include pricing mechanisms or measurement for carbon sink. The carbon pricing mechanism and coherent measurement are required for markets to form. External pricing mechanism would lead to improved policy effectiveness.

Farmers will participate in voluntary programs if support is higher than cost and/or income losses occurred. If farmers can gain additional benefits (income) by participating in voluntary programs, they have an incentive to participate. In the policy regime, benefits are not compensated. Additional external compensation for carbon farming would increase the participation rate in the voluntary programs. Thus, the external compensation would lead to improved policy performance.

5.1.2 Public Funding, Forest sinks

Regarding forests, the EU does not have the same kind of common policies as CAP in agriculture. Forest sinks are part of the EU Land Use Land Use Change and Forestry (LULUCF) policy framework, which determines obligations to Member States regarding the total sink in each country. Apart from that, Member States have their own commitments to decrease GHG-emissions or to achieve carbon neutrality. These obligations have normally also nationally specified targets for carbon sinks preservation and increasing. To achieve both EU LULUCF and national targets Member States use national state aid schemes. They vary from state to state, although they must in line with EU State Aid Rules.

5.1.3 Private funding and compliance carbon removal credit markets

Carbon removals are not included to the EU mandatory market-based instruments such as Emission Trading Scheme. There are some examples from the other market-based system outside EU where this has done, such as California cap-and-trade program. (More information, see our market analysis (Carbon Farming Scheme 2020a))

California established an emissions trading scheme in 2006 to guide the state's climate and energy policies. It was initiated in 2012, and the program started its first compliance period in January 2013. To improve how the state addresses air quality, the California Legislature, in 2017, included in its extension of Cap-and-Trade a program to further reduce local air pollution. Since 2014, entities participating have been able to use offsets up to 8% of their obligations with only domestic projects. Offset credits are greenhouse gas (GHG) emission reductions or sequestered carbon that meet regulatory criteria. Most of the offset credits issued are from forest projects.

5.1.4 Private funding and voluntary carbon credit markets

According to FAO (2010) ''the voluntary market has become very important for agriculture and forestry projects. Voluntary carbon credits (VER) are mainly purchased by the private sector. Corporate social responsibility (CSR) and public relations are the most common motivations for buying carbon credits. Other reasons are considerations such as certification, reputation, and environmental and social benefits. Some companies offer clients to neutralise their carbon. The private sector can either purchase carbon credits directly from projects, companies or from carbon funds''.

5.1.5 Public funding and Private funding – Advantages and challenges

Table 8 lists some advantages and challenges of public funding of carbon farming and carbon forestry, while Table 9 lists advantages and challenges of private funding.

Table 8 Advantages and challenges of public funding of carbon farming and carbon forestry

Public funding of carbon farming and carbon forestry
Advantages
Supports the implementation of EU and national climate targets for sinks
Possibility to tailor the incentive system to support certain measures and to target different amounts of support according to needs
Possibility to tailor support also for other policy objectives (for example promoting biodiversity)
Support systems are long-term refined methods for agriculture and forest, which can be expanded as needed, e.g., promoting carbon farming and forestry
By creating an EU-wide scheme possibility to minimize double counting of sinks using national or wider registers
Possibility to minimize carbon leakage
Possibility to develop common high-quality CRCs: Scaling and managing common rules, criteria, and methodologies under same scheme
Network of national authorities to inform and advise projects under the scheme
Challenges
System creation slowness (such as CAP)
Limited public money
Limited and targeted systems may slow down the uptake of other carbon sequestration methods
The current support schemes are mainly action-based and do not reward real and measured carbon sequestration
State aid rules may make it difficult to use public and private money simultaneously in biological carbon sequestration projects
Regulatory and / or financial additionality criteria may set requirements and limitations for the use of public funding (See Additionality in section 7.1.2)

Table 9 Advantages and challenges of private funding of carbon farming and carbon forestry

Private funding of carbon farming and carbon forestry
Advantages
Additional private funding enables more nature-based sinks than a situation where money comes only from public sources
Enabling a cost-effective climate change mitigation system, especially if operators in other sectors are allowed to meet their GHG obligations also by increasing nature based sinks (see section 6)
Private entities in the voluntary market are more agile than public funding for internal system changes and system scaling across national borders
Functioning market systems already exist, and voluntary carbon markets have been growing for the last few years very rapidly.
Challenges
Lack of unified CRC managing system (e.g., validation, criteria, methodologies, MRV, etc.). All private schemes have their own criteria and management system, which are not easy to compare and are more local, national, or global. Schemes which fulfil European sustainable standards and focus on European markets do not exist.
How to combine public support and private funding in projects so that the combination meets e.g., EU state aid rules and additionality criteria?
Double counting challenge. As an example, additional sinks that are counted at the same time by companies and in the national GHG inventories.

5.2. Funding methods

There are various options for financing the increase of nature based carbon sinks. Action-based funding (Section 5.2.1) provides funding to the operator in accordance with the measures. Result-based funding (Section 5.2.2) is tied to a verified increase in carbon sequestration. Ex-ante funding is based on the expected amount of carbon sink increase, while in ex-post method is tied to verified increase in carbon sinks (Section 5.2.3).

Different financing models have their own advantages and challenges from the point of view of both the investor and the financier of the actions. Carbon sequesters want to get adequate and timely funding to cover the costs. From the financier perspective, on the other hand, cost-effectiveness, and the results (carbon sink increases) are very important. The benefits and challenges of each form of funding are discussed in more detail in the relevant sections of this report.

5.2.1 Action-based funding

COWI et al. (2021) defines Action-based carbon farming as ''a scheme where a farmer or landowner receives a payment for implementing defined management actions, independently of the resulting impact of those actions. Action-based model is widely used in the EU and Member States in agriculture (CAP) and promoting forest practices. Payments are commonly used for compliance with very specific farming or forest practices or technologies which have been selected by the managing authority for the assumed environmental benefits''.

Table 10 Advantages and challenges of action-based funding in carbon farming and carbon forestry

Action-based funding in carbon farming and carbon forestry
Advantages
As a rule, the carbon farmer or carbon forester receives the money immediately after completing the measures / investments. This reduces the operator's uncertainty about receiving support.
Measures can be tailored to funding models that consider individual characteristics of the different measures
The action-based financing model is familiar to decision makers, as it is widely used as a form of public support for both agriculture and forestry
In both agriculture and forestry, states have ready an advisory network on support for operators in this sector
Challenges
Action-based funding has no direct link to captured carbon. There is an uncertainty whether the result will be generated at all.
The action-based model is not suitable for the carbon market if you want to pay for the sequestered carbon.
Support measures targeted at specific measures limit the use and development of actions, which do not have similar aid possibilities

5.2.2 Result-based funding

Result-based carbon farming is defined by COWI et al. (2021) in the following way ''a scheme where a farmer or landowner receives a payment for reducing net GHG fluxes from their land, whether that is by reducing their GHG emissions or by sequestering and storing carbon. A result-based approach requires a direct and explicit link between the results delivered (e.g., GHG emissions avoided, or carbon sequestered) and the payments that the land manager receives. It differs from the more familiar action-based schemes, where the farmer is paid for complying with very specific farming practices or technologies, which have been selected by the managing authority for the assumed climate mitigation benefits''.

Advantages and challenges of a result-based scheme for carbon farming are described in COWI et al. (2021) in Table 11.

Table 11 Advantages and challenges of result-based funding in carbon farming and carbon forestry (COWI et al. 2021)

Result-based funding in carbon farming and carbon forestry
Advantages
Flexibility for the farmer – encouragement of adaptability, innovation, and entrepreneurship
Clearer link between payment and carbon impacts for buyers – higher credibility/appeal and potential for higher additionality
carbon impacts are an objective, and not a side-effect of sustainable agriculture – potentially higher effectiveness
lower adverse selection of parcels with lower yields by farmers (i.e., with lower opportunity costs)
educational role for farmers, foresters and society as a whole.
Challenges
potential higher financial risks/uncertainty for farmers
potential higher transaction costs for developers
challenges related to monitoring, reporting and verification of climate mitigation results (costs, degree of reliability/ robustness)
challenges of ensuring additionality and of securing permanence of the carbon impacts
the time needed for change in reliable measurements is potentially long, and in some cases the change is appreciable only after the project life span
higher flexibility given to farmers also means that strong advisory support needs to be built into scheme design; however, capacity or resources for this may be lacking.

5.2.3 Ex-ante and ex post credits

According to Arnoldus and Bymolt (2018) ''ex-ante credit is issued by the certification body before the emission reduction has occurred. First, the project needs to be certified by an independent auditor, who also verifies the conservative calculation of the credits that will be generated within a future time frame. The certification body then issues ex-ante credits, which can then be entered into a registry and sold. Periodically, an independent auditor needs to verify whether the credits have indeed been produced. The ex-post credit is sold after the credit has been produced and issued by the certification body''.

According to I4CE (2019) ''ex-ante credits are specifically relevant for long-term projects like forestry projects, which need substantial expenditure investments at the beginning and for which the actual carbon sequestration benefit can take years or decades. Ex-ante credits therefore allow to provide the necessary funding to start the long-term projects that cannot really fit into the ex-post classic schemes''.

Ex ante and ex post credits: benefits and challenges

The World Bank (2018) describes the benefits and challenges regarding ex ante and ex post funding. These are listed in Table 12 and Table 13.

Table 12 Advantages and challenges of ex ante funding in carbon farming and carbon forestry (World Bank 2018)

Ex ante funding in carbon farming and carbon forestry
Advantages
Simple: This option is the simplest from a technical perspective. There are no concerns, for example, with double counting or aligning multiple MRV systems.
Flexible: A country can decide how to spend the funds in a variety of ways (including to achieve non-carbon benefits). This may also include using funding to leverage private investments.
Challenges
Requires up-front investment: This finance will likely need to come from the government unless development assistance may be used (without concerns of "double payment").
Weaker incentives: Because it does not reward performance, it may be said to have weaker incentives; as such, it will be difficult to engage some private sector actors.
Allocation inefficiency: A key challenge is how to determine an equitable allocation of funds, and if funds are intended to further mitigation, how to ensure funds are used for higher value efforts.

Table 13 Advantages and challenges of ex post funding in carbon farming and carbon forestry (World Bank 2018)

Ex post funding in carbon farming and carbon forestry
Advantages
Stronger incentives: Certain types of stakeholders may respond well to performance metrics (e.g., the private sector).
Catalyses private investment: Because a potential return on investment can engage private finance, this option may be useful for governments with insufficient resources or that do not have strong fiscal levers.
Challenges
Risk of non-performance: In some cases, the allocation of finance or emission reductions will only be as high as the jurisdictional performance. In such cases, there are risks to either subnational units, or the private sector and local actors, who engage in programs or projects that are nested within the higher-level envelope—in particular, if a local project performs well, but the jurisdiction does not perform equally well, depending on the approach to nesting, the financial rewards are limited. The risk of non-performance will need to be borne by the jurisdiction or projects—and in the latter case, will dampen local investments.

5.3. Combination of funding sources or methods

Each funding source of, and method of, carbon farming and carbon forestry financing has its own advantages and challenges, which are described in above Sections of this report. Combinations of different funding sources and methods can be used to create a system that brings together the best features of different combined parts.

Carbon Contract for Difference (CCfD, Section 5.3.1) is an example of a combination of public and private funding. In it, the producer receives a constant price for the carbon sequestration (strike price). It is a combination of CRC market price (private money) and the difference between strike price and market price (public money). Strike price method creates a more stable operating environment and stronger incentive for the carbon sequestration investor than a pure market-based system.

Woodland Carbon Code (Section 5.3.2) is an example of the method that combines ex-post and ex-ante funding in forestry carbon sequestration projects. As described in the afforestation example (Section 3.2), carbon sequestration in forests is a relatively slow process. On the other hand, afforestation costs are concentrated at the beginning of the project. With Woodland Carbon Code's combined funding, the forester also receives income financing in the early stages of the project, which provides an incentive for action better than a result-based financing model alone.

5.3.1 Carbon Contracts for Difference

Carbon Contracts for Difference (CCfD) are a mechanism whereby the aid grantor and an investor in a climate change mitigating project set a fixed carbon price by agreeing to pay the difference compared to the market price.

Using CCfD's to ensure stable and predictable prices as the carbon market becomes established and private funding takes over could create the necessary initial push for carbon farming investment.

Carbon contracts for difference lower the investment risks and therefore investment costs, and give an incentive for investing (e.g., when the low price of CRC is not incentivizing for more actions). Carbon contracts for difference are an answer to the following two problems:

- uncertain price level of the final product (e.g., price of CRC), or
- the price level of the final product is too low regarding repayment of the investment.

With CCfD, the difference of carbon price (such as CRC price) and beforehand agreed strike price is paid. This means, the producer gets a pre-set price for the product, just like in feed-in tariff systems (See Figure 5).

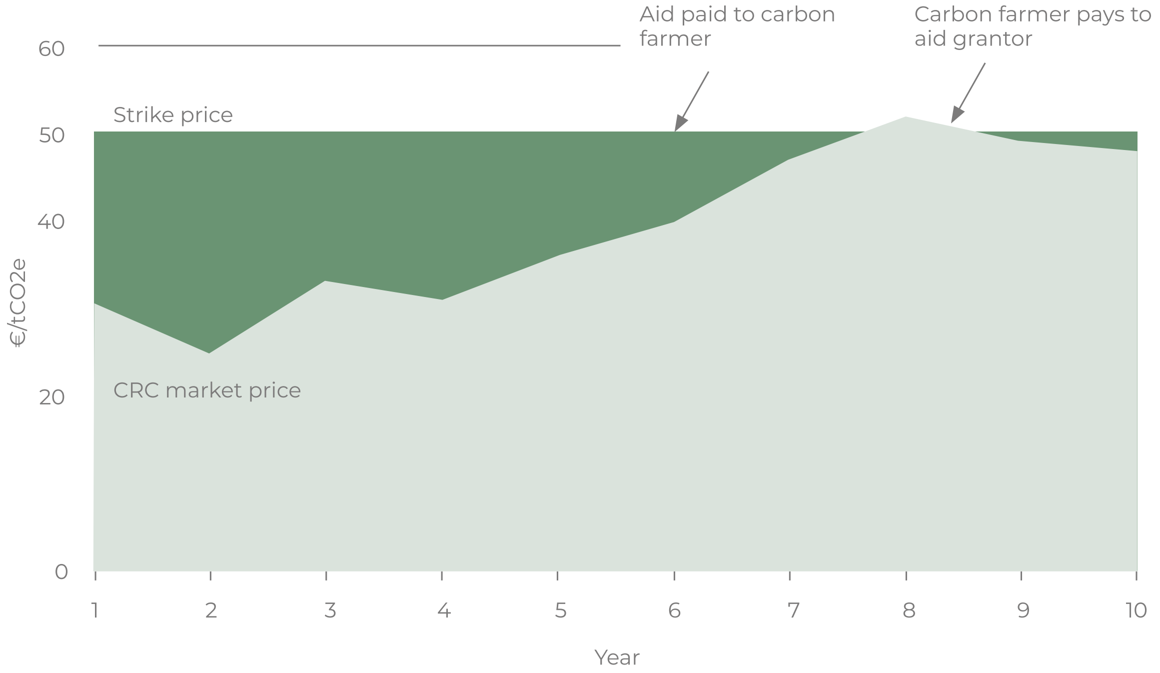


Figure 5 The principle of Carbon Contracts for Difference in CRC markets

The contract for CCfD is made for a certain time, and the need for the aid should stop when the sink enhancing actions become more common and the CRC market is liquid.

The aid can be granted by e.g., the EU, a member state, the European Investment Bank, or financial markets. The aid could be formulated different ways such as:

- Fixed strike price for all measures
- Fixed strike price for limited number of different measures
- Different fixed strike price for different measures
- Tender-based fixed strike price

In the systems, where fixed strike price is set without tendering, operators have a sure indication of the price they will receive for carbon sequestration under the CCfD before applying the aid. It is not known in advance how many new carbon sinks will be created within the system. The total cost of the scheme for the State is also unknown in advance, as it depends on both the development of the CRC market price and the volume of carbon sequestration covered by the scheme.

In the tender-based system, the strike price will be determined based on the offers. In this system, too, the total cost to the State is unknown in advance because it depends on the CRC market price.

CCfD -model has also been developed as a financial instrument linked to EU emission trading. According to ICI (2020) ''CCfD's pay out the difference between the price of emissions allowances (EUAs) and the contract price, thus effectively ensuring a guaranteed carbon price for the project. In exchange for this insurance, investors are liable for payment if the carbon price exceeds the contract's strike price. Companies would thus have an incentive to make climate-friendly, innovative investments and thereby reduce their CO2 emissions''.

CCfD ensures a stable price for the final product for the operator. Similar forms of support have been used in several countries to promote renewable energy such as wind power. In commonly used feed-in tariff systems, a wind power producer receives for electricity a guaranteed price, which may be different for different forms of production (onshore, offshore). When the market price of electricity is below the guaranteed price, the state pays the difference. The system has been necessary in a situation where the cost of wind electricity production clearly exceeded the market price for electricity. Since then, with the development of wind power technology, production costs have dropped significantly. In many cases, new wind farms are now competitive in the electricity market without state subsidies.

5.3.2 Woodland Carbon Code combined funding

According to homepages (UK Woodland carbon code 2021) ''The Woodland Carbon Code is the voluntary standard for UK woodland creation projects where claims are made about the carbon dioxide they sequester. Independent validation and verification to this standard provides assurance and clarity about the carbon savings of these sustainably managed woodlands.

The Woodland Carbon Code issues carbon units which represent measurable amounts of carbon dioxide (CO2) removed from the atmosphere by trees as they grow – one unit is 1 tonne of carbon dioxide equivalent removed from the atmosphere. As trees take a while to grow and sequester carbon dioxide, we have two types of units available to purchase. Companies can compensate for their UK-based emissions using carbon units from WCC projects.

A **Woodland Carbon Unit (WCU)** is a tonne of CO2e which has been sequestered in a WCC-verified woodland. It has been independently verified, is guaranteed to be there, and can be used by companies to report against UK-based emissions or to use in claims of carbon neutrality or Net Zero emissions.

A **Pending Issuance Unit (PIU)** is effectively a 'promise to deliver' a Woodland Carbon Unit in future, based on predicted sequestration. It is not 'guaranteed' and cannot be used to report against UK-based emissions until verified. However, it allows companies to plan to compensate for future UK-based emissions or make credible CSR statements in support of woodland creation''.

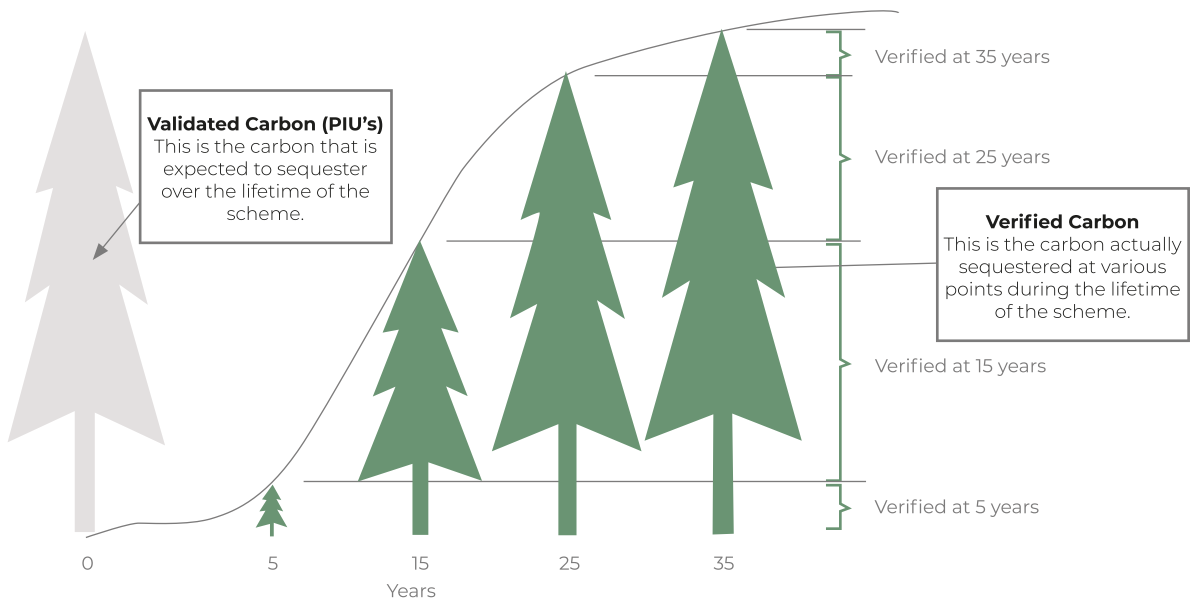


Figure 6 Woodland Carbon Units and Pending Issuance Units in UK Woodland Carbon Code (UK Woodland carbon code 2021)

6 Incentive to purchase CRCs

The Carbon Removal Credit (CRC) market can be a voluntary market or compliance market. A voluntary market is already existent to some extent, and the incentive to buy CRCs in a voluntary market is for example decrease carbon footprint or reach voluntary company-specific sustainability target or the incentive is purely marketing-driven.

Here compliance market is defined as a system where a company can use a CRC as a mechanism that contributes to fulfilling legally binding climate targets. As described in our market analysis (Carbon Farming Scheme 2020a), compliance markets already exist in some countries, but as of yet there is no EU wide market of CRCs where CRCs could be used to fulfil obligatory mandates. Example and learnings could be taken from e.g. national CRC compliance markets, EU ETS and CORSIA.

6.1. CRC compliance market

By creating a compliance market for CRC's, we are able to bring carbon sinks to the same line with other emission reduction measures. This means, that by bringing carbon sinks to the same market place with emission reductions the valuation of carbon sinks will be comparable with emission reductions, and the most cost-effective measures can be taken to achieve the climate goals. This does not mean, however, that all our emissions should be offset with carbon sinks as carbon sinks would become equal alternatives for emission reductions. Securing that all possible emission reductions are obtained, can be done e.g. by setting a limit for the use of carbon sinks in fulfilling climate targets. For example, the California cap-and-trade program sets a limit of 8 % for offsets, while rest of the obligation must be fulfilled with other means. Climate targets can even be made more ambitious if carbon sinks are accepted as a mean to fulfil part of the targets. Furthermore, as discussed in our market analysis (Carbon Farming Scheme 2020a), great amount of emission reductions are still needed, and our current emissions are so high that there is not enough additional carbon sinks to offset all.

There are several benefits in compliance CRC markets:

- **Cost-efficiency:** abatement cost is lower when economic operators have more tools for reaching their climate targets, and the most cost-efficient means are used first. Lower abatement cost does not only benefit the companies, but mostly end consumers (e.g. in the case of fuel suppliers, lower abatement cost results in lower fuel prices.)
- **Higher compensation for farmers and foresters:** Allowing economic operators to use CRCs along with other emission reduction methods, the abatement cost in the sector impacts on the economic operators' willingness to pay for CRCs. If CRCs are allowed as a mean to fulfil climate obligations along with economic operators current climate measures in sectors where the abatement cost is already high, the willingness to pay for CRCs is likely to be high as well. The more economic operators are willing to pay for CRCs, the more money probably flows to carbon sink project owners.

- **Create demand for European high standard carbon sinks:** by creating a compliance market, policy makers can be more sure that carbon sinks are created. By setting an obligation where CRCs comply, economic operators are more likely to buy CRCs than in voluntary markets where buying CRCs is completely voluntary. By trusting in only voluntary markets, policy makers cannot be sure that there will be enough demand for CRCs and that enough carbon sinks are created for climate targets to be achieved.
- **Possibility for fast scale up:** The faster the compliance market is set, the faster the demand for CRCs will grow and carbon sinks are created. We need to invest in carbon sinks already now, to create a stable and secure supply of carbon sinks when we need them in the future.
- **Secure private capital flow to carbon sinks:** If CRCs are recognized as a mean for economic operators to fulfil climate targets, it creates investment security for farmers and foresters to invest in carbon farming projects as they know there will be CRC demand created by legislation.

In our market analysis (Carbon Farming Scheme 2020a), the demand for CRCs in an EU wide compliance market was estimated assuming that legislation would allow the use of CRCs in fulfilling emission reduction obligations in the EU. According to the analysis, the potential demand of CRCs is far greater than the potential supply of nature-based CRCs in the EU.

In our market analysis (Carbon Farming Scheme 2020a) the ETS sector was seen technically well suited for the introduction of CRCs, as credits of 1 ton of CO2e are already traded in the ETS. The EU ETS already has the structure needed for a CRC market, as the system includes e.g. rules for monitoring, measuring and verification and a register for emission allowances. Adding CRCs to the EU ETS would require the amendment of new type of units to be used alongside with emission allowances in similar way as CDMs and JIs have been used in the EU ETS.

Our market analysis (Carbon Farming Scheme 2020a) also showed that the ESR sector, and especially the transport sector holds a great volumetric demand for CRCs. The currently high abatement cost in the transport sector predicts high willingness to pay for CRCs if they could be used to fulfil more ambitious climate targets. Especially the road and aviation transport sectors already have a climate regulation structure where it would be possible to add the use of CRCs as an extra mean to comply with climate targets.

The possibility of implementation of CRCs into the climate regulation of different sectors in the EU is discussed in more detail in our market analysis (Carbon Farming Scheme 2020a). The climate targets in the EU are going to be increased and we suggest allowing the use of CRCs in fulfilling the increasing part of the targets instead of offsetting emissions under the current climate targets and decreasing the ambition of emission reductions. In the European Commission work program for 2021, the revisions and initiatives linked to the European Green Deal climate actions and in particular the climate target plan’s 55 % net reduction target are presented under the Fit for 55 package.

The following section introduces a case example on implementing CRCs in the transport sector climate regulation. We chose road transport as the case example as we operate in the road transport sector and know well the sectors' current climate regulation, available emission reduction options, and formation of abatement cost and willingness to pay for climate actions.

6.2. Case example – CRCs in transport sector

The extremely high abatement cost in road transport sector is one factor advocating for implementing CRCs in the transport sector. According to our market analysis (Carbon Farming Scheme 2020a), the carbon price in the road transport sector has been 100-330 €/tCO2e (DG internal policies 2015), but according to our internal estimation the cost could even be tripled by 2030. As a comparison, the abatement cost in the ETS sector is the price of emission allowances, being between 16.61- 56.65 €/tCO2e during 2020 and the first half of 2021 (Ember 2021).

The emissions in the road transport are regulated under the Fuel Quality Directive (98/70/EC, FQD in short) and Renewable Energy Directive (Renewable Energy Directive I 2009/28/EC and II (EU) 2018/2001, RED in short), aiming to decrease the emissions and increase the share of renewable fuel in transport. Even though either of the policy measures in the road sector are not directly market based measures, they have led to the formation of a carbon price in the road transport. For example, the emission reduction value of biofuels effects on the market price of biofuels and the German emission-based obligation for fuel suppliers has a great impact on the biofuel market prices due to the high demand for biofuels in German markets.

As of yet there is no official report on the fulfilment of FQD 7a § in each EU member state, but it has been indicated in various events (e.g. DG Clima et al. 2021) that many member states have not reached the target of 6 % fuel emission intensity reduction. Not being able to reach the FQD 7a § target indicates that it is very difficult to achieve emission reductions in the transport sector. Liquid biofuels are expensive and many of them have a blending limit. Other energy carriers such as electricity, biogas and hydrogen require a change in the car fleet and infrastructure and liquid e-fuels require time and investments before they become widely available. Adopting CRCs as an emission reduction mean in transport sector could help the sector in the transition period before the car fleet and infrastructure has changed more towards electric, gas and hydrogen, e-fuels become commercially available and while the only way to reduce emissions of the current car fleet is using biofuels.

The FQD and RED concern all the member states, but each member state has chosen their best way of implementing the directives. This has led to the situation where in some countries the national FQD target is so high, that the national RED target for transport can be achieved automatically by fulfilling the national FQD target. In some countries, it is the other way around. Most of the member states however, have implemented the directives in a way that both of them are equally ambitious. Figure 7 demonstrates the way of implementation of FQD and RED in each EU member state and classifies the countries as RED target-led, FQD target-led and both RED and FQD target-led countries.

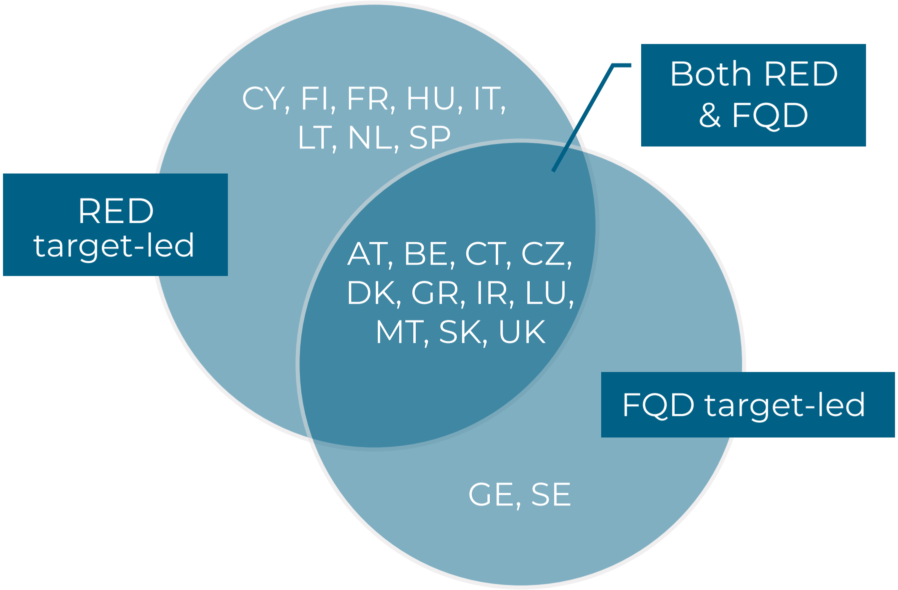


Figure 7 Transposition of RED and FDQ targets for transport (Technopolis Group 2021)

There are various possibilities on how to implement a CRC mandate into transport sector's increasing climate targets. These include:

- Allowing CRCs to fulfil part of the FQD 7 a § obligation
- Allowing CRCs to fulfil part of the RED obligation
- Allowing CRCs to fulfil part of the national obligations exceeding the EU targets
- Including CRCs in the emission trading system planned for the transport sector[1]

CRCs would fit well in an emission trading system where allowances of 1 ton of CO2e are traded. If an emission trading system is implemented for transport emissions, CRCs could be designed to be part of the system already from the beginning. In this way, the use of CRCs could be taken into account already in the initial design phase of the overall system. Currently, we do not have any information on how the ETS for transport emissions would be constructed. However, CRCs could be included in the system in a similar way as CDMs and JIs in the EU ETS.

The following section introduces a case example for implementing CRCs to the FQD 7 a § target in the EU level.

[1] According to the Green Deal, the European Commission is assessing a possibility of using emissions trading scheme as a mechanism to achieve emission reductions in the some of the current ESR sectors, including transport sector

6.2.1 Implementation of CRCs to the FQD 7 a § target in the EU level

The Fuel Quality Directive (2009/30/EC) 7 a § sets a 6 % fuel emission intensity reduction obligation for fuel suppliers for 2020, compared to the 2010 levels. The 6% reduction obligation has been agreed to continue after 2020, until the legislation has been re-evaluated.

As 2020 is the first year with a binding FQD target, there are no reports on the fulfilment of the target as of yet. It can be, however, assumed that a significant part of the FQD target is achieved by supplying renewable energy, such as biofuels, to consumption, as also RED is encouraging in the supply of renewable energy in transport. The FQD however, introduces also certain types of carbon credits and carbon sinks as means to fulfil the target.

The Fuel Quality Directive 7 a § with its implementing directive ((EU) 2015/652) allow fuel suppliers to use two types of carbon credits to achieve emission reductions. According the FQD 7a § 2 c countries may set an indicative additional target of 2% reduction for fuel emission intensity to be achieved with CDM projects in the fuel supply sector. We are not aware of any country that has implemented the indicative additional targets the FQD offers. The other credit type, upstream emission reductions (UER), can be used to fulfil the 6 % emission reduction obligation. The UER credits can be achieved only from emission reductions achieved in fossil fuel production prior to the raw material entering a refinery or a processing plant. According to the Commissions guidance note on UER's, UER's resulting from CDM or JI projects could have been used as long as the constraints set in the FQD implementing directive are followed. At least in Germany UERs have been purchased by fuel suppliers. Furthermore, the FQD 7 a § 2 b offers a possibility to set an indicative additional target of 2 %, which can be achieved by either supplying energy for transport or by using "any technology (including carbon capture and storage) capable of reducing life cycle greenhouse gas emissions per unit of energy from fuel or energy supplied".

As stated above, the FQD 7 a § already offers the possibility to use carbon credits (CDM and UER) and technology-based carbon sinks for fulfilling the target. However, the restriction is that the emissions must have been reduced or carbon sinks formed in the supply chain of fuel production. This means that nature-based carbon sinks from LULUCF or agriculture are not currently allowed to be used in achieving the FQD 7 a § target.

For nature-based carbon sinks to be allowed to fulfil the FQD 7 a § target, changes in the legislation are required. As the FQD 7a § target is an emission reduction based target, implementing CRCs to FQD require less regulatory changes as implementing CRCs to RED, where the target is to supply renewable energy instead of reducing emissions. Furthermore, the FQD 7a § already includes the possibility to use carbon credits and technology-based carbon sinks as a mean to fulfil part of the target (if the target is increased). Implementing CRCs to FQD 7 a §, would require a change in the directive, being for example an additional clause allowing the use of CRCs in fulfilling the target. The following decisions would need to be taken for the clause:

- Should the use of CRCs in fulfilling the FQD 7a § target be allowed in all the member states, or should it be something the member states can choose to implement (as the current clause for CDMs)
- If CRCs are allowed, should the target be increased (as the current clause for CDMs)

Furthermore, double accounting of carbon sinks to different sectors should be prevented, and a decision should be made on whether carbon sinks should be accounted on the sector where they are formed or in the sector which pays for them.

The Technical Guidance Handbook ordered by DG Clima (COWI et al. 2021, p. 69) identifies questions to be assessed when carbon farming schemes are linked and integrated with national, EU and international climate targets. These questions are introduced and assessed for the case example in Table 14.

Table 14 Evaluation of questions to be assessed when carbon farming schemes are linked and integrated with national, EU and international climate targets. Questions from the Technical Guidance Handbook by COWI et al. (2021)

Questions to be assessed when carbon farming schemes are linked and integrated with national, EU and international climate targets (COWI et al. 2021)	Evaluation for implementation of CRCs in FQD 7 a §
Which Ministry or department should be responsible for these schemes? What kind of setup is required at national level to ensure coordination and integrity?	The FQD directive should be changed so that it allows CRCs to be used in fulfilling the target. However, at national level a decision should be taken on whether the FQD 7 a § target is increased from 6 % and if CRCs are eligible for fulfilling the target. This decision could be made by involving the same regulatory parties which are in charge of implementing the FQD 7 a §.
What should the role of the Commission be in relation to national and regional schemes?	The implementation could go the same route as with FQD 7 a §. The regulating body of the FQD in the European Commission is DG Clima.
With which other regional, national or EU policies does the scheme need to be coordinated to avoid policy conflict?	Currently, sustainability criteria for biofuels used to fulfil the FQD 7 a § target are set in the RED. Sustainability criteria for nature-based carbon sinks are discussed in section 7 of this report. Sustainability criteria for carbon sinks could be set in RED or some other separate directive (e.g. a directive concerning CRCs, biodiversity, or social aspects (such as the forthcoming EU human rights due diligence directive).) Taxonomy directive should be in line with the sustainability criteria set for CRCs. To prevent double accounting, a decision should be made on whether carbon sinks should be accounted on the sector where they are formed or in the sector which pays for them.
If the carbon farming scheme is linked to national inventories, how should coordination be governed?	Clear definition for carbon removals and its target for climate mitigation. The accounting rules need to be developed to make a distinction of national inventory and tradable CRC, if it is decided to separate.
How should climate action data be recorded to simplify integration into national GHG inventories?	The CRC MRV rules and development and advanced data management in scheme governance are a way to collect sufficient data to record gained climate actions.

7. Criteria for carbon farming and carbon forestry

Carbon farming and carbon forestry affect widely into the nature and people and not only those directly involved. Carbon farming and carbon forestry actions may also have indirect favorable or inconvenient effects. Therefore, in addition to carbon criteria all aspects of sustainability should be considered when building the new scheme and certification system. There are three fields of sustainability to be considered in carbon farming scheme: effects on carbon balance i.e. carbon related criteria, other ecological impacts such as biodiversity and social aspects such as economic development and human rights.

To be able to meet climate and sustainable targets with carbon farming and carbon forestry, we need to set common criteria for the actions. Criteria set rules from climate, social and environmental aspects, which are equally important to form sustainably removed GHG with nature-based solutions in farms and forests.

7.1. Criteria model example in renewable energy sector

There are existing directives such as Renewable Energy Directive (Renewable Energy Directive I 2009/28/EC and II (EU) 2018/2001) and directive taxonomy of sustainable finance (EU 2020/852) that have sustainability criteria in place. Renewable energy directive sets the sustainability criteria for biofuels which prohibit calculating the emission reductions towards renewable energy targets if sustainability criteria is not met by biofuel. Similarly, the criteria could be set for the carbon removals and especially when carbon removal certificates are used to fulfill emission reduction targets. Additionally, aligning the criteria with the taxonomy would advance the financing of the carbon farming projects. However, the criteria setting should be based on careful consideration so those criteria are not too stringent for carbon farming which would prevent actions to be attractive for farmers and forest owners.

Carbon farming and carbon forestry affect widely into the nature and people and not only those directly involved. Carbon farming and carbon forestry actions may also have indirect favorable or inconvenient effects. Therefore, in addition to carbon criteria all aspects of sustainability should be considered when building the new scheme and certification system. There are three fields of sustainability to be considered in carbon farming scheme: effects on carbon balance i.e. carbon related criteria, other environmental impacts such as biodiversity and social aspects such as economic development and human rights.

7.2. Following Do no harm -principle in the criteria

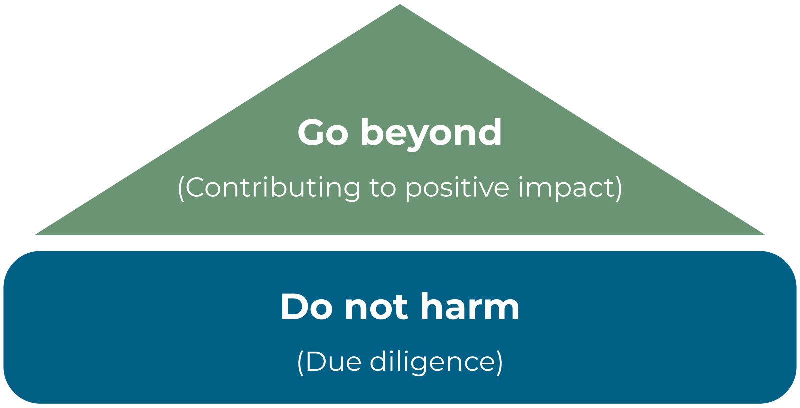


Figure 8 Do no harm forms the basis, and needs to be in place before being able to go beyond and focus on 'do good'

In the implementation of carbon farming and carbon forestry projects, parties should suggest to follow the "do no harm" -principle. Projects should be evaluated as a whole and consider the effects on environment as well as people. Obeying "do no harm" principle would be a first step to ensure climate integrity and rights of the people involved.

The "go beyond" criteria of positive impact are not requirements as such, but should be seen as encouragement to look beyond the risk management approach and look at opportunities to go beyond the baseline responsibility to do no harm, as well.

7.3. Carbon criteria

Carbon criteria forms the climate objective and goals for carbon removals achieved in carbon farming and carbon forestry actions. Criteria sets indicators to measure removed GHG emissions from the atmosphere. Common definition to carbon removals should be formed with carbon criteria and aligned with Paris Agreement rules.

If CRCs are used to substitute emission reductions, we should ensure that the climate impact resulting from the CRCs is at minimum equivalent to the actual emission reductions in order not to increase the overall net emissions. However, if the aim is to support the increase of carbon sinks and not substitute emission reductions, the requirements for CRCs do not necessarily need to be as high regarding e.g. permanence. In compliance markets CRCs do not substitute emission reductions if climate targets are increased and a cap for using CRCs is set when CRCs are implemented in the system.

(carbon)plan (2020), Allen et al. (2020), and TSVCM (2020) describe the meaning and usage of the terms carbon removal, avoided emission and emission reduction. According to Allen et al. (2020) emission reductions include avoided emissions. Examples that Allen et al. (2020) and TSVCM (2020) give on emission reduction and avoidance are replacement of fossil fuel with renewable energy, avoided deforestation, methane capture as an improved waste disposal, and programmes to update inefficient cook stoves. Examples on carbon removal include nature-based solutions such as reforestation and technology-based solutions such as carbon capture and storage (TSVCM 2020). More detailed explanation and examples on emission reductions, avoided emissions and carbon removal can be found from (carbon)plan (2020).

Both (carbon)plan (2020) and Allen et al. (2020) conclude that carbon removal, emission reduction and emission avoidance can all have the same impact on the atmosphere, but it depends on the criteria fulfilled, especially additionality and permanence are mentioned. From climate point of view, it does not necessarily matter if the project reduces, avoids or removes emissions. What seems to effect on the amount of realized climate good, depends greatly on the baseline on which the project is compared with. Therefore, the climate impact of the CRCs can be ensured by setting certain criteria which the CRCs must fulfil.

When considering the carbon criteria, the aim should be in desirable climate effect and net change in GHG emissions and removals. Permanence, additionality, carbon leakage and double counting are criteria which define the definitive outcome of the carbon sequestering projects and net change in GHG emissions and removals. When studying carbon farming and forestry projects and their relation to carbon criteria setting, one finding is that the exactly similar criteria cannot be put in place for projects in different sectors. Despite of this limitation, it is possible to set a common target for criteria on the upper level which then should be same for all projects those participating to carbon market. The following subsections dive into more detail in carbon criteria on permanence, additionality and baseline, carbon leakage, and double counting.

7.3.1 Permanence

In the framework of carbon sequestration, permanence describes the situation where removal of carbon dioxide from the atmosphere is permanent, and not reversed back to atmosphere at any future point in time (Carbon Offset guide 2021). The demand for permanent carbon removals relies strongly on Paris Agreement which emphasizes the long-term solutions in climate change mitigation. For example, the CORSIA agreement states that carbon credits are eligible only if they are permanent or the non-permanence risk is controlled by monitoring and in case of reversals compensation takes place (ICAO 2019).

Carbon sinks produced on the land-use sector are not perpetual due to the natural carbon cycle. Consequently, it is necessary to pay attention to minimizing the risk of non-permanence of emission reductions and carbon sequestration. "The non-permanence risk refers to the risk of carbon sequestration projects suddenly reemitting carbon into the atmosphere, for example following natural disturbances (forest fire, storm, pest attack…)" (I4CE 2019). Monitoring and modelling the uncertainties assists to identify project specific non-permanence risks and points where reversals may occur and address them in full.

On project level the permanence is not guaranteed to last indefinitely. The timeline of the permanence promise varies between 2 – 100 years or it is only referred as project duration time. This is confusing to credit buyers and for example Microsoft has evaluated projects using term durability instead of permanence in their carbon credit portfolio. Table 15 lists examples of the project duration in different carbon farming and carbon forestry schemes.

The European Commission's Technical Guidance Handbook (COWI et al. 2021) presents various methods to handle the non-permanence risk such as buffer accounts, eligibility criteria, long term contracts, separate result-based rewards for long term retention, stakeholder buy-in, development of other long-term markets, transfer land to non-commercial ownership and permanent restrictions for future land use. The buffer account is most commonly used method to control non-intentional reversal i.e., non-permanence risk of the projects and most of the projects have such in place. In a carbon farming scheme buffer account may be a virtual common pot or project specific account. It is crucial in the buffer setting that its level is not underestimated, and non-permanence risks are evaluated rigorously. As an example, Verra offers an 'AFOLU Non-Permanence Risk Tool' for evaluating natural, internal and externals risks which project may face and defines the buffer quantity based on the result of the evaluation.

Table 15 Examples of the carbon farming and carbon forestry schemes, project duration, permanence promise and buffer reserves. (Ökoregion Kaindorf 2021; Ministére de la transition écologique 2021; Climate Action Reserve 2021; Nori 2021; Gold Standard 2021; UK Woodland Carbon Code 2021; Verra 2021; Gobierno de España 2021; Puro.earth 2021)

Argiculture / forestry project	Project / scheme name	Voluntary scheme: Global / National / Private	Project duration (years)	Permanence promise after project termination	Buffer
Argiculture	Kaindorf Ecoregion	National	2-5	5 years maintaining	1/3 of the sales revenue
Argiculture	Label Bas Carbone	National	5		10% - 20% discount is applied
Argiculture	Soil Enrichment protocol	Private	10	2 x renewable, up 30 years	
Argiculture	NORI protocol	Private	10	10 years after last credit sale, renewable upon using dynamic baseline	
Argiculture	Gold Standard	Global	5-20		
Forestry	Woodland Carbon Code	National	40-100		20% of the credits
Forestry	Verra	Global	30-100		
Forestry	Label Bas Carbone	National	30		10% - 25% discount is applied
Forestry	Registro Huella de Carbono	National	30		fixed rate of 10% of estimated carbon units
Argiculture / Biochar	Puro. Earth	Private	50	Over 1000 years	upfront 10% reduction
Argiculture / lignin-based soil amendment *LIFE Carbon Farming Scehme project pilot	Puro.Earth	Private	20		

According to Allen et al. (2020) emission reductions (including avoided emissions) and carbon removals have exactly the same impact on the atmosphere in near term. They classify climate actions to five categories, which all have different characteristics on permanence (Figure 9). Using this classification system, they draw a trajectory on which types of climate actions are needed between 2020 and 2050, leading on their statement that emission reductions, emission avoidance and carbon storages are needed, but that investment to carbon removal should be started immediately (Figure 10). They state that we should concentrate on investing in carbon removals now, so that we are able to use them in the future when we must offset the remaining emissions which we are not able to reduce (to be in line with the Paris Agreement goals). Starting with short-term carbon storing gives time for scaling up actions leading to long-term permanence. The path from commencing with short-term permanence actions which would lead to a demand for long term permanence, requires that the rules for different level of permanence are set.

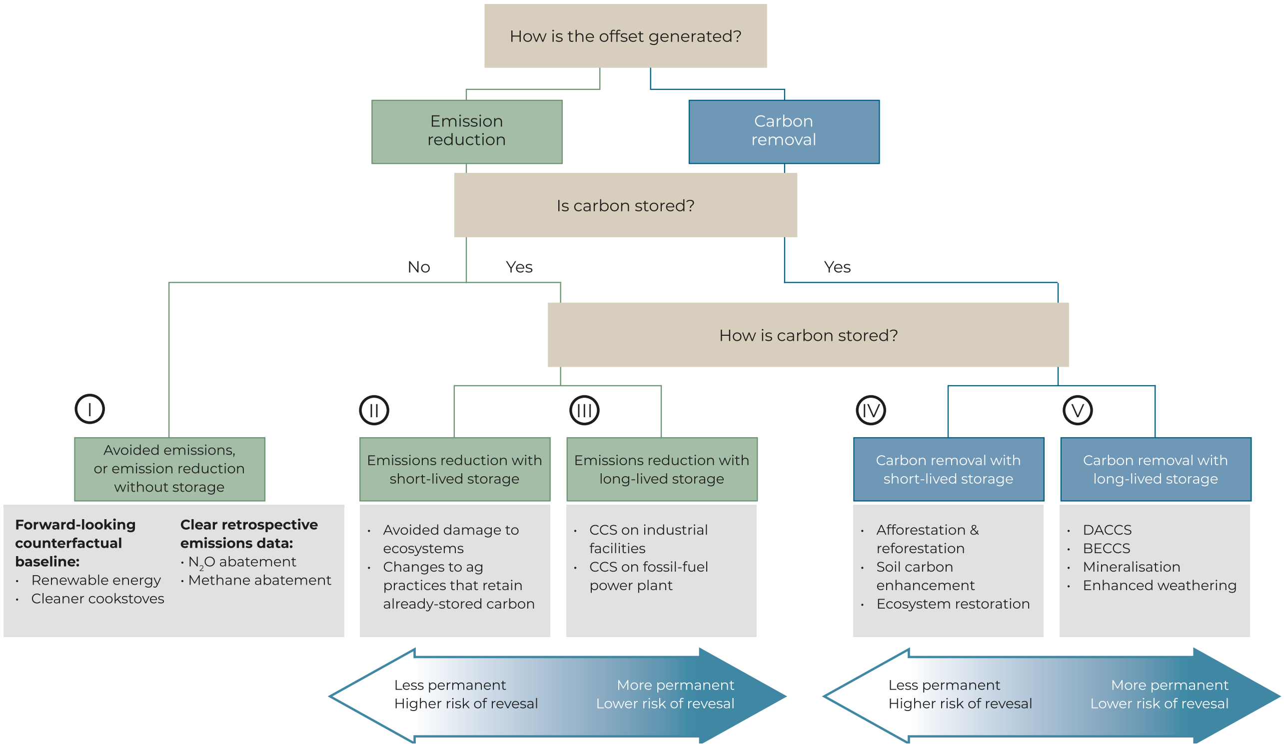


Figure 9 Taxonomy of Carbon Offsets (Allen et al. 2020)

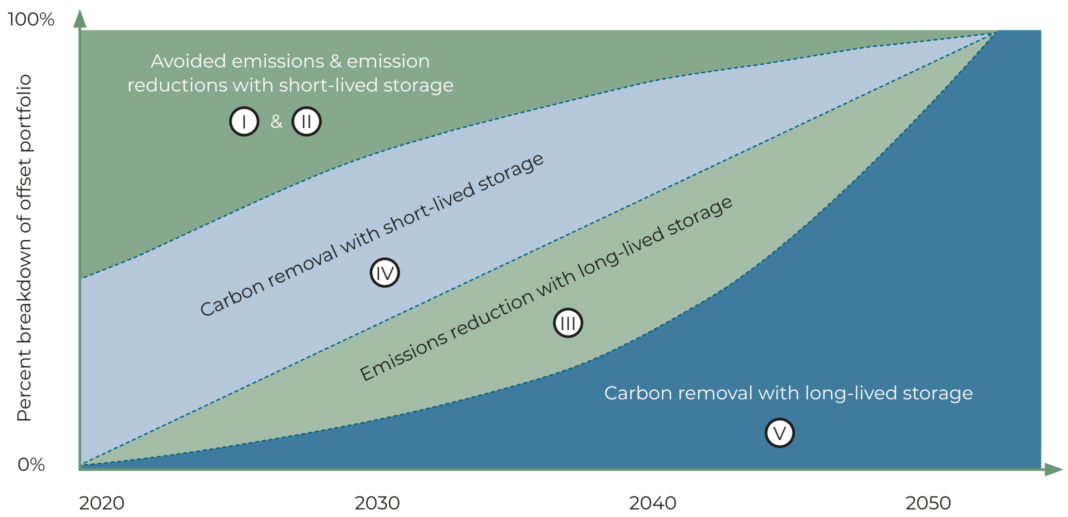


Figure 10 Example net zero aligned offsetting trajectory (Allen et al. 2020)

Further questions to investigate on permanence:

1. How scheme incentivizes projects to achieve long-term carbon sequestration?
2. What tools scheme can provide to assess non-permanence risks and are the tools suitable for all projects?
3. How scheme guides project owners to handle risk of reversals?
4. Does scheme offer different rules and criteria for projects with different longevity on permanence?

7.3.2 Additionality

Additionality is the process of assessing whether a proposed activity is different than its baseline. Presenting convincing additionality in carbon sequestration project is crucial factor for achieving true climate impact and GHG reduction in atmosphere. Three aspects of additionality are considered and tested most often in project level evaluations: financial, environmental, and regulatory additionality.

Financial additionality refers to actions that the project owner would only take if they received rewards from the mechanism correspondingly without the mechanism rewards, the costs of the action would outweigh the benefits.

Environmental additionality refers to whether the mechanism induces climate actions that would not have occurred in the absence of the mechanism and that lead to additional GHG reductions from atmosphere.

The basic approach to derive environmental additionality is using the measurement approach, comparing the value of carbon stock in soil or in biomass at the start of the project with the predictable value at the end of the project period. The main criticism of environmental additionality is that it contains the implicit assumption that all lower emitting technologies, practices, or behaviour than those in the reference scenario either: a) face barriers and will not occur in the baseline; or b) that even if they would occur in the baseline, they would still benefit from being considered additional and being rewarded. Hence, the validity of this additionality concept requires an accurate assessment of the reference or baseline scenario. If this concept is achievable, it can be as equally stringent as other concepts.

Regulatory Additionality refers to a situation where credits shall not be earned for actions that are mandated by law or to achieve compliance with policy requirements. As an example, in both California and Quebec, legal additionality has been imposed such that in the linked markets, offset projects must be additional to both jurisdictions' legal requirements.

The usual problem with the additionality is that it is a subjective attribute and evaluated without quantitative measurements (Gillenwater 2012). On scheme level it is necessary to define the requirements for additionality and connect it to baseline setting. Carefully set baseline can offer objectivity and quantitative measures for monitoring and testing the additionality. The challenge is to connect baselines and additionality from project level to international climate targets.

Testing additionality

Most of the current schemes test additionality in project planning phase. Additionality is difficult to determine in practice due to its nature of subjectivity. Therefore, many different tools have been developed to improve the accuracy of evaluations and to minimize the administrative burden. Additionality can be evaluated with two different approaches: project-based additionality testing and performance standards. In project-based additionality testing each project is evaluated on a case-by-case basis. Commonly used, for example CDM tool, additionality tests for project-based evaluation are legal and regulatory additionality test, investment test, barriers test and common practice test where all steps are not mandatory. This CDM tool for the demonstration and assessment of additionality is widely used by for example in Verra, Gold Standard and Woodland Carbon Code methodologies. In order to achieve additionality, the scheme should offer the regime to measure the baseline from the start of the scheme's period of operation (COWI et al. 2021). Performance standard evaluation is testing additionality from technological perspective and tests whether a certain technology or practice is in common use. There may be local barriers for practices which may be common in some other place and therefore there may be a need for creating regional additionality assessments (World bank 2016).

Further questions to investigate on additionality:

1. How different i.e. financial, regulatory and environmental additionalities are defined in scheme? For example, financial additionality may be difficult to address if carbon farming actions are subsidized by scheme.
2. What are scheme's tools for testing additionality? Can tools assess the level of non-additional risk instead of being a feature that either is 100% in place or is not 100% in place? Can tools offer regional assessment for testing additionality?

7.3.3 Baseline

The Paris Agreement draft suggests several options for baseline. It is still undecided which baseline options will be allowed in the Paris Agreement. It has been suggested that the methodology should "encourage an increase in ambition over time". The baselines are suggested to be "taking into account relevant national, regional or local circumstances" and possibly also "ensuring environmental integrity". The baselines suggested in the Paris Agreement are for calculating emission reductions, however, it is still unsure if they are meant to be applied also for carbon removals. The current baseline suggestions for the draft are:

- Performance-based approach
- An approach based on "business as usual" emissions
- An approach based on historical emissions
- Benchmark baseline approach, with an ambitious benchmark representing a level of GHG emissions for activities within a defined scope and boundary

The baseline options suggested for the Paris Agreement have been analysed in OEDC & IEA (2019).

We evaluated the following baseline options and their suitability for carbon sinks in carbon farming and carbon forestry practices:

- Business as usual
- Historic emissions approach
- Performance based approach
- Benchmark approach
- Best available technology approach

OEDC & IEA (2019) and an internal workshop and discussions have been used as a base for the evaluation.

Three of these (Business as usual, historic emissions approach and benchmark approach) seem to fit well as an environmental baseline for carbon sinks. The other two options seem to work better as a value of comparison, and not as a baseline as such.

Issues common to all the baseline suggestions:

Must decide:

A. The locality of the baseline. In other words, if the baseline is set e.g. as EU wide, nationally, farm level, or based on field level.

B. If the baseline is modified over time in case of changes e.g. in climate, climate targets or technology occur.

In the case of point, A, the narrower is the area in concern, the fairer is the system for the farmer, as the farmer is competing against itself, instead of other farmers in the area of concern. This also leads to the situation where carbon farming is feasible in more farms, and not just in those which are closer to the baseline in their existing situation. It should be noted that often there is more potential for carbon sequestration in those areas where actions for carbon sequestration have not been done yet. In those farms, the expenses of the initial carbon sequestrated is also lowest, as no actions, even the most inexpensive ones have not been executed yet.

For the point B, updating the baseline over time would make sense to not to lose the ambition of climate targets and to ensure additionality is achieved at every point of time. However, in case of long projects, knowing the baseline might change over time might turn out to be a risk for the farmers, as the amount of carbon removals achieved is highly dependent on the baseline level.

Business as usual baseline

Definition: Create a future scenario on emissions/sinks in a normal situation. The future scenario is based for example on EU climate targets. After carbon has been sequestered, compare the actual situation to the scenario.

If the baseline is set on according to the current climate targets, meaning zero-emissions at the LULUCF sector, only carbon sequestrated on top of the climate targets would be eligible. Thus, this would ensure the EU would achieve its climate target's in the LULUCF sector as only the carbon sequestrated on top of that would be eligible to be sold to other sectors.

Table 16 Advantages and challenges of business as usual baseline

Advantages
• The zero-emissions target in the LULUCF sector could be achieved even though carbon removals would be sold to other sectors. • Simple baseline, which is also easy to understand by buyers. • Carbon sequestration would be concentrated on areas with the highest potential and viability for carbon sequestration.
Challenges
• Requires a lot of data. • Requires a lot of assumptions on the future.
Other comments
• The destruction of carbon sinks before commissioning the programme should be prevented. A way to prevent this could be e.g. prohibiting land use change retrospectively.

Historic emissions baseline

Definition: the baseline follows the historic emissions trend. The most sensible would seem to be to set the baseline according to a historic trend, not a single year.

Table 17 Advantages and challenges of historic emissions baseline

Advantages
• Easy to determine, only need the historical datas. • EU nationwide data is available in the LULUCF inventories. However, details lacking from the data varies depending on country.
Challenges
• Does not consider the current emissions targets, and thus does not encourage to ambitio. • Does not consider the development of technology or current emissions targets unless baseline is updated regularly.
Other comments
• The destruction of carbon sinks before commissioning the programme can be easily prevented if there is enough historic data to show the historic land use.

Performance-based approach

Definition: Evaluate the carbon removals achieved by comparing it to similar actions made elsewhere. The reference level can be set in different ways: e.g. best achieved level, best available level, or average achievements of top x %.

Using the performance-based approach as an environmental baseline would mean that carbon sequestered should be determined by measuring the carbon level before and after the activity, and the result should be compared with the reference result. In this case, only actions that would result to more carbon sinks than the reference value of that activity, would be additional. This would not serve the purpose of the scheme, which is sequestering carbon, not optimising the results of actions. Another issue supporting the unsuitability of performance-based baseline, is that with current measurement technology and accuracy, it would be practically hard or even impossible to conduct reliable measurements before and after each action.

The performance-based approach in setting a baseline fits well to emission reductions in e.g. energy production. However, in the case of carbon sinks, this approach would work better as a reference value for achieved results. If the carbon removals due to the same action performed elsewhere would be measured, this value could be applied for each time the same action is performed under similar conditions. With this kind of approach, other type of baseline (i.e. economic or legal) could be applied, if seen relevant. For example, a certain amount of carbon could be agreed to be sequestered with a certain action under certain conditions, if the economic and/or legal additionality requirements would be fulfilled.

Table 18 Advantages and challenges of performance based baseline

Advantages
• -
Challenges
• Requires measurement before and after activity - expensive and not reliable. • Encourages to maximizing efficiency of actions, not maximizing the carbon sequestration. • Carbon sequestrated by an activity is highly dependent on the type of soil and climate, which would lead to actions only in areas with the best result potential for certain actions.

Table 19 Advantages and challenges of performance based approach for reference value

Advantages
• Fit for actions which's results are independent on location
Challenges
• Too simple; assuming the same results in several places due to same action.

Benchmark approach

Definition: based on ambitious reference value representing a level of GHG emissions for activities within a defined scope and boundary.

The benchmark approach can be considered as one type of performance-based approach. The difference is that the benchmark approach is even more ambitious, as the reference value is set with ambition, not necessarily based on peer results. However, the benchmark approach would not fit as a reference value, as the reference value would be higher than the actual achieved good, due to the ambitious level of the reference value.

This kind of benchmark might be too ambitious for some farmers, especially for those who are starting with a low carbon sink. Here it is important to note that those lands with low carbon sink are often the ones with highest potential on carbon farming. Here again, the more specifically is the benchmark set regarding areas (nationwide benchmark vs. field based), the smaller the gap that farmers have to reach to be able to reach the baseline before being able to produce additional carbon sinks.

The benchmark baseline would certainly be additional due to the ambitious baseline. As carbon farming has many other benefits in addition to carbon sequestration, a question arises, if carbon farming is feasible for other reasons too. Financing meant for carbon sequestration should only be used for the carbon benefits of carbon farming, while other benefits from carbon farming could be financed from other sources (e.g. money meant for carbon sequestration should not be directed to improved water supply due to carbon farming.) Co-benefits of carbon farming might themself be encouraging enough to practice carbon farming until a certain point. Only after this point has been reached, society's money meant for emissions reductions should be directed for carbon farming. Therefore, showing economic additionality is important.

Table 20 Advantages and challenges of benchmark baseline

Advantages
• Additional due to ambitious baseline.
Challenges
• Too high of an ambition might discourage farmers to participate. • Discourages participation of farmers with land of low carbon, and highest potential on increasing the sinks. • Requires data/research on different soils.
Other comments
• Could CAP encourage to carbon farming until the baseline?

What if baseline is set according to critical threshold concentration of soil organic carbon?

The pressure to increase crop production has led to expansion of agriculture land area and intensification of cropland management. Irrigation and fertilization are such practices that are used to increase yields, but they have also led to degradation of land and waters. These negative side-effects have risen the question how crop productivity could be maintained and enhanced while at the same time decreasing the environmental impact (i.e., sustainable intensification).

Land degradation is a process where soil loses its productive capacity. One concrete result of this is the loss of soil organic matter, which can be measured as a soil organic carbon. Soil organic matter is important part of soil, and it affects many soil properties from water and nutrient holding capacity to soil structure (Robertson et al. 2014). Building and managing soil organic matter ensures stable crop productivity and decreases the need of external inputs, such as mineral fertilizers. The critical level of soil organic matter, or more accurately, the critical level of soil organic carbon has been identified to annual crops in temperate regions. The critical threshold value for soil organic carbon is approximately 2%, under this concentration, the soil functions are threatened which affects negatively to the yields (Oldfield et al. 2019). In other words, increasing soil organic carbon concentration to 2% increases also yield levels, which means that carbon sequestration up to that point adds agronomic benefits to farmer. Soils can accumulate larger concentrations of carbon into soils, but after the threshold value, there is no linear relationship with yield levels. Increasing soil organic carbon could potentially also maintain current yields but reduce considerably (potential even to 50-70% reductions) the need of nitrogen fertilization (Oldfield et al. 2019).

If additionality criterion is interpreted so that these agronomic benefits are considered, the baseline should be set based on this critical threshold value, and only after other benefits, the farmer could receive payment from the sequestrated carbon.

Baseline set according to threshold level would be only possible if such critical values can be identified to different regions and soil types. Increasing soil organic carbon content from low levels (e.g., 0.5%) to 2.0% is a very large increase and it would also require significant amount of organic inputs (e.g., farmyard manure, compost) which may not be available to farmers due to cost and access reasons (Poulton et al. 2018). To build such carbon body to soil also takes several years, even decades (Poulton et al. 2018). On the other hand, this approach would ensure that carbon payments are truly additional. To reach that critical threshold value would require long term changes in land management practices, especially in most degraded lands, but farmers would be rewarded with agronomic benefits while climate would benefit from continuous carbon sequestration.

Soils are naturally different, and even if organic soils are excluded from this discussion, the natural soil organic carbon content in mineral soils varies. This sets landowners to unfair situation. If baseline is set to a level of critical threshold value, some farmers reach baseline right off while others try to build the stock, even though their management practices have been similar before. However, the threshold value baseline is ambitious, and it thus acknowledges the farmers that have already done practice to sequester carbon to soils. This ambitious approach needs public funding like farming subsidies to incentivize multiple benefit practices to reach critical soil organic carbon level. Both public and private funding for soil carbon sequestration should also reward for maintaining carbon stocks (Joona 2020).

Best available technology approach

Definition: A type of "performance-based approach", where a best available technology (BAT) used as a reference. Restrictions like economic feasibility could be used when choosing the best available technology, and the best available technology could be dependent on the country and activity.

As Table 21 indicates, the best available technology approach might fit better for emission reductions in e.g. energy production, not to carbon sequestration.

Table 21 Advantages and challenges of best available technology approach

Advantages
• -
Challenges
• The BAT list is not always up to date, as new technologies might exist but is waiting for evaluation to be able to enter the list. • The BAT list is often subjective and too static. Hard to keep updated and to incorporate regional/local circumstances. • BAT would work if we had overproduction of carbon sinks, and we would only want the best. However, now we should encourage also the worst to work.

Further questions to investigate on baseline:

1. How to set the baseline which is additional on project level, national level and EU level or even international level?
2. Is it even necessary to build baseline that is additional in all levels mentioned in previous question? Would very ambitious baseline hinder the up-scaling carbon farming actions?
3. How to set baseline on project level in order to achieve real removals and still avoid over-crediting?
4. How baseline is considered with practices that lead only to emission reductions e.g. change in cultivation practices on organic land?

7.3.4 Carbon leakage

Carbon leakage may occur in multiple levels, between countries, economic unions, national and regional level. Carbon leakage is a situation when emission reductions in one place conduct increased emission in another place for example industrial production transferred to a country with vague NDCs (Nationally Determined Contributions). Carbon leakage may also occur in situation when increased carbon sequestration in one place leads to less sequestered carbon on another location for example relocated logging. Carbon leakage is attached to production costs and pricing of the products or costs related to climate policies hence in other words carbon leakage is an economic phenomenon.

Murray et al. (2007) states that the more sensitive the supply is to price change, and the less sensitive demand is to price change, the larger is the carbon leakage. Also, according to Nurmi & Ollikainen, carbon leakage is more problem in smaller projects than in bigger projects, as in smaller projects the price does not change much, but demand will be quickly fulfilled elsewhere.

On agricultural sector "policies that shift in land use practices can alter prices and influence the behavior of individuals not engaged in the policy" Murray et al 2007. As an example, a change in tillage practices may lead to reduction of supply which would increase prices and overall lead to increase of farmland area to fulfill the demand on the market.

For forested area an example of leakage is described in Nurmi & Ollikainen's report. Carbon leakage is problematic if the carbon market scheme is voluntary for foresters. When not all the foresters are not part of the scheme, the ones not part of the scheme will be able to profit by increasing their wood supply due to decreased wood supply by voluntary carbon foresters. The problem appears when foresters part of the scheme will be rewarded for additional carbon storage, but foresters not part of the scheme will not be punished for decreased carbon storage. However, carbon leakage is a problem only when carbon storage leads to decreased supply. For example, wasteland forestation does not lead to carbon leakage since it does not affect to wood supply to market.

Further questions to investigate on carbon leakage

1. How to increase biomass i.e. sequestered carbon in forests and respond to growing demand on renewable materials and prevent carbon leak simultaneously?
2. How to ensure that carbon farming methods which may (temporarily) decrease yield and increase prices for crops does not lead to a situation where becomes pressure to increase farming area simultaneously?

7.3.5 Double counting

Double counting of carbon removals is a risk for environmental integrity when global emissions increase due to international carbon credit transfers instead of decreasing. Double counting occurs if credits are counted twice under different accounting systems. Under Paris agreement all countries are setting their own emission reduction targets, National Determined Contributions (NDC) which may lead to a situation where credits are counted on project level and to national emission reductions. As a result, the total GHG emissions are higher than reported by countries. Paris Agreement (6.2.) clearly aims to prevent double counting and aims to ensure environmental integrity where especially voluntary based mitigation outcomes are internationally transferred towards NDCs.

There are several occurrences for double counting (ICAO 2019):

1. Double issuance arises if more than one CRC is issued for the same emissions or emission reductions. Robust registry system or reliable program can control the risk of double issuance.
2. Double use occurs if same issued CRC is used twice or is duplicated in registries. Reliable transparency of registries may prevent double use of CRCs.
3. Double claiming is a result when same mitigation action is counted by multiple parties. Common international accounting rules can hinder double claiming.

Variation and diversity on NDC accounting between countries is a key challenge when tackling double counting. Robust and transparent accounting system with common accounting rules for transfers inside EU could assist ensuring environmental integrity. Challenges for counting arises also from the CRC units where different metrics e.g. GWP values may be used.

Article 6 is attempting to set the rules for International Transferred Mitigation Outcomes (ITMOs). Before PA rulebook is agreed and unified accounting system is in place, Carbon farming scheme could set the rules or guidance how project owner can actively prohibit double counting. For example, CORSIA demands proof from the projects on how double counting is addressed. If international transfers are allowed from the scheme there should be a system to prevent double claiming and way for project to address the credits outside EU.

Further questions to investigate on double counting:

1. How the scheme steers the registry, issuance and retirement of credits to prevent double use?
2. How the scheme builds the boundaries between international, EU, national and local levels to prevent double claiming?
3. What are the counting systems and units used in scheme and are the same for all participants acting in the market?
4. What actions are needed from the different participants e.g., farmers to avoid double counting?

7.4. Environmental impact

Do no harm criteria should be a minimum requirement also for other environmental impacts such as biodiversity, water system, or land use change. It is not self-evident that all carbon farming and carbon forestry actions will provide environmental co-benefits e.g., planting invasive species may lead to unwanted risks beside carbon accumulation. European union has long tradition in assessing the effects of certain projects on environment (Environmental Impact Assessment (EIA) Directive 2011/92/EU and amendments 2014/52/EU), which forms the rules for environmental impact evaluation in the Europe Union and could be considered for setting a base for do no harm criteria on scheme level or project level. Additionally, carbon farming and forestry have a great opportunity to implement going beyond actions rather than just keep on do no harm criteria and create a positive environmental effect. In case a project would create verifiable positive effect, it could also create added value and attractiveness in the market.

Further questions/actions to investigate on environmental impact

1. What are the legal requirements for environmental impact assessment? Does national legislation require environmental impact assessment for carbon farming / forestry project?
2. How Environmental impact are assessed in different carbon farming schemes on voluntary market?
3. Who would be a proper party to carry out impact assessment?
4. Does “one size fit for all” or does the impact assessment model need to be scalable?
5. LIFE CarbonFarmingScheme work package A1 will assess possible negative environmental impacts while modelling carbon sequestration in test farms and forests.

7.4.1 Biodiversity

On carbon farming and carbon forestry actions biodiversity is strongly one part of carbon sequestration process. Therefore, biodiversity could be one criterion on such applications that are related and depend on the nature. Technical solutions such as direct air capture has likely different effects and need distinct examination.

EU biodiversity strategy outlines the plans to improve and enlarge a coherent network of protected areas, restore and build ecological corridors for improving nature's resilience capability and use all ecosystems in sustainable manner (EC 2020c). There is evidence that by increasing biodiversity the nature's resilience improves and soil organic carbon accumulation grows which indicate that such systems are able offer carbon credits with lower non-permanence risk and eventually also buffers would be lower (Liu et al 2018, Nef et al 2021, Oliver et al 2015, Prommer et al 2019).

Carbon farming and carbon forestry actions are both supporting the biodiversity targets and corresponds to EU Forest Strategy where plan is to plant 3 billion additional trees inside EU borders by 2030 and additionally on agriculture the regenerative farming practices endorse to reduce fertilizers. The minimum requirement for carbon removal certificates should be no-harm doing criteria and tools to avoid critical damages to biodiversity. More ambitious approach would consider biodiversity as an advantage and would set target for biodiversity enhancement through nature-based solutions. It is evident that carbon farming and carbon forestry actions will vary and clear comparability between different features on credits could make a difference on price and attractiveness of credit. Despite the fact that content of the CRC will be even more complex by including biodiversity to criteria, the scheme should offer the credits in simple and understandable package to all participants.

Further questions/actions to investigate on biodiversity:

1. What requirements are already in place for biodiversity in EU area schemes that concern land use?
2. Does/Can scheme regulate biodiversity in similar manner than other criteria e.g., leakage?
3. Can biodiversity be covered in carbon credits by scoring the biodiversity actions which would improve the quality, and which would increase the value of such credit?
4. LIFE CarbonFarmingScheme work package A4 will study further incorporate a summary of the impact of carbon farming practices on biodiversity and include aspects of impact on nutrient leaching and climate resilience.

7.5. Social criteria

7.5.1 Do no harm: due diligence

The 'do no harm' principle is proposed to form the basis for all projects. This means that parties should respect human rights and take a human-rights impact centered approach in identifying potential impacts of the project, and furthermore address and account for the impact appropriately.

To respect human rights is the baseline for all corporate social responsibility. Once the do no harm perspective is ensured, it is encouraged to go beyond this and contribute on positive impact on society.

In this regard, parties are suggested to respect and follow international guidelines (in particular the OECD guidelines for Multinational Enterprises and UN Guiding Principles on Business and Human Rights) and international laws, conventions and treaties (by ILO and UN). By human rights, it is being referred to all universally recognized human rights often clustered as follows: labour rights, economic, social and cultural rights, civil and political rights, and rights and protections belonging to vulnerable groups or individuals. In the European Union, the Commission is in the process of preparing a draft legislation on mandatory human rights and environmental due diligence. The draft legislation is notably based on the OECD guidelines for Multinational Enterprises and UNGPs.

The social criteria are suggested to be set up along with other criteria first and foremost to ensure that carbon farming and carbon forestry is to be conducted without doing harm to people and individuals. With proper due diligence being in place, it can be ensured that carbon farming and carbon forestry addresses any possible negative impacts.

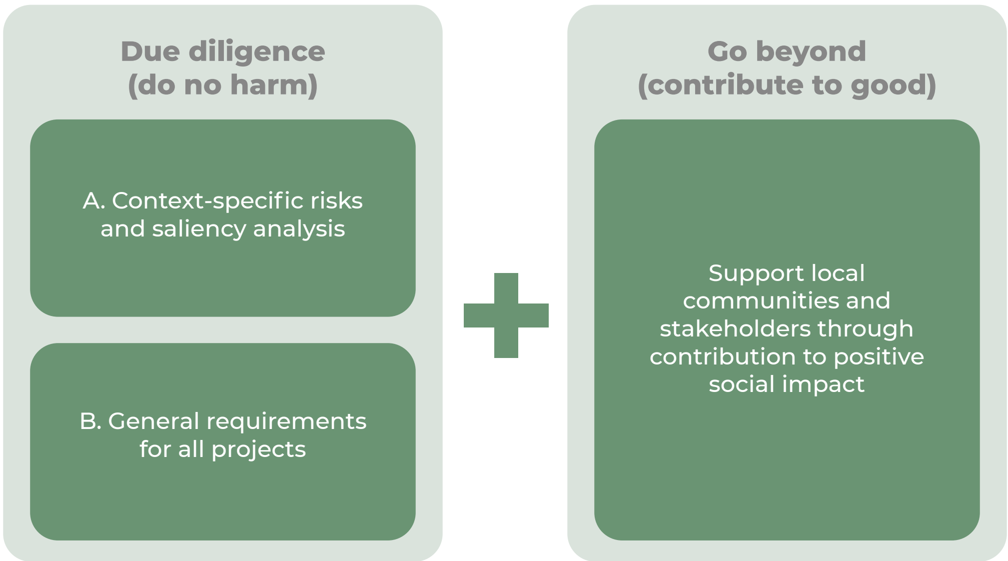


Figure 11 Set-up of the social criteria for carbon farming and carbon forestry

Further questions/actions to investigate on do no harm principle:
The LIFE CarbonFarmingScheme recognise the OECD guidelines for Multinational Enterprises and UN Guiding Principles on Business and Human Rights and international laws, conventions, and treaties (by ILO and UN) and in the European Union, the Commission preparation for a draft legislation on mandatory human rights and environmental due diligence. Based on these, what kind of model can be formed for due diligence?

1. How the overall process of due diligence and human rights impact assessment could look like?
2. Consider if “one size fits for all” or does the impact assessments model need to be scalable? Do impact assessments cover all parties regardless of size? Consider if the impact assessments are on-going or periodically conducted exercises.
3. Consider who would be a proper party to carry out impact assessments and what are the general competences required from the assessors.

These questions are suggested to be further investigated in the LIFE CarbonFarmingScheme working package C3.

7.5.1.1 Social criteria for do no harm

The social criteria that fall under this do no harm principle can be divided in two parts:

A) Social criteria that are context-specific, and require a risk-based approach and saliency analysis.

B) Social criteria that are required for all carbon farming and carbon forestry projects, regardless of country, location, type of project, etc.

A. Context-specific risks

Projects should analyse (identify and assess) human rights risks and impacts. All universally recognized human rights should be considered when seeking to analyse impacts of a project;

- Economic, social and cultural rights
- Civil and political rights
- Labour rights
- Rights belonging to particularly vulnerable groups and individuals

Analysing the human rights context should be done for country, regional and local level, and include business activities and partners involved in the project. When conducting the contextual analysis, laws in the country of the project should be analyzed to identify whether there are areas of concern as benchmarked with international human rights standards.

Understanding human rights stakeholder perspectives is crucial in the human rights analysis. Such stakeholders may include the following (on global, regional, country or local level); unions, workers, watchdog organizations, NGOs, think-tank organisations, national human rights institutions, United Nations, ILO, intergovernmental organisations, etc. Reviewing credible public media is also good practice. It is also noted that human rights risks are often closely interlinked with corruption and unethical business practices, as well as environmental impacts.

Whilst projects need to address all their impacts on human rights, they should in accordance with international standards prioritize the most severe ones, meaning the most severe ones to those humans that are affected. Those impacts on people that stand out as being highest risk, are often referred to as salient human rights issues. The analysis of salient issues is based on evaluation of a potential or actual adverse impact severity - scale (gravity), scope (number of individuals), and remediability (possibility to restore to prior situations) to human rights.

Further questions to investigate on country context review:

A key component of analysing (identifying and assessing) human rights impacts, as well as acting on them– is to listen to the affected stakeholders about their views on impacts and plans on how to mitigate the impacts.

1. Investigate how to conduct stakeholder mapping and how to approach stakeholder engagement, including considerations to sensitivities of rightsholders and what constitutes good practice.
2. Considerations on how to determine context-specific risks and impacts and conduct saliency analysis.

These questions are suggested to be further investigated in the LIFE CarbonFarmingScheme working package C3.

B. General requirements for all carbon farming and carbon forestry projects

The general requirements are social criteria that should be required for all carbon farming and carbon forestry projects, regardless of country, location, type of project, etc. LIFE CarbonFarmingScheme project has recognised general social criteria, that are expected to be salient for all projects. These requirements in carbon farming and carbon forestry projects are suggested to include at least following:

- Workers' freedom of association and right to organize and collective bargaining.
- No Forced Labour
- Minimum Age / Child Labour
- Remuneration
- No discrimination
- Decent working hours
- OHS (occupational health & safety)
- Recruitment
- Complaints mechanism
- Rights of migrant workers
- Access to health care and education
- Land-rights

Further questions to investigate on general requirements:

1. To validate and further develop the general minimum criteria, it is suggested to be tested and validated with affected stakeholders. Based on this validation it can be considered, if any other general requirements for social criteria should be included.

This question is suggested to be further investigated in the LIFE CarbonFarmingScheme working package C3.

7.5.2 Going beyond – contributing to positive social impact

This principle is defined as positive impact on people or individuals and can only be seen as going beyond and to 'do good' if the do no harm principle, baseline responsibility, is properly implemented first, and no harm is being done to environment nor people through business practices and any harm that does occur is properly managed and mitigated.

Farmers and foresters should be encouraged to apply the do good principle to the carbon farming and carbon forestry projects they propose. This means that projects with a positive effect on people (whether these are workers or people in the community) could be rewarded.

Some examples to determine if a project has a positive social impact:

- Baseline responsibility: Have salient issues and negative impacts been identified and properly mitigated? (due diligence on do no harm principle)
- Is this project bringing benefits to socially disadvantaged groups? How?
- What are social needs of the (local) community, workers, or other people affected by the carbon farming project? How will these needs be met through the project?
- Does the project contribute to local employment? Are male/female workers both represented?
- Does the project promote the sustainable transfer of knowledge?
- Other – what are the benefits of this project for people?

Further questions to investigate on going beyond:

1. What kind of positive social effects on people have been recognized in the existing carbon farming schemes?

7.5.3 Developing and validating the social criteria

The do no harm principle should form the baseline for all activity and means that there are right tools in place to prevent human rights impacts, potential harm to individuals and people, as a result of a project or business activity. In order to form due diligence appropriately, this approach should be risk-based: parties need to identify where potential risks to human rights and thus people may occur, and account for and mitigate those risks accordingly. For all potentially affected individuals, a grievance mechanism must be in place where grievances are transparently and properly handled.

This proposed approach for social criteria and model is respectively suggested to be tested, validated and further developed conjunction of implementing the Working Package C3 ‘Socio-economic impacts’ of this LIFE CarbonFarmingScheme project. The work will include engagement with the affected rights-holders as this is a key requirement for each of the due diligence steps, which means that adversely affected stakeholders have to be listened to in order to understand whether it is correctly identifying and managing the impact.

Actions to investigate on the LIFE CarbonFarmingScheme Working Package C3 ‘Socio-economic impacts’:

1. Consider and develop suggestion on how the overall process of due diligence and social impact assessment could look like
2. Investigate how to conduct stakeholder mapping and how to approach stakeholder engagement
3. Consider how to determine context-specific risks and impacts and conduct saliency analysis
4. Through engagement with stakeholders validate and further develop the general social criteria
5. Through piloting an impact assessment, gain understanding of the social (potential and actual) risks and impacts of carbon farming initiative and gain understanding of the possible ways to manage and mitigate impacts
6. Consider who would be a proper party to carry out impact assessments and what are the general competences required from the assessors

8. Monitoring, reporting and verification

Monitoring, reporting and verification (MRV) is an important part of the value chain of CRC especially when carbon farming projects receive result-based funding and CRCs are sold in a market place. Monitoring of carbon sinks refers to measuring or modelling the amount of carbon sequestered. Our report on calculation methods (Carbon Farming Scheme 2020b) goes into more details in different monitoring methods. Reporting of carbon sinks refers to reporting of the values related to the quantity and quality of the carbon sink, obtained in the monitoring phase. Finally, verification of carbon sinks refers to verifying the validity of the values to be reported.

I4CE (2019) and a study ordered by the Finnish Ministry of the Environment (2019) identified the high cost of MRV as one problem in the current European CRC market. Complicated, burdensome, and expensive processes related to MRV can be a barrier for market entry for farmers and foresters. Some carbon market systems have already implemented simplified and innovative ways to lower these costs, yet more solutions are still needed to be implemented to encourage the participation of all the projects with high potential on carbon farming. Often scheme or project developers have to make a compromise between the expense and precision of monitoring the amount of carbon sequestrated.

8.1. Monitoring, reporting and verification of biofuels

The use of biofuels in fulfilling EU and national climate targets is regulated the Renewable Energy Directive, which also sets sustainability criteria and the requirements for MRV. In this section the MRV system used for biofuels is described in order to understand other systems present currently and how we could learn from them when building new ones.

Companies can demonstrate the sustainability of biofuels by establishing a sustainability scheme. Sustainability schemes are similar to quality systems or management systems which can be certified by third party certification bodies. The voluntary and national schemes recognized by the EU are valid in all the EU member states when companies want to demonstrate sustainability of their biofuels.

The sustainability schemes of companies must be approved or audited to those parts which are not already certified. For example, if an economic operator buys biofuels with a voluntary scheme sustainability certificate, only the operations after receiving the certificate, for example mass balance and documentation have to be approved or audited.

An economic operator with an approved sustainability scheme can provide a proof of sustainability for biofuel and bioliquid batches. A proof of sustainability includes the sustainability information of a certain batch of biofuel. The proof of sustainability must include at least the following information:

- A unique number that identifies the batches
- Quantity and type of biofuel or bioliquid
- Feedstock used
- Origin of the feedstock
- Greenhouse gas emission reduction and calculation method

Companies must report the authorities about the biofuels and bioliquids claimed sustainable each year. Depending on the company and the nature of operation, these are the biofuels and/or bioliquids produced, supplied to consumption or combusted. According to most schemes the companies must be audited by an external independent auditor yearly.

Unsustainable biofuels cannot be used for filling the biofuel obligations or claiming tax exemptions. Also, state aid cannot be received. If the sustainability of biofuels is not demonstrated, they are treated as fossil fuels.

Monitoring

The Renewable Energy Directive sets rules for how the share of renewable energy and the emission reduction of renewable fuels is calculated and gives default values for the energy content and life-cycle emissions of fuels.

For showing that sustainability criteria are fulfilled, economic operators are required to use a mass balance system.

Economic operators establish sustainability scheme to monitor sustainability.

Reporting

According to the Renewable Energy Directive economic operators must report on the greenhouse gas emission reductions and fulfilment of sustainability criteria. The member states must report the information further to the commission.

Verifying

According to the Renewable Energy Directive, member states must ensure that economic operators report reliable information and that an independent auditing is arranged for the submitted information: “The auditing shall verify that the systems used by economic operators are accurate, reliable and protected against fraud, including verification ensuring that materials are not intentionally modified or discarded so that the consignment or part thereof could become a waste or residue. It shall evaluate the frequency and methodology of sampling and the robustness of the data.”

Voluntary schemes approved by the commission and national schemes have been set up for verifying the compliance of renewable fuels. More detailed rules for voluntary schemes have been set with communications and other documents from the commission.

Estimating and verifying carbon stocks from biofuel feedstocks

According to Renewable Energy Directive, emissions from the entire life cycle of biofuels must be calculated. The following type of carbon sinks are taken into account in the calculation:

- annualized emissions from carbon stock changes caused by land-use change
- emission savings from soil carbon accumulation via improved agricultural management
- emission savings from CO_2 capture and geological storage
- emission savings from CO_2 capture and replacement

Improved agricultural management can include practices such as (EU 2010/C 160/02):

- shifting to reduced or zero-tillage
- improved crop rotations and/or cover crops, including crop residue management
- improved fertiliser or manure management
- use of soil improver (e.g. compost)

According to communication from the EU commission (EU 2010/C 160/02) the soil carbon accumulation can be calculated using the formula for annualised emissions from carbon stock changes caused by land use change set in Renewable Energy Directive Annex V, part C, point 7. The calculation method for carbon stocks in the Renewable Energy Directive are based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — volume 4.

According to the Renewable Energy Directive, the emission savings from soil carbon accumulation via improved agricultural management can be accounted only if there is solid and verifiable evidence to proof this. For example, measurements can be taken before the cultivation takes place and with measurements taken within several years intervals.

According to the sustainability criteria set in the Renewable Energy Directive, biofuel shall not be obtained from raw material grown in land with high-carbon stock. Instead of requiring measurements of the carbon content of land, the directive categorizes three different types of land as high-carbon stock land. Land with high-carbon stock is defined as land which in January 2008 was wetland, continuously forested area or had tree height and canopy cover within certain values, but no-longer has the same status.

The land status can be verified from e.g. aerial photographs, satellite images, maps, land register entries/databases and site surveys (EU 2010/C 160/02). Satellite images, for example, help to verify if there has been land conversion in or after January 2008, and if the land is classified as land with high-biodiversity value (e.g. forest land, peatland, wetlands, highly biodiverse grassland).

Tools have been developed for auditors, and for example ISCC (widely used voluntary sustainability scheme) approves the use of GRAS tool (https://www.gras-system.org/) for auditors to confirm that the biofuel feedstock fulfils land-use and biodiversity related sustainability criteria set in the Renewable Energy Directive. The GRAS tool is a free web-based application where spatial data on carbon stock, land use change, biodiversity aspects and social indices have been combined on a map.

In addition to using tools and land data, auditors must visit the sites related to biofuel value chain (raw material plantations, biofuel production plants etc.). Only part of the sites is audited. According to the ISCC scheme rules (ISCC 2020), the minimum sample size is calculated by using the square root of the sites multiplied with a risk factor based on the auditors risk assessment of the sites.

Similar types of data banks and spatial data could be useful also in verifying EU-based CRCs. For example, the national forest inventory in Finland utilizes satellite remote sensing data (multisource inventory where several data sources, like field measurements, satellite data and digital maps are used). In addition, site visits from independent auditors should be required, as with biofuels.

In the biofuels field, a reliable system for ensuring sustainability and criteria fulfilment from the entire value chain enables trading of trustworthy certificates. Learning from the best practices of the biofuel field and other systems such as emission trading systems, could help to build a robust chain of custody system for verifying the criteria fulfilment of CRCs and enable the trading of CRCs.

9. Datapoints

9.1. Data requirements for carbon farming and forestry

There are management practises that are known to affect positively to the size of the different carbon pools in forests and arable land (see sections 3.1 and 3.2). Science based carbon accumulation estimations under certain practises are conducted in working package A1 of this LIFE CarbonFarmingScheme project. Because there are variety of different approaches available and not all are technologically and scientifically at the same phase, measures to demonstrate carbon accumulation on farm level were selected according to current knowledge level. This means that needed scientific background should already exist, practises should be possible to implement, and data needed for calculations should be such that different landowners are able to provide the information or data already exists, because it has been collected to some other purposes. Selected practises to the agriculture were:

- Adding nutrient fibers such as different pulp mill sludges
- Manure application
- Intensification of cultivation into a smaller area, allowing land area for permanent grassland and/or forest growth
- Increasing the cutting height of grasses
- Predicted yield increase (10% or 15%) with improving the knowledge level of good farming practices (reducing the knowledge capacity gap).

For forest carbon sequestration enhancement, the selected practises were:

- Fertilization
- Extending the harvest rotation
- Increasing the forest area.

Calculations for estimated carbon accumulation are conducted based on information collected from farmers via preliminary surveys and interviews. Results are collected and reported by end of October 2021 according to project timetable. Preliminary data needed for carbon accumulation estimations were identified in work package A1 of this LIFE CarbonFarmingScheme project (Table 22) for carbon farming and carbon forestry. Data requirements differ between these two approaches of carbon sequestration and as mentioned, more detailed examples will be presented later.

Table 22 Preliminary data needed for carbon accumulation calculations

Carbon farming	Carbon forestry

• **Main production type**
  o Area
  o Methods
• **Cultivation history**
  o Crop rotation
  o Yield levels
• **Estimation ages of the fields** (When was the forest or swamp cleared into field use)
• **Soil type**
• **Crop production**
  o Crop type, yield level, cultivation area and time of each crop
• **Fertilization**
  o Type, amount and area
• **Animal husbandry** (number of animals per year)
	• **Location specific information**
	  o Coordinates
	  o Altitude
	  o Marine or lake index
	• **Main soil type**
	• **Seeding method**
	• **Fertilization**
	  o Type, amount and area
	• **Forest stand types** (main group or subgroup)
	  o Tree species
	  o Estimation age of the forest
	  o Area
	  o Forest growth capacity
	  o Previous measures

Common important information is climatic region, soil type and overall plant growth capacity under different practices. With agricultural methods, the important information also considers plant carbon allocation (root: shoot ratio, root exudates), residual management and added organic soil amendments. In agriculture, the carbon is sequestrated to soils and the pools considered in these calculations are plant root biomass, dead plant biomass and soil organic carbon. In forestry practices, the data needed for monitoring the carbon sequestration also considers litter input, carbon allocation and fertilization. Forest carbon pools included here are aboveground and below ground biomass and soil organic carbon.

In general, to monitor the carbon accumulation several datapoints are required for robust estimations of changes. The aimed accuracy level determines the final set of needed information. Because the variation and complexity of different carbon farming and forestry approaches, it would be beneficial to set criteria for data requirements. Monitoring criteria can be set in various levels, for example scheme and project level, which allows the implementation of different practises and drives the methodology development towards such monitoring methods, where land managers can evaluate impact of conducted practices in a relatively short time period. Such criteria are listed for example in EU Technical handbook for result based carbon farming (COWI et al 2021), where four simple principles are identified.

9.2. Digitalization and data management in carbon farming and forestry

Data requirements and availability in agriculture and forestry sectors are increasing constantly and carbon farming and forestry schemes are accelerating this demand and increase even more. Efficient use and collection of data is needed because the complexity of interactions in a field. Because this complexity, the set of variables is large and to optimize environmental and agronomic/economic benefits requires complex computation, which is not possible to conduct at adequate scale by land managers by hand. Gathering and utilizing data requires methods and tools which help land managers to mathematically solve the optimization problem and to secure the carbon sequestration. Technologies such as digitally equipped agricultural equipment's, drones, sensors, robots, and artificial intelligence are nowadays used more to gather data for farming and forestry purposes (Fardusi et al. 2017, Heege 2013). These so-called smart farming/forestry technologies increases the amount of data available. Above technologies combined to geographical information system also enables the precision farming/forestry which can be used to solve also the optimization equation. With precision farming/forestry, land managers do not need to relay that much about averaging and accumulated knowledge, but parcels and differences in those can be treated individually with high precision. For example, sowing, fertilizing, irrigating, and harvesting can be done more efficiently, when parcels specific needs can be taken into consideration.

Digitalization increases the amount of data, and the estimated increase is quite steep (Figure 12). To utilize and share the data, different digital platforms could be developed. Well designed platforms provide resources and services which land managers can utilize in their decision making. Digital platforms are more effective if they attract more users. The more the land managers are sharing their data the more accurate predictions the application can provide. Weather data, remote sensing data and input specifications are information that can make digital platforms more attractive (Kenney et al. 2020). For carbon farming and forestry purposes, platforms that gather and share specific data collected by individual land managers could be used to develop more cost-effective monitoring methods for carbon sequestration (e.g. modelling stock changes, or other novel approaches).

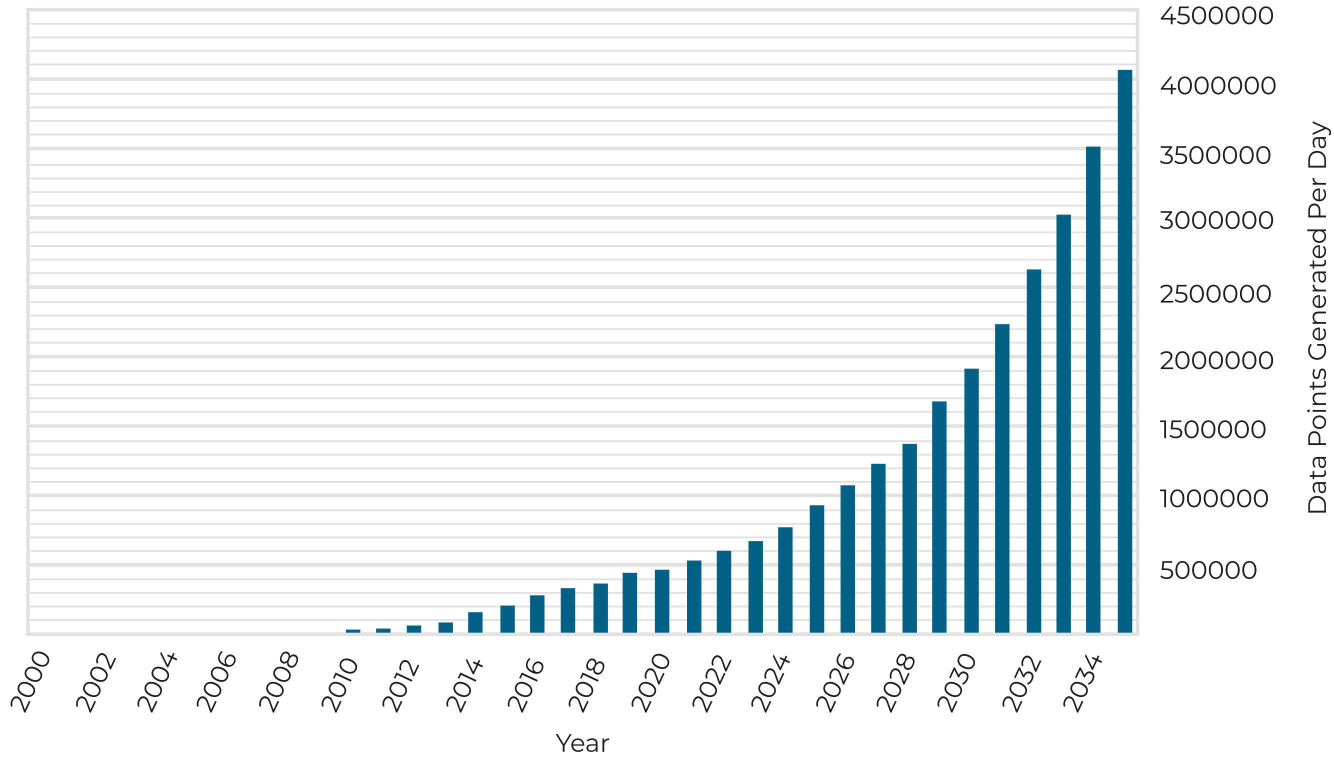


Figure 12 Estimated amount of data generated by the average farm per day (Meola 2016)

Digitalization of agriculture and forestry sectors provide benefits for individual and societies, but it also raises important questions such as how data is organized, who will own the data, are digital platforms developed, and who will gain the benefits. It is also important to understand how data can be processed and extracted, and to determine which data is valuable to whom. Modern farming and forestry are also very depended on different machines and to be able to collect and utilize data in farm level, technologies should be compliant with each other's (at least at some level) and such that they could be integrated to already existing equipment's. For carbon farming and forestry, there is a demand for high quality farm level data from variables that are hard to quantify even with modern technologies (for example soil organic carbon concentration). This might set the land managers to unequal position, because not all are able to use smart farming technologies (for example because of cost reasons), if data requirements and how technology depended they are, are not addressed well.

9.3. Case example: Farm Sustainability Tool for nutrients (FaST) and Atfarm by Yara

Farm Sustainability Tool for nutrients (FaST) is a digital platform that aims to promote sustainable use of fertilizers and digitalization of the agricultural sector in the EU. FaST utilizes the satellite remote sensing data and provides the information to land managers via digital application. With this digital application, farmer can calculate right amount of fertilization to specific area.

Purpose of plant fertilization is to provide nutrients for soils for high crop yields, but without affecting the environment. EU Farm to Fork Strategy sets the target to reduce nutrient losses from agriculture at least 50% by 2030 and more ambitious measures are needed to meet that goal. Fertilization usage can be made more efficient with utilizing the best available practices, like precision farming, in parcel and farm level. Soils and crops vary within individual fields and thus the site-specific fertilization is needed. Sensing methods are utilized in site-specific control of fertilizations, and one possible approach is to sense the nutrient status in crops via optical reflectance from remote (more information can be found from our previous report Carbon Farming Scheme 2020b and info box) and then link that information to parcel or farm level information. Remote sensing can be done from satellite platforms with different approaches and in Europe, Copernicus program provides satellite services that can be utilized in vegetation mapping with Galileo geographical information system.

The FaST is a digital advisory service, which should help individual farmers to improve agronomic and environmental status of their farms by supporting the nutrient planning. It also provides concrete information about legislation and regulation regarding fertilization, increases cooperation and collaboration and increase knowledge of own data. FaST tool benefits also Paying Agencies by providing environmental data, two-way communication, and compliance monitoring. And even though FaST will provide applications also to Paying Agencies and Managing Authorities, it is not used to ensure farmers compliance and farmers input levels. Tool includes several benefits, and one important aspect is to help farmers to optimize the fertilization level for economic, agronomic, and environmental benefits. FaST application will enhance the sustainable agriculture and data handling.

Info box. Fundaments of remote sensing for site-specific fertilization

Information about crop status can be collected by observing differences in reflectance along sections of the electromagnetic spectrum. Optical sensing of nitrogen is based on the effects of nitrogen supply on the crops. Nitrogen increases the chlorophyll concentration per unit area in the leaves and the growth of plant mass (leaf-area-index) of a crop. Knowledge about these interactions enables linking of nitrogen sensing signals to changes in crops via mathematical models, algorithms. With this information, the amount of fertilization can be calculated based on the knowledge of previous yield. Commonly used standard approach to sense the crop canopy via remote sensing is "Normalized Difference Vegetation Index (NDVI)", which can be easily calculated from the reflectance sensed by satellite sensors. The NDVI measures the difference between near-infrared and red light, and the healthier the vegetation is, the more it reflects the near-infrared. Current satellite systems have good spatial and temporal resolution which enables the site-specific nitrogen fertilizing, and other precision farming, based on field maps that are obtained by remote sensing of crop canopies.

Site-specific fertilizing strategies via algorithms include several uncertainties (more information can be found our previous report Carbon Farming Scheme 2020b), and it also includes one problem that can't be solved: amount of fertilization is calculated based on information that are related to the past of the crop and the adequate supply in some weeks of the future can be different than predicted. These uncertainties arise from the fact that weather and water supply of the crop is not known in advance. But regardless of uncertainties the precision farming and site-specific fertilization provides several benefits (Heege 2013).

Member States should implement the FaST at the latest in 2024, and it can be any digital application that provides at minimum: the balance calculation of main nutrients, legal requirements for nutrients, soil data (based on available information and analysis) and IACS (the Integrated Administration and Control System) data relevant for nutrient management.

Member States can customize the common FaST system, use already existing compliance tools, or develop completely own tool with common minimum requirements. One example of existing (but not fully compliance) tool for site-specific nutrient management is Atfarm Smart Farming-tool developed by Yara. Atfarm utilizes satellite images for monitoring crop canopy development which enables the creation of distribution maps for fertilization. Atfarm uses specific algorithms developed to grasses and crops in EU area.

Atfarm is digital platform, where farmer can upload maps and field location to the tool. Application provides satellite pictures, where farmer can choose the picture which presents the last crop or grass yield. With that information, and information about type of fertilization and target yield, the tool creates parcel specific map, where nitrogen input is presented with values kg/ha. This information can be uploaded for example in raster shape data, and then transported to tractors guidance system, ISOBUS system or digital fertilization spreader. If farmer lacks smart farming technologies, the map can also be printed and used as a regular map which instructions to follow.

According to Yara, the Atfarm application improves the nutrient use efficiency and reduces the risk of over and under fertilization, which affects positively to the yield level and quality. Site-specific nitrogen application reduces also the risk of nitrogen losses around 1-6 kg of nitrogen per hectare, depending on the soil type. Nitrogen use efficiency can possibly increase the value of yield even up to 46 €/ha. Atfarm is not currently compliant with FaST requirements, but it can provide for example the nitrogen distribution maps and documented information about nutrient use.

10. Conclusions

The EU aims to increase the carbon sequestration as all the climate change mitigation actions should be considered in order to reach our ambitious climate targets and stop the climate warming to 1.5 degrees. Currently, the EU commission is looking at developing policy for negative emissions and finding the best ways to incentivize carbon sequestration.

To scale nature based carbon sinks in the near future, we must create policy, rules and incentives already now. The following steps must be taken to be able to trade reliable carbon removal credits (CRC) in the EU:

1. Create common EU wide criteria for nature based carbon sinks to enable high quality and trustworthy CRCs. Criteria for carbon farming and forestry are discussed in more detail in section 7.
2. Create common EU wide rules for MRV (monitoring, reporting and verification) practices to enable high quality and trustworthy CRCs. The rules for MRV must be set in a way that the practices are not too burdensome but fulfil the required level of accuracy. MRV is discussed in more detail in section 8.

To scale up the high quality EU nature based carbon sinks, we must set incentive systems:

1. 1. This report introduces different funding methods and their combinations which can act as an incentive for carbon farming and carbon forestry. Carbon Contracts for Difference combine public and private funding and lower the carbon sequesters' investment risk by ensuring stable and predictable income from CRCs.
2. A compliance market for CRCs is a way to create demand for carbon removal credits while financing to nature based carbon sinks flows from private sectors.

This report is produced as a part of LIFE preparatory project LIFE CarbonFarmingScheme "Expanding carbon sequestration activities by providing best practices and guidance for future carbon farming schemes" -project. As a final report of the project, we present guidance of regulatory and policy aspects towards implementation of an incentive scheme.

11. References

Allen, M., Axelsson, K., Caldecott, B., Hale, T., Hepburn, C., Hickey, C., Mitchell-Larson, E., Malhi, Y., Otto, F., Seddon, N., Smith, S. 2020. The Oxford Principles for Net Zero Aligned Carbon Offsetting. University of Oxford. Smith School of Enterprise and the Environment. Available at: https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf

Allianz Research. 2020. European Climate Policy Goes Global. Available at: https://www.eulerhermes.com/content/dam/onemarketing/ehndbx/eulerhermes_com/en_gl/erd/publications/pdf/2020_10_14_CarbonBorderTax.pdf

Benjamin Görlach, Elizabeth Zelljadt. Carbon Leak Risks in the Post-Paris World By Ecologic Institute, Pfalzburger Straße 43/44, D-10717 Berlin, On behalf of the German Environment Agency CLIMATE CHANGE 43/2019, EVUPLAN of the Federal Ministry of Economic Affairs and Energy, Research Report within Project No. (FKZ) 3717 42 506 0, Report No. (UBA-FB) FB000217/ZW

Brian C. Murray & Brent Sohngen & Martin T. Ross Economic consequences of consideration of permanence, leak and additionality for soil carbon sequestration project. Climatic Change (2007) 80:127–143. DOI 10.1007/s10584-006-9169-4

Carbon Farming Scheme. 2020a. Analysis of the market demand mechanisms and the demand potential for land-based carbon credits. Available at: https://content.st1.fi/sites/default/files/2021-02/LIFE-CarbonFarmingScheme-MarketAnalysis-040221.pdf

Carbon Farming Scheme. 2020b. Draft report on calculation methods to be applied in estimating quantitatively agricultural and forest carbon sinks and their stability. Available at: https://content.st1.fi/sites/default/files/2021-02/LIFE-CarbonFarmingScheme-calculation-methods-120221-compressed.pdf

Carbon offset guide. 2021. Additionality. Accessed on 14.6.2021. Available at: https://www.offsetguide.org/high-quality-offsets/additionality/

Carbon Offset Guide. 2021. Permanence. Accessed on 14.6.2021. Available at: https://www.offsetguide.org/high-quality-offsets/permanence/

(carbon)plan. 2020. Carbon removal mechanisms https://carbonplan.org/research/carbon-removal-mechanisms

Climate Action Reserve. 2021. Soil enrichment protocol. Accessed on 14.6.2021. Available at: https://www.climateactionreserve.org/how/protocols/soil-enrichment/

COWI & Ecologic Institute and IEEP. 2021. Technical Guidance Handbook - setting up and implementing result-based carbon farming mechanisms in the EU Report to the European Commission, DG Climate Action, under Contract No. CLIMA/C.3/ETU/2018/007. COWI, Kongens Lyngby.

DG Clima, Technopolis Group, COWI & Exergia. 2021. Final workshop to support the evaluation of art.7a of the Fuel Quality Directive. Organized on 20.4.2021.

DG internal policies. 2015. The impact of biofuels on transport and the environment, and their connection with agricultural development in Europe (IP/B/TRAN.IC/2012_117).

EC. 2020a. COM/2020/562. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562

EC. 2020b. EU Green Deal (carbon border adjustment mechanism). Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12228-Carbon-BorderAdjustment-Mechanism

EC. 2020c. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS - EU Biodiversity Strategy for 2030 - Bringing nature back into our lives. Brussels, 20.5.2020 COM(2020) 380 final. European Commission

EC. 2021. COM/2021/82. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

Ecosphere. 2021. A solution to overcome double-counting in carbon markets. Accessed on 14.6.2021. Available in: https://ecosphere.plus/2018/06/29/solution-for-double-counting-in-carbon-markets/

Ember. 2021. Available in: https://ember-climate.org/carbon-price-viewer/. Accessed on 30th June 2021.

EU. 2010/C 160/02. Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels.

European Commission. EU Space Data for Sustainable Farming. 2020. Accessed on 17.6.2021. Available at: https://fastplatform.eu/

FAO. 2012. VGGT - Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. Available at: http://www.fao.org/policy-support/mechanisms/mechanisms-details/en/c/448858/

FAO. 2016. FPIC - Free, Prior and Informed Consent. Available at: http://www.fao.org/indigenous-peoples/our-pillars/fpic/en/

Fardusi, M., Chianucci, F. and Barbati, A. 2017.Concept to Practice of Geospatial-Information Tools to Assist Forest Management and Planning Under Precision Forestry Framework: a Review. Annals of Silvicultural Research 41.1: 3–14.

Finnish Ministry of the Environment. 2019. Kohti hiilipörssiä? Suomessa esitetyt hiilipörssiin liittyvät aloitteet tutkimuskirjallisuuden ja kansainvälisten kokemusten valossa. Ympäristöministeriön julkaisuja. Vol. 2019:17.

Gobierno de España. 2021. Huella carbono del Ministerio para la Transición Ecológica. Accessed on 14.6.2021. Available at: https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/informesHuella-MITECO.aspx

Gold Standard. 2015. Double Counting Guideline, Scopes Land Use & Forests (LU&F), Energy & Waste (E&W) Version Version 1.0, Valid since November 2015

Gold Standard. 2021. Accessed on 14.6.2021. Available at: https://www.goldstandard.org/

Government of Western Australia. 2021. Carbon farming: applying biochar to increase soil organic carbon. Available at: https://www.agric.wa.gov.au/soil-carbon/carbon-farming-applying-biochar-increase-soil-organic-carbon

Heege, H. 2013. Precision in Crop Farming Site Specific Concepts and Sensing Methods: Applications and Results.

Helge Sigurd Næss-Schmidt, Martin Bo Westh Hansen, Sixten Rygner Holm and Bjarke Modvig Lumby Carbon leak in the Nordic countries, What are the risks and how to design effective preventive policies? Nordic Council of Ministers 2019, TemaNord 2019:525

I4CE. 2019. Domestic carbon standards in Europe: Overview and perspectives. Available in: https://www.i4ce.org/wp-core/wp-content/uploads/2020/02/0218-i4ce3153-DomecticCarbonStandards.pdf

ICAO. 2019. CORSIA Emissions Unit Eligibility Criteria. March 2019.

ICF Consulting Services Limited and Fraunhofer ISI. 2020. Industrial Innovation: Pathways to deep decarbonisation of Industry Part 3: Policy implications. Available at: https://ec.europa.eu/clima/sites/clima/files/strategies/2050/docs/industrial_innovation_part_3_en.pdf

IPCC. 2018. Special Report: Global warming of 1.5°C. Available at: https://www.ipcc.ch/sr15/

IPCC. 2000. Robert T. Watson, Ian R. Noble, Bert Bolin, N. H. Ravindranath, David J. Verardo and David J. Dokken: Land Use, Land-Use Change and Forest. Available at: https://archive.ipcc.ch/ipccreports/sres/land_use/index.php?idp=0

ISCC. 2020. ISCC 206 Group Certification. Version 3.1. Available at: ISCC 206 Group Certification_3.1_trackchange (iscc-system.org).

Joona, J. 2020. Farmers need incentives to increase soil carbon stocks. Accessed 14.5.2021. Available at: https://carbonaction.org/fi/viljelijat-tarvitsevat-kannustimia-maaperan-hiilivaraston-kasvattamiseen/

Kenney, M., Serhan, H. & Trystram, G. 2020. Digitalization and Platforms in Agriculture: Organizations, Power Asymmetry, and Collective Action Solutions. ETLA Working Papers No 78. Available at: http://pub.etla.fi/ETLA-Working-Papers-78.pdf

Lambert Schneider & Stephanie La Hoz Theuer (2018): Environmental integrity of international carbon market mechanisms under the Paris Agreement, Climate Policy, DOI: 10.1080/14693062.2018.1521332

Liu X et al. 2018 Tree species richness increases ecosystem carbon storage in subtropical forests. Proc. R. Soc. B 285: 20181240. http://dx.doi.org/10.1098/rspb.2018.1240

Meola, A. 2016. Why IoT, big data and smart farming is the future of agriculture. Business Insider (October 11). Available at: http://www.onfarm.com/iot-big-data-smart-farming-future-agriculture/

Michael Arnoldus Roger Bymolt. 2018. A Guide to Developing Carbon Credit Projects, 2018. Available at: https://www.kit.nl/wp-content/uploads/2018/08/1916_Carbon-Credits-web.pdf

MICHAEL GILLENWATER, What is Additionality? Part 1: A long standing problem.Greenhouse Gas Management Institute, Silver Spring, MD. Discussion Paper (version 03). January 2012

Ministére de la transition écologique. 2021. Label bas-carbone : récompenser les acteurs de la lutte contre le changement climatique. Available at: https://www.ecologie.gouv.fr/label-bas-carbone?page=2#e4

Natural Resources Institute Finland. Unpublished research material received from Natural Resources Institute Finland, utilizing the data from Saarsalmi et al.

Natural Resources Management and Environment Department Food and Agriculture Organization of the United Nations (FAO) Rome, 2010: Carbon Finance Possibilities for Agriculture, Forestry and Other Land Use Projects in a Smallholder Context. Available at: http://www.fao.org/3/i1632e/i1632e.pdf

Nef et al. 2021 Initial Investment in Diversity Is the Efficient Thing to Do for Resilient. Forest Landscape Restoration Frontiers in Forests and Global Change | www.frontiersin.org. 6 January 2021 | Volume 3 | Article 615682

Nori. 2021. Accessed on 14.6.2021. Available at: https://nori.com/

OECD. 2007. The Implementation Costs of Agricultural Policies. 196 p. https://doi.org/10.1787/9789264024540-en.

OEDC & IEA. 2019. Designing the Article 6.4 mechanism: assessing selected baseline approaches and their implications. Climate Change Expert Group. Paper No. 2019(5). Available at: https://www.oecd.org/environment/cc/Designing-the-Article-6-4-mechanism-assessing-selected-baseline-approaches-and-their-implications.pdf

Oldfield, E., Bradford, M. and Stephen W. 2019. Global meta-analysis of the relationship between soil organic matter and crop yields. Soil 5:15–32.

Oliver T et al. 2015. Review Biodiversity and Resilience of Ecosystem Functions. Trends in Ecology & Evolution, November 2015, Vol. 30, No. 11 Elsevier Ltd http://dx.doi.org/10.1016/j.tree.2015.08.009

Ollikainen, M., Lankoski, J., & Nuutinen, S. 2008. Policy-related transaction costs of agricultural policies in Finland. Agricultural and Food Science, 17(3), 193–209. https://doi.org/10.2137/145960608786118848

Poulton, P., Johnston, J., Macdonald, A., White, R., and Powlson, D. 2018. Major limitations to achieving "4 per 1000" increases in soil organic carbon stock in temperate regions: Evidence from long-term experiments at Rothamsted Research, United Kingdom. Glob. Change Biol. 24 :2563–2584,

Prommer et al. 2019. Increased microbial growth, biomass, and turnover drive soil organic carbon accumulation at higher plant diversity. Glob Change Biol. 2020;26:669–681. _ wileyonlinelibrary.com/journal/gcb

Puro.earth. 2021. Accessed on 14.6.2021. Available at: https://puro.earth/

Robertson, G., Gross, K., Hamilton, S., Landis, D., Schmidt, T., Snapp, S. and Swinton, S. 2014. Farming for ecosystem services: An ecological approach to production agriculture. Bioscience 64:404–415.

Stockholm Environment Institute. 2019. Available in: https://www.sei.org/featured/double-counting-of-emission-reductions-paris-agreement/

Technopolis Group. 2021. Presentation in workshop: Final workshop to support the evaluation of art.7a of the Fuel Quality Directive. Organized by DG Clima, Technopolis Group, COWI and Exergia. 20.4.2021.

TSVCM. 2020. Taskforce on scaling voluntary carbon markets. Consultation document. Available at: https://www.iif.com/Portals/1/Files/TSVCM_Consultation_Document.pdf

UK Woodland carbon code. 2021. Accessed on 14.6.2021. Available at: https://woodlandcarboncode.org.uk/

United Nations. 2015. Paris Agreement

Vatn, A. Kvakkestad, V. and Rørstad P. K. 2002. Policies for multifunctional agriculture: The trade-off between transaction costs and precision. Agricultural University of Norway. Department of Economics and Social Sciences. Report No. 23

Verra. 2015. Double Counting in ICAO's CORSIA: Issues and Solutions. 8 May 2017. Available at: https://verra.org/double-counting-in-icaos-corsia-issues-and-solutions/

Verra. 2021. Accessed on 14.6.2021. Available at: https://verra.org/

World Bank. 2012. Carbon sequestration in agricultural soils. Available at: https://documents1.worldbank.org/curated/en/751961468336701332/pdf/673950REVISED000CarbonSeq0Web0final.pdf

World Bank. 2016. "Carbon Credits and Additionality: Past, Present, and Future." PMR Technical Note 13. Partnership for Market Readiness, World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO

World Bank. 2021. Greenhouse Gas Analysis at the World Bank, 2012. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/18365/697110P11055700as0Analysis00PUBLIC0.pdf?sequence=1&isAllowed=y

World Bank, Forest Carbon Partnership, BioCarbon Fund. 2018. Approaches to REDD++ Nesting. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/29720/125270.pdf?sequence=8&isAllowed=y

Yara. Crop nutrition solutions. 2021. Accessed on 17.6.2021. Available at: https://www.yara.com/crop-nutrition/digital-farming/ and private e-mail conversation

Ökoregion Kaindorf. 2021. Accessed on 14.6.2021. Available at: https://www.oekoregion-kaindorf.at/index.php?id=187

Kenney, M., Serhan, H. & Trystram, G. 2020. Digitalization and Platforms in Agriculture: Organizations, Power Asymmetry, and Collective Action Solutions. ETLA Working Papers No 78. Available at: http://pub.etla.fi/ETLA-Working-Papers-78.pdf

Appendix 1.

Instrument and system costs of selected measures to enhance carbon sequestration

Calculation methodology

This analysis aims to measure cost structure of three different set of instruments to enhance carbon sequestration. The selected instruments fall under four different categories: soil improvements, forest fertilization and afforestation and reforestation.

Calculation methodology is based on transaction cost theory and draws from the literature on transactions costs in agri-environmental support scheme (OECD 2007, Ollikainen et. al. 2008, Vatn et al. 2002). Based on the literature we estimate the design, implementation and monitoring costs of a particular instrument as a percentage of total instrument cost.

In addition, based on the data collected from different collaborators (Natural Resources Institute, Tyynelä farm) and operators (Green Carbon, South Pole, Puro, Soilfood), we estimate the system cost, and system cost range for each category of instruments analysed.

The analysis covers four subsequent steps:

1. estimation of instrument cost per hectare (including design, implementation, monitoring), and sensitivity analysis of these costs
2. estimation of break-even CO_2/tn price (the minimum price covering costs estimated in step 1)
3. estimation of system cost (validation, verification, register, trading)
4. calculation of the total costs, average annual costs, lower and upper limits for a 20-year program period

The results are presented for each category of instruments in the following tables.

Definition of cost-structure

The costs incurred in similar policy schemes are often categorised as set-up costs, implementation costs and participation costs (OECD 2007, Ollikainen et al. 2008). These costs include research and information costs, design, enactment and evaluation, distribution and monitoring as well as participation costs, among others. Sub-categories of policy related transactions costs are described in Figure 1.

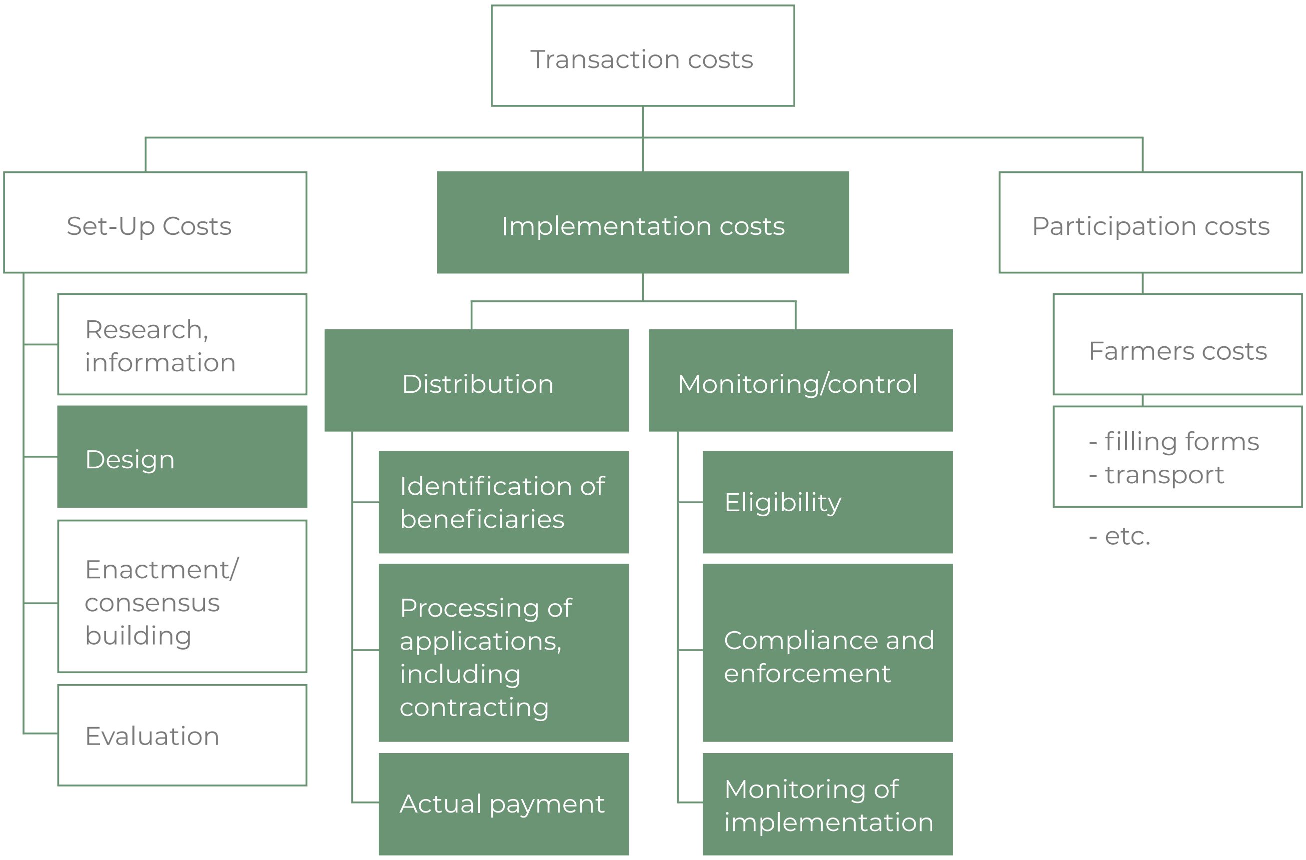


Figure 1. Policy related transaction cost in agri-environmental policies (Ollikainen et al. 2008, 197).

In carbon schemes also costs of trading, registering and clearance are often included. In our analysis we define the costs as instruments costs, per hectare costs and system costs:

1. Per hectare instruments cost – cost incurred on the implementation of the policy instruments. These costs are mainly paid by actor (farmer, forest owner) and they cover the costs of all raw materials, logistics, operation etc.
2. Per hectare transaction costs (TC) – the per hectare transaction costs are estimated design, implementation and monitoring costs as a proportion of instrument costs.
3. System costs – program-based costs stemming from validation, verification, register and trading. These costs occur regardless of the size of the project, and are assumed constant within the project period (20 years)

Table 1. Definition of the system costs

Validation	project validation
Verification	verification of credits
Register	registration fees (per estimated annual credits), annual registry fees, issuance fees
Trading	trading service fees

Table 2. Definition of the calculated transaction costs

Definition of costs			
	Design	**Implementation**	**Monitoring**
Transaction costs	Costs incurring from design and planning of the policy instrument, compensation scheme, monitoring and the overall operating system. Mainly research and administrative cost, and partly indirect.	Costs incurring from targeting, instrument selection, defining beneficiaries and compensation mechanisms, contracting, among others.	Costs incurring from measuring eligibility, compliance, monitoring of implementation, reporting, and auditing

In estimating the per hectare transaction costs, we utilise the study by Ollikainen et al. (2008) on the policy-related transaction costs (PRTCs) of agri-environmental support in Finland. These estimated PRTCs are presented in Table 3.

According to Ollikainen et al. (2008), transactions cost on agri-environmental support scheme range from basic payments' 1,46 per cent of total payments to 33,06 per cent in special measures. PRTCs for additional measures range from 3,70 to 9,81 per cent, while total PRTCs are 6,69 per cent. PRTCs for special measures are significantly higher. Thus, targeted and specific policy instruments have higher transaction costs compared to more general and widely applicable instruments.

Based on these results, we approximate per hectare transaction costs as 6 per cent of the instrument cost. The data received from the South Pole support this selection. In addition, to observe the role of transaction costs in total instrument costs, a sensitivity analysis with 1 per cent and 10 per cent TC is conducted.

Table 3. Policy-related transaction costs of the selected Finnish agri-environmental policy measures (Ollikainen et al. 2008)

	PRTCs/ subsidy or instrument
Basic Measures (total)	1,46 %
Additional measures (total)	6,69 %
More accurate fertilization	9,81 %
Plan cover in winter and reduced tillage	8,04 %
Additional measures on livestock farms	3,70 %
Special measures (total)	33,06 %
Buffer zones	42,83 %
Traditional biotopes	28,77 %

The relative share of PRTCs and their distribution between instrument design, implementation and monitoring are presented in Table 4. In our calculations, we use the percentage distribution of the total support scheme.

Table 4. Policy related transaction costs in agri-environmental support (Ollikainen et al. 2008)

Agri-environmental support	PRTCs in design, %	PRTCs in implementation, %	PRTC in monitoring, %
Basic Measures	39	39	22
Additional measures	16	26	58
Special measures	36	55	22
Total	23	35	42

Summary of variables

Utilised instrument costs, estimated carbon sequestration per hectare, and instrument cycle are presented in Table 5. All figures are based on information collected from different collaborators, operators and research. Program period was set to 20 years. Project verification every 5 years.

Table 5. Estimated carbon sequestration/ha, instrument cycle and instrument cost utilised in the calculation (Source: Natural Resources Institute, Tyynelä Farm, Soilfood, Puro, Green Carbon, South Pole, own calculations)

	CO_2 tn/ha	cycle	instrument cost (€/ha/a)
Soil improvements			
Manure	5,1	every 3 years	100,00
Zerofibre (Pulp mill sludge)	6,6	every 5 years	80,00
Nutrient fibre (mixed pulp mill sludge)	10,6	every 3 years	133,33
Bio-compost	5,9	every 5 years	48,00
Forest fertilization			
Mineral soil N fertilization	6,5	annual	450,00
Peatland ash fertilization	6,6	annual	500,00
Afforestation			
Reforestation/Afforestation	6,1	founding/one time	117,5

Results

Soil improvements

Table 5. Instrument and transaction costs of selected soil improvement instruments

Manure	Cost €/ha/a	100,00			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	0,23	0,35	0,42	1,0	101,00
6 %	1,38	2,1	2,52	6,0	106,00
10 %	2,3	3,5	4,2	10,0	110,00
Zerofibre	Costs €/ha/a	80,00			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	0,18	0,28	0,34	0,8	80,80
6 %	1,10	1,68	2,02	4,8	84,80
10 %	1,84	2,8	3,36	8,0	88,00
Nutrient fibre					
	Costs €/ha/a	133,33			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	0,31	0,47	0,56	1,3	134,67
6 %	1,84	2,80	3,36	8,0	141,33
10 %	3,07	4,67	5,60	13,3	146,67
Bio-compost	Costs €/ha/a	48,00			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	0,11	0,17	0,20	0,5	48,48
6 %	0,66	1,01	1,21	2,9	50,88
10 %	1,10	1,68	2,02	4,8	52,80

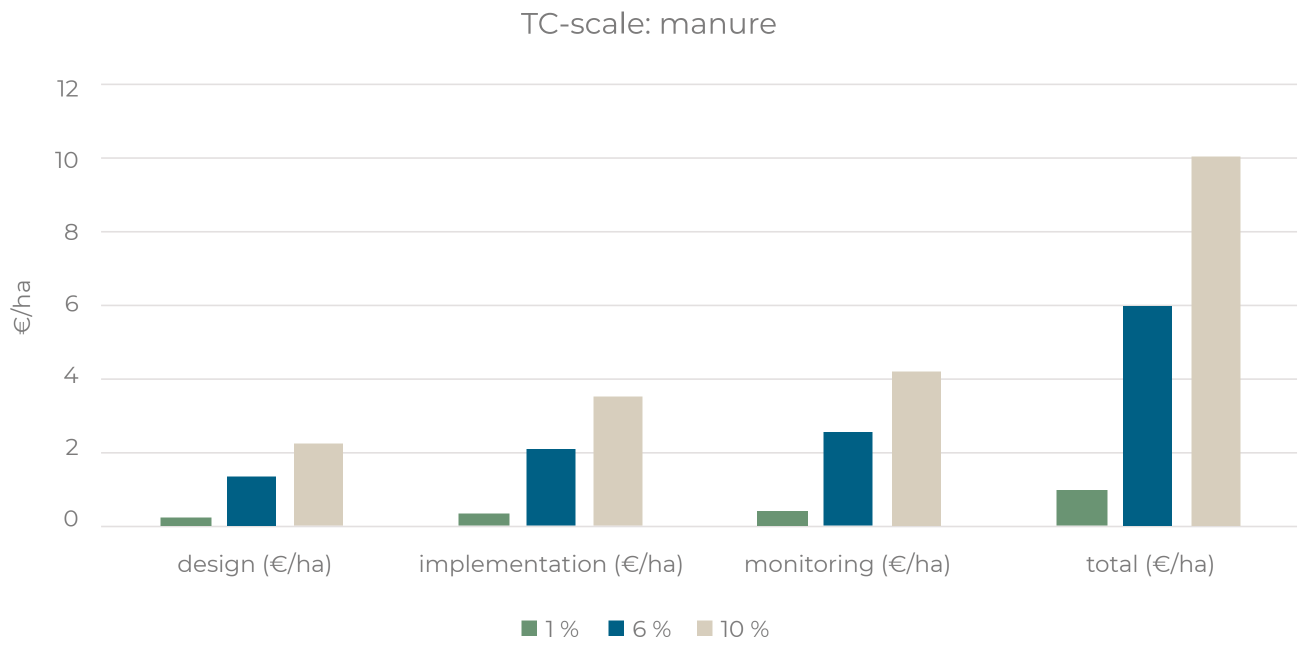


Figure 2. Sensitivity analysis of transaction costs for manure

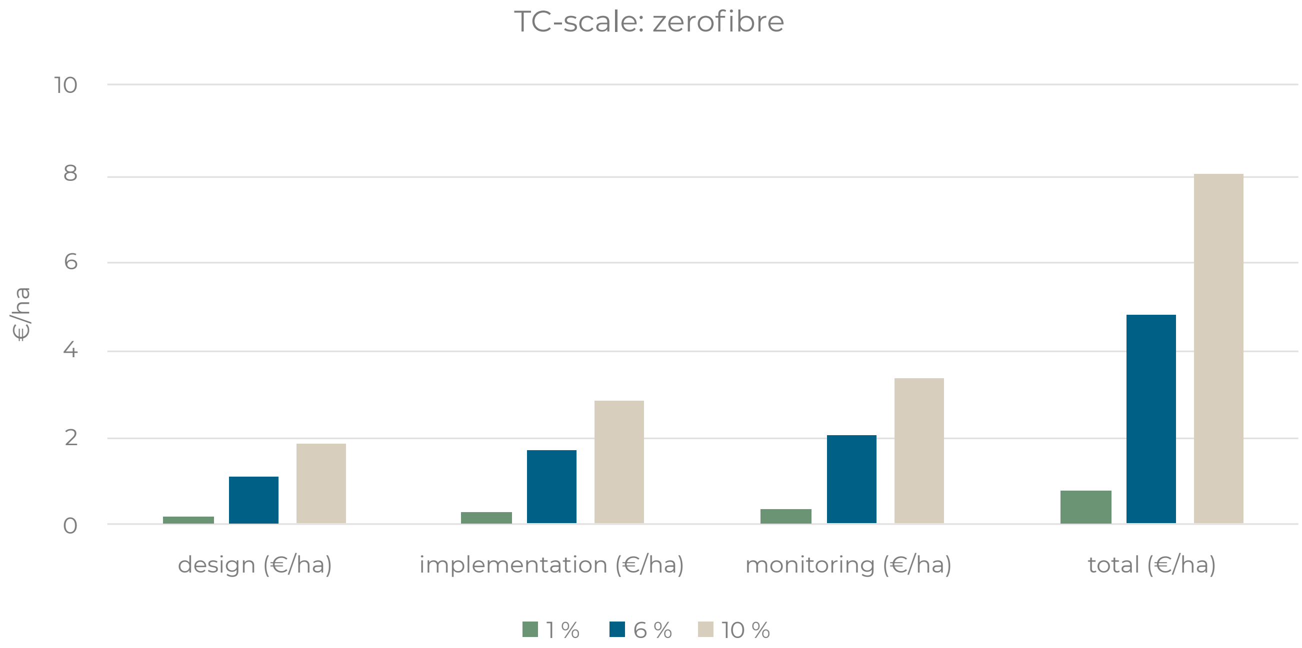


Figure 3. Sensitivity analysis of transaction costs for zerofibre

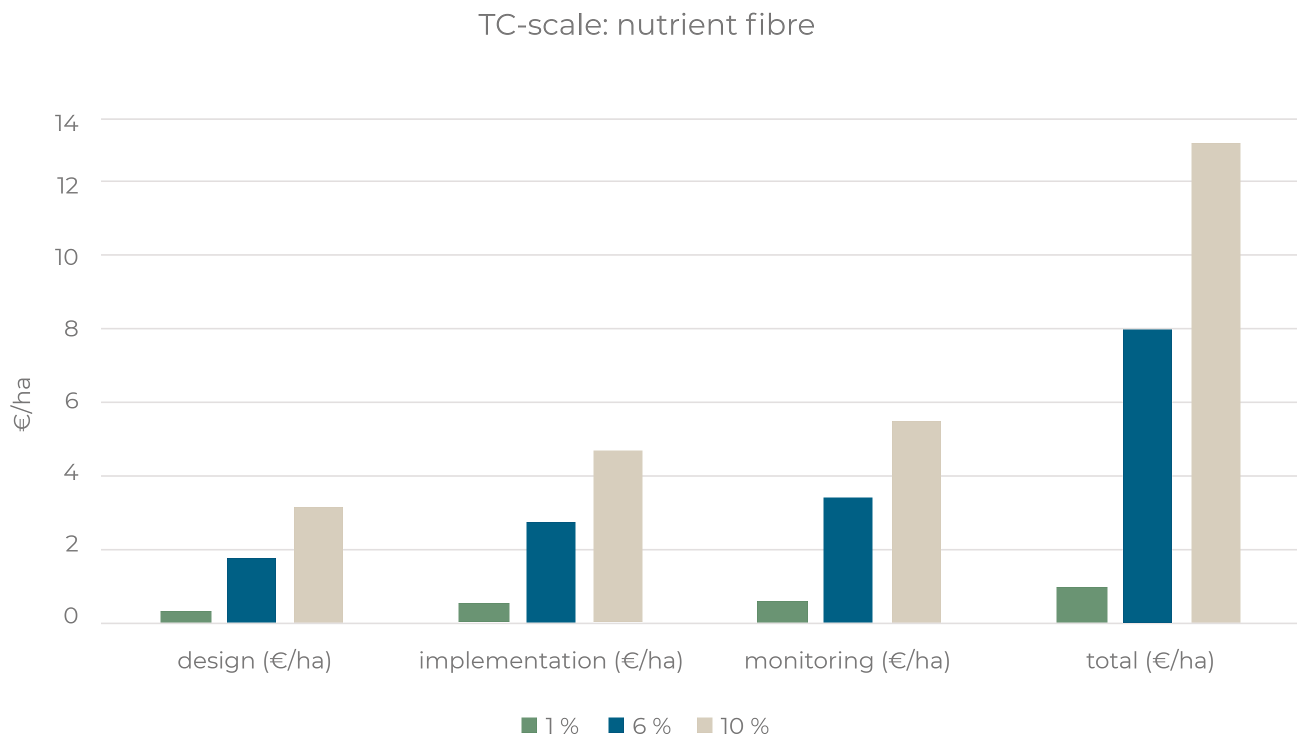


Figure 4. Sensitivity analysis of transaction costs for nutrient fibre

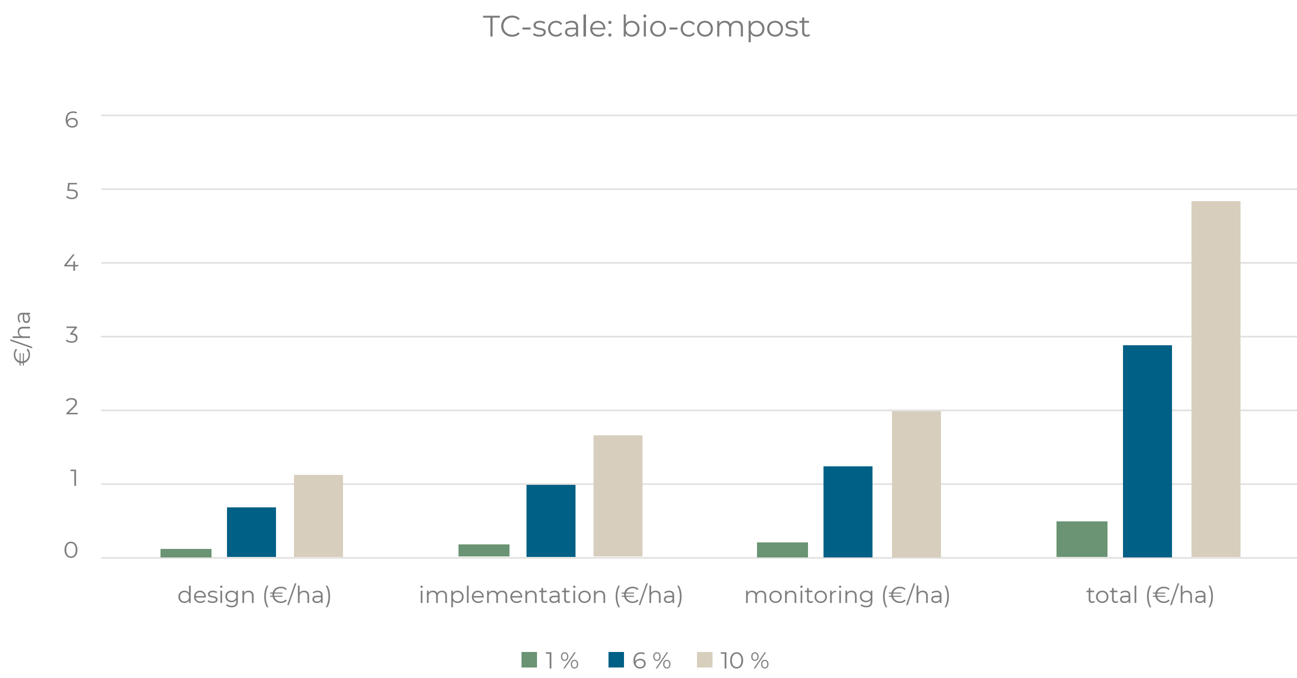


Figure 5. Sensitivity analysis of transaction costs for bio-compost

Table 6. System and total costs of soil improvements

SOIL IMPROVEMENTS							
Instrument cost (€/ha)	Program period, years	20					
lower limit	Validation cost (€)	system verification (€) (every 5 years)	register (€)	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
192	60 000	40 000	10 000	120 000	16,0	230 208	11 510
upper limit	Validation cost (€)	system verification (€) (every 5 years)	register (€)	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
887	120 000	120 000	20 000	120 000	266,7	381 153	19 058

Forest fertilization

Table 7. Instrument and transaction costs of selected forest fertilization instruments

FOREST FERTILIZATION					
Mineral soil N fertilization	Costs €/ha/a	450,00			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	1,04	1,58	1,89	4,5	454,50
6 %	6,21	9,45	11,34	27,0	477,00
10 %	10,35	15,75	18,9	45,0	495,00
Peatland ash fertilization	Costs €/ha/a	500,00			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	1,15	1,75	2,10	5,0	505,00
6 %	6,90	10,50	12,60	30,0	530,00
10 %	11,5	17,5	21	50,0	550,00

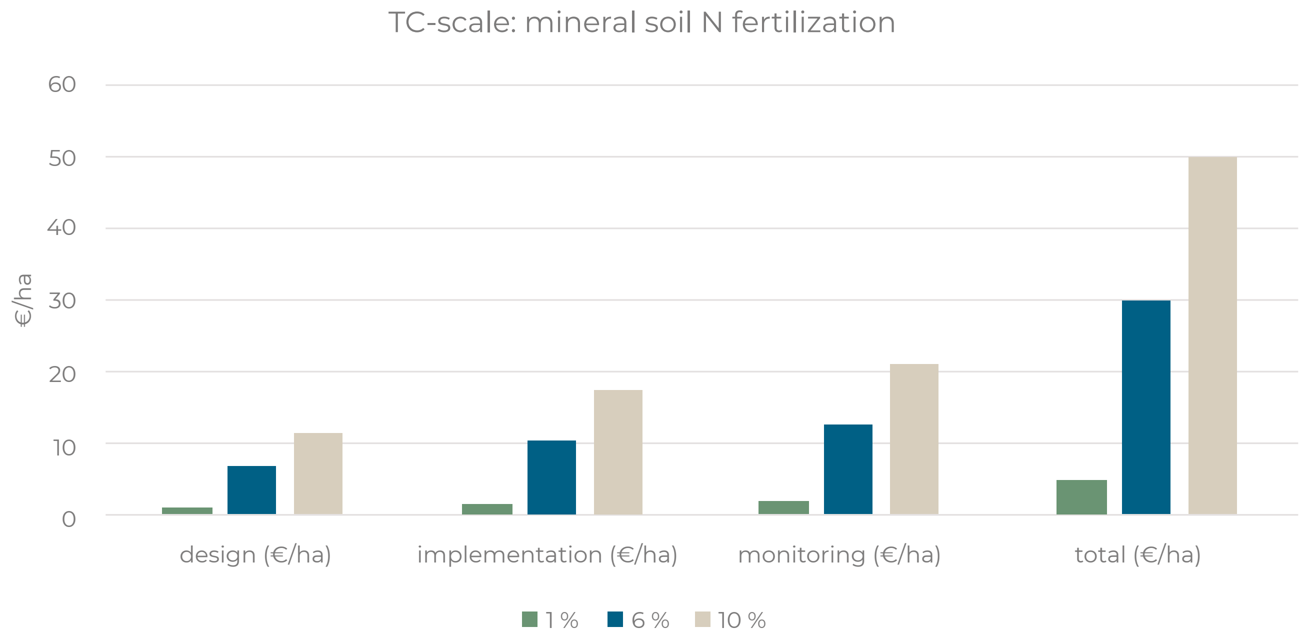


Figure 6. Sensitivity analysis of transaction costs for mineral soil N fertilization

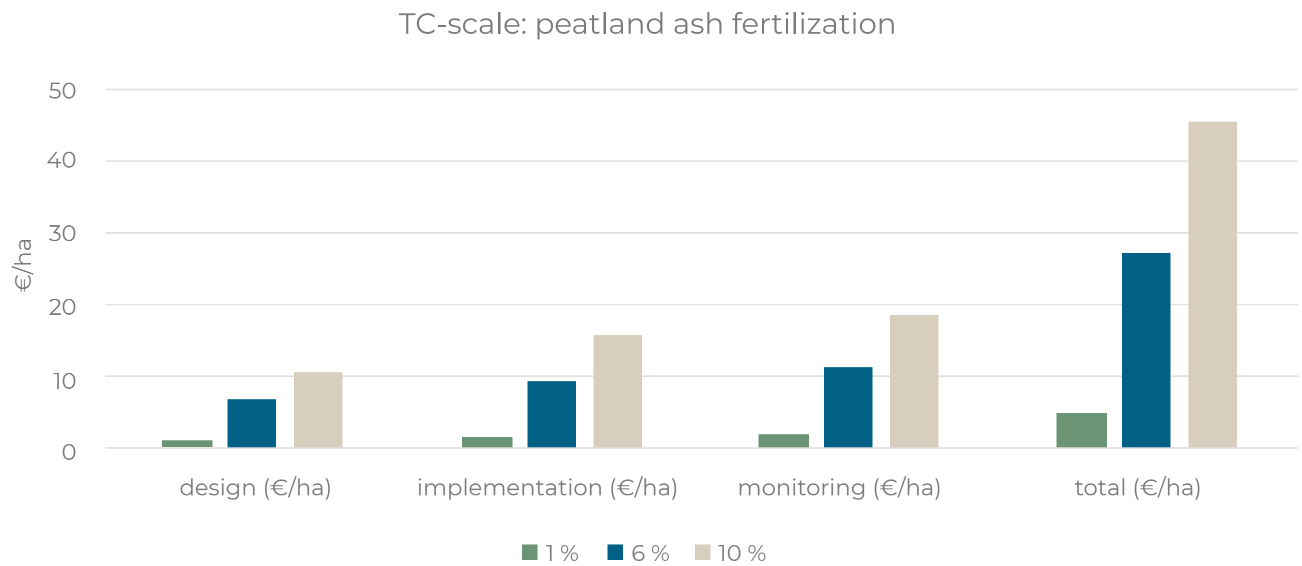


Figure 7. Sensitivity analysis of transaction costs for peatland ash fertilization

Table 8. System and total costs of forest fertilization

FOREST FERTILIZATION							
Instrument cost (€/ha)	Program period, years	20					
lower limit	Validation cost (€)	system verification (€/ha) (every 5 years)	register (€)/ annual	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
9 000	60 000	2	10 000	120 000	90,0	199 092	9 955
upper limit	Validation cost (€)	system verification (€/ha) (every 5 years)	register (€)/ annual	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
10 000	120 000	40	20 000	120 000	1000,0	271 040	13 552

Afforestation

Table 9. Instrument and transaction costs of afforestation/reforestation

AFFORESTATION					
	Program period, years	20			
	Costs €/ha	Costs €/ha/a			
Instrument cost (€/ha)	2350,00	117,5			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	0,27	0,41	0,49	1,2	118,68
6 %	1,62	2,47	2,96	7,1	124,55
10 %	2,70	4,11	4,94	11,8	129,25

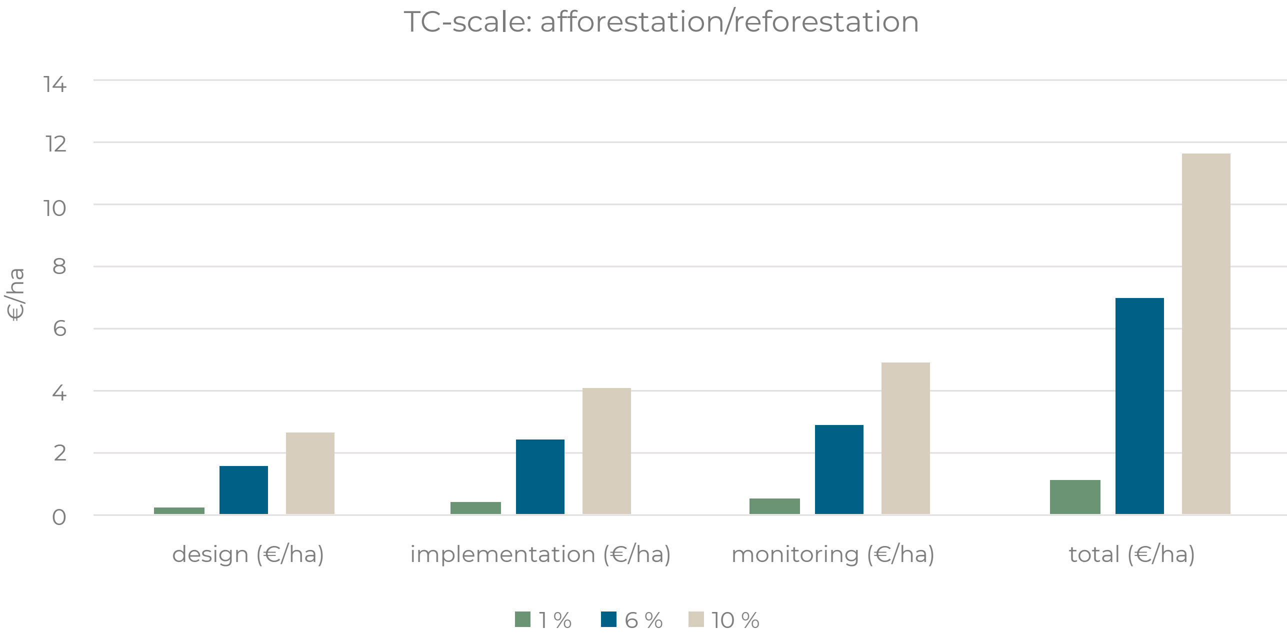


Figure 8. Sensitivity analysis of transaction costs for afforestation/reforestation

Table 10. System and total costs of afforestation/reforestation

AFFORESTATION / REFORESTATION							
Instrument cost (€/ha)	Program period, years	20					
lower limit	Validation cost (€)	system verification (€) (every 5 years)	register (€)/ annual	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
2350	60 000	40 000	10 000	120 000	23,5	232 374	11 619
upper limit	Validation cost (€)	system verification (€) (every 5 years)	register (€)/ annual	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
2350	120 000	120 000	20 000	120 000	235,0	382 585	19 129

Appendix 2.

Instrument and system costs of biochar

Summary of variables

Utilised instrument costs, estimated carbon sequestration per hectare, and instrument cycle are presented in Table 3. All figures are based on information collected from different collaborators, operators and research. Program period was set to 20 years. Project verification every 5 years.

Table 1. Estimated carbon sequestration/ha, instrument cycle and instrument cost utilised in the calculation (Source: Natural Resources Institute, Tyynelä Farm, Soilfood, Puro, Green Carbon, South Pole, own calculations)

	CO2 tn/ha	cycle	instrument cost (€/CO2 tn)	spreading (tn/ha)
Biochar				
Industrial biochar	3,7	every 10 years	580	25

Assumptions:

- biochar spreading every 10-years
- instrument cost 580 €/CO_2 tn
- tonne of biochar sequestrates 3,7 tn of CO_2, assumed impact 80 per cent à 2,96 tn of CO_2 per tn of biochar
- cost of CO_2 per tn 1716,80 €
- spreading 25 tn/ha
- hectare cost 42 920 €/ha/10 years
- average annual cost 4 292 €/ha in 20-year program

Results

Table 2. Instrument and transaction costs of biochar

Biochar					
	Program period, years	20			
	Costs €/ha	Costs €/ha/a			
Instrument cost (€/ha)	85 840	4292			
	design (€/ha)	implementation (€/ha)	monitoring (€/ha)	total (€/ha)	total cost €/ha/a
1 %	9,87	15,02	18,03	42,9	4334,92
6 %	59,23	90,13	108,16	257,5	4549,52
10 %	98,72	150,22	180,26	429,2	4721,20

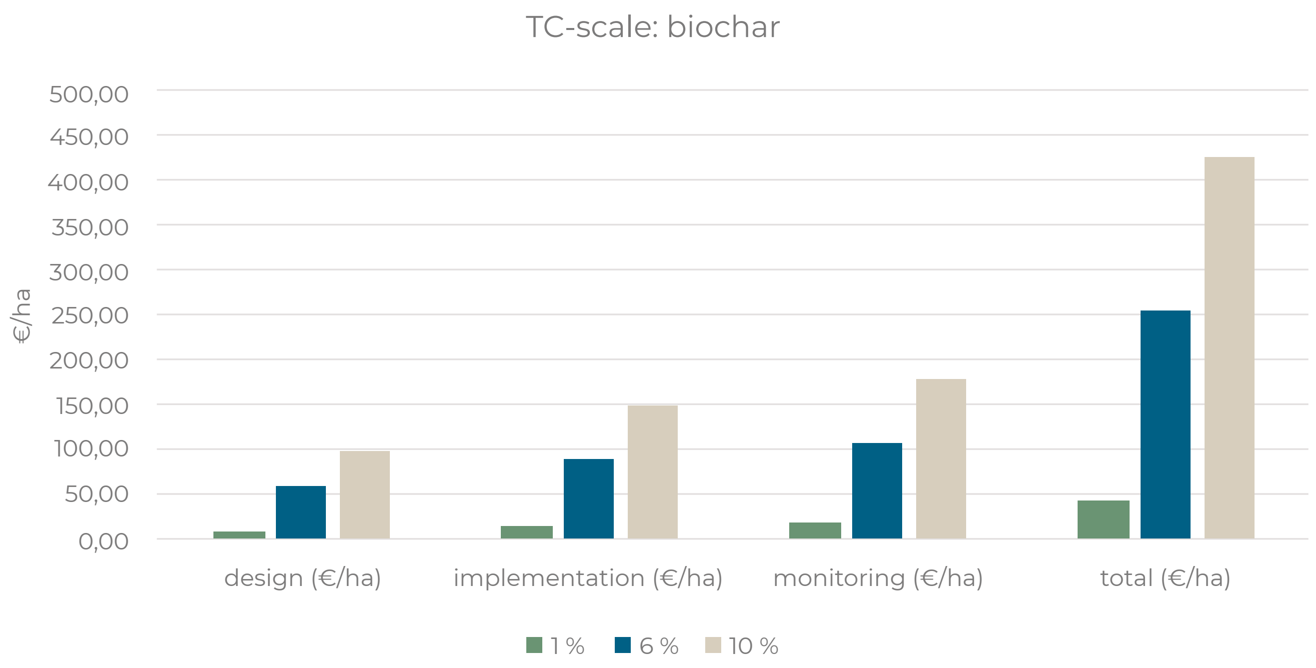


Figure 1. Transaction costs-scale for biochar

Table 3. System and total costs of biochar

BIOCHAR							
Instrument cost (€/ha)	Program period, years	20					
lower limit	Validation cost (€)	system verification (€) (every 5-years)	register (€)/ annual	trading (€)	TC (€/ha)	total cost (€)	average annual cost (€)
85840	60 000	40 000	10 000	120 000	858	316 698	15 835
upper limit	Validation cost (€)	system verification (€) (every 5-years)	register (€)/ annual	trading (€)	(TC €/ha)	total cost (€)	average annual cost (€)
85840	120 000	120 000	20 000	120 000	8 584	474 424	23 721