Project Document (PD)

Soil Capital

Climate Change Mitigation Project for Arable Farming: Operational Framework for EU CRCF alignment

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Acronyms and abbreviations

AFOLU	agriculture forestry and other land use
API	application programming interface
BEG	Baseline Expert Group
CAP	common agricultural policy
CAR	Climate Action Reserve
CAR SEP	Climate Action Reserve Soil Enrichment Protocol
CFT	Cool Farm Tool
CFG	crop functional group
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CRCF	EU Carbon Removals Certification Framework
CSRD	EU Corporate Sustainability Reporting Directive
DEFRA	Department of Environment, Food and Rural Affairs
DNDC	DeComposition and DeNitrification
EC	European Commission
EF	emission factor
EFA	Ecological Focus Area
ERR	emissions reductions and removals
ES	emission source
FCAA	French Carbon Agri Association
GHG	greenhouse gas
GIS	Geographic Information System
GS	gold standard
ha	hectare
IALM	Improved Agricultural Land Management
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
MECE	Mutually Exclusive, Collectively Exhaustive

MRV	monitoring, reporting and verification
MUSLE	modified universal soil loss equation
N_2O	nitrous oxide
NUTS	Nomenclature of Territorial Units for Statistics
PC	practice category
RTF	Regenerating Together Framework
RUSLE	revised universal soil loss equation
SAI	Sustainable Agriculture Initiative
SALM	Sustainable Agricultural and Land Management
SBTi	Science-Based Targets initiative
SBTN	Science-Based Targets Network
SOC	soil organic carbon
SOM	soil organic matter
SSRs	sources, sinks and reservoirs
t	tonne
tCO2e	tonne of carbon dioxide equivalent
TCFD	Taskforce on Climate-related Financial Disclosures
TDD	total degree days to maturity
TNFD	Taskforce on Nature-related Financial Disclosures
UNFCCC	United Nations Framework Convention on Climate Change
USLE	universal soil loss equation
VCS	Verified Carbon Standard
VERRs	verified emission reductions and removals
WCC	Woodland Carbon Code

Summary of the Project

This Project, the Soil Capital Climate Change Mitigation Project for Arable Farming: Operational Framework for EU CRCF alignment, targets arable farmers in France, Belgium and the UK who are committed to adopting regenerative agriculture practices and maintaining them. Each farmer commits to a five-year crediting period, which can be repeated a maximum of four times, followed by a 10-year retention period. The duration of the Project is 30 years maximum. The purpose of the Project is for these farmers to benefit from technical support and earn financial rewards for altering their farming practices that result in greenhouse gas (GHG) emission reductions and removals (ERRs).

The Project builds on the design of an earlier project initiated by Soil Capital for farmers in the same geographies, but includes various design features intended to align the Project with the European Union(EU)'s Carbon Removal Certification Framework (CRCF). Full alignment with the EU CRCF was not possible at the time this Project was designed (2024) because the CRCF's detailed methodology - to be presented in a Delegated Act - was still forthcoming at the time. However, the overarching CRCF regulation had been adopted into law[1] at the time and makes clear four fundamental quality criteria for carbon removals to be certified by the EU in the future:

1. Quantification - the combination of soil analysis and modelling, using Tier 3 approaches
2. Additionality - the use of standardised baselines, not least to accommodate the efforts of early adopters, or individual baselines if data does not allow
3. Permanence - ongoing monitoring to confirm long-lasting removals
4. Sustainability - quantification of co-benefits of practices implemented on domains like soil health and biodiversity alongside carbon impacts

While differences with Soil Capital's earlier project are aimed at integrating the above EU CRCF quality criteria in this Project's design, its fundamental purpose remains unchanged.

Of the world's 4,924 M hectares (ha) of land used for agriculture, approximately 28% is arable land (FAO, 2016) – land that is cultivated (ploughed or tilled) regularly, generally under a system of crop rotation. However, arable land is being lost at a rate of over 10 M ha per year due to over-intensive farming, which results in the depletion of nutrients and soil erosion (Pimentel et al., 1995). Furthermore, intensive agriculture has caused arable soils to release 40–60% of their organic carbon into the atmosphere (UK Environment Agency, 2019, p.3).

Regenerative agriculture can be defined as, "farming and grazing practices that reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity, resulting in both carbon drawdown and improving the water cycle" (Carbon Underground, 2017, page 1). Regenerative agriculture differentiates itself from other sustainable agriculture practices by focusing on more than the reduced negative impacts of farming practices and instead ensures that agriculture has a net positive effect on environmental issues, ranging from climate change to soil erosion to overuse of pesticides.

This Project has been developed by Soil Capital, an independent agronomy firm whose headquarters are in Belgium. Since 2013, the Soil Capital team has managed, or advised on, nearly 200,000 ha of farmland under transition to regenerative agriculture across five continents. While a wide range of practices can be combined to rebuild soil organic matter, Soil Capital has ascertained that they all fall under six principles, which are applicable across geographies, soil types, climatic zones and farm types:

1. reducing soil disturbance (tillage), with a view to its ultimate elimination;
2. reducing use of synthetic inputs (pesticides and fertilisers) via increased use efficiency and/or their replacement by organic sources, with a view to their ultimate elimination;

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202403012

3. maximising soil coverage over time with living roots, e.g. via increasingly systematic implementation of cover crops (including catch crops, intercrops);
4. maximising organic matter restitution the soil via an increase use of organic amendments and a greater incorporation of crop residues into the soil post-harvest;
5. maximising the functional role of biodiversity (moving beyond monocultures, livestock integration[2]);
6. adapting design to local context, so that the farmers that know their land best can adapt practices according to local soil, climate, topography, market and other realities.

However, several barriers prevent farmers, on the one hand, from transitioning to regenerative agriculture practices on a large scale today (Groupe BPCE, 2019) and, on the other hand, from maintaining their efforts (see full barrier analysis in Section 3). These barriers include, among others: (i) farmers fear making an economic loss during their transition, either because of new operational costs that are introduced or lower yields that result (or both); (ii) farmers see little market incentive that rewards them for taking the risks they see in the transition; and (iii) they lack the confidence that alternative practices will work for them when they face any number of agronomic and operational challenges.

Soil Capital identifies an opportunity through this Project to empower more farmers to transition from conventional to regenerative agriculture practices and maintain their efforts by enabling them to gain technical support and earn new financial rewards for farming practice changes that result in the reduction and removal of GHG emissions. Soil Capital equally encourages farmers that have previously implemented regenerative agricultural practices to sustain their endeavours in order to dissuade them from reverting to conventional practices when faced with unexpected barriers that they may encounter.

The Project aims to enrol more than 3,000 farmers in the first five years. Farmers will be able to enrol each year, with 600 farmers throughout France, Belgium and the UK already enrolled by the year 2024.

Soil Capital has chosen to use ISO standard 14064-2[3] (initially published in 2006 and updated in 2019) for this Project. The ISO 14064-2 standard provides governments, businesses, regions and other organisations with a complementary set of tools to quantify, monitor, report and verify GHG emissions. The ISO 14064-2 standard supports organisations who participate in both regulated and voluntary programmes such as emissions trading schemes and public reporting, using a globally recognised standard.

The Project combines the use of two models for the quantification of changes to net GHG emissions from farming practice changes. On one hand, an activity-based, globally applicable empirical model called the Cool Farm Tool (CFT) (Hillier et al., 2011) for non soil-based GHG emissions. On the other hand, DNDC, a process-based model calibrated and validated for the specific conditions of the Project area, for soil-based GHG emissions and removals.

The CFT is a third-party tool, developed and continuously improved by a consortium of leading European Universities such as Edinburgh, Cambridge, Aberdeen, Wageningen and Oxford, who work together through a non-profit organisation called the Cool Farm Alliance. The CFT calculates the emissions of the three main GHGs associated with the production of agricultural crops: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The CFT incorporates the IPCC Tier 1 and Tier 2 method.

The DeNitrification-DeComposition model (DNDC) simulates the carbon (C) and nitrogen (N) processes within agro-ecosystems. It has the capacity to simulate crop growth, soil organic

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[2] While arable and livestock farming have become increasingly separated over recent decades, livestock grazing of cover or cash crops on arable land can in fact not only provide a natural source of organic matter, but it can also encourage new plant growth, which stimulates the plants to pump more carbon into the soil. This drives nutrient recycling by feeding biology.

[3] https://www.iso.org/standard/66454.html

carbon stocks and trace gas emissions including N_2O and CH_4 from the soil. To date DNDC has been extensively applied on cropland and grassland systems in both the USA and Europe and has been published in over 500 peer reviewed academic journals. The DNDC model was initially developed to estimate nitrous oxide emissions in US soils by Li et al.(1992). The model runs on a daily time step and is capable of simulating both aerobic and anaerobic soil conditions. DNDC conducts a full accounting of carbon and nitrogen cycling by simulating the impacts of major ecological drivers (climate, soil, vegetation and management practices, including those included within the Project boundary such as tillage and nitrogen inputs from organic or synthetic fertilisers) on soil climate conditions, plant growth, and decomposition (Figure 1).

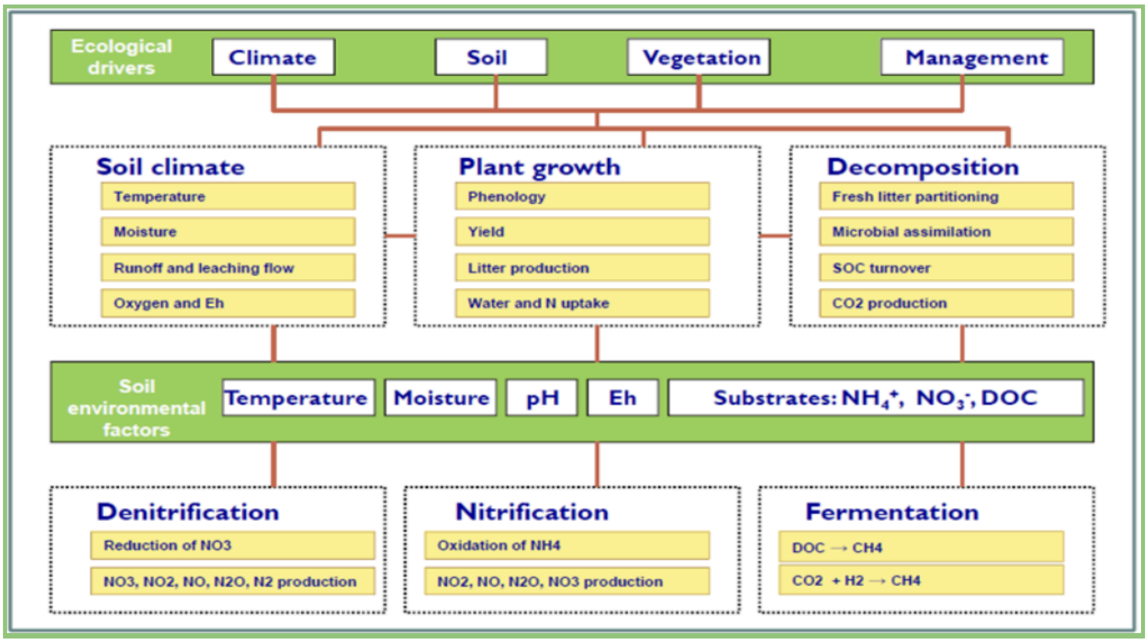

Figure 1 : DNDC drivers (green boxes) and process-based sub-modules (dashed boxes).

Agricultural management practices directly modify the soil climate and plant growth sub-modules and indirectly alter organic matter decomposition and nutrient cycling (denitrification, nitrification, fermentation).

(Source : Regrow, 2024)

The model is built using classical laws of physics, chemistry, and biology, as well as empirical equations generated from laboratory studies to parameterize specific biogeochemical processes. The DNDC model has been applied across a wide range of agro-ecosystems globally, extensively validated and peer reviewed in over 200 peer-reviewed publications (Giltrap et al. 2010; Gilhespy et al. 2014; Yeluripati et al.2015). Multiple versions of DNDC have been created for research, education, and marketing purposes since the model's initial development. Currently version 9.5 of DNDC is publicly available and infrequently maintained by the University of New Hampshire. Regrow has developed the most recent version of DNDC (v12.1.0) under an exclusive commercial licence to support the scaling of ecosystem services markets.

In both the baseline and Project scenarios used in this Project, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are included in scope. This includes :

- From DNDC : CO_2 emissions and removals associated with soil carbon stock change (as a result of, for instance, changes to tillage practices, cover cropping, residue management or organic fertilisers use), CH_4 emissions from the soil, and N_2O emissions from crop residue management, synthetic and organic fertiliser use.
- From CFT : CO_2 emissions and removals associated with changes to the biomass of trees, fuel and energy use, synthetic fertiliser and pesticide production

- From IPCC emission factors : CH_4 and N_20 emissions from livestock via manure management and enteric fermentation.

All the farmers enrolled on the Project must use the same dedicated farm diagnostic tool, mySoilCapital, for analysis of their net GHG emissions in both the baseline and Project scenarios. mySoilCapital uses a farm's operational and practice data to calculate net GHG emission reductions and removals, and other key agronomic, soil, economical and environmental metrics on a per crop and whole-farm basis. mySoilCapital was developed by Soil Capital and is the first farm-level data collection tool for analysis of performance across carbon, soil health, water, biodiversity and farmer livelihood indicators, and it benchmarks one farm's performance against relevant local peers. When analysing a farm's net GHG emissions and removals, mySoilCapital purely focuses on the functionality of the CFT and DNDC via bespoke application programming interfaces (APIs).

Each farm participating in this Project will have at the beginning of each crediting period, an individual, net GHG emission and removal assessment of their historical practices using mySoilCapital. Following this individual historical practice assessment, each individual farmer is allocated one of the following two baseline scenarios:

1. Baseline scenario 1 – continuation of the current situation, i.e., common practice of the individual farm;

2. Baseline scenario 2 – common agricultural practices of the region.

These two baseline scenarios imply two definitions of baseline emissions levels:

1. Baseline scenario 1: any farm whose historical practices result in a positive GHG inventory at the beginning of their crediting period will use their own individual GHG inventory as their baseline throughout the crediting period via the yearly construction of a counterfactual baseline scenario, which is explained fully in Section 3. This counterfactual baseline represents, for each project year, what would have happened in the absence of the project. Therefore it represents the continuation of the 3-year historical practices in the prevailing weather of the project year. This methodology ensures that only practice changes lead to ERRs for BS1 farmers, not the weather conditions.

2. Baseline scenario 2: any farm whose historical practices result in a negative GHG inventory at the beginning of their crediting period will use a regional common practice baseline as their baseline throughout the crediting period. This common practice baseline reflects the common farming practices of the region defined as the statutory and market conditions in which the activity takes place. The common practice baseline is calculated for each region to reflect regionally specific parameters (such as type of crops, soil characteristics and weather conditions), which is explained fully in Section 3. As is the case for baseline scenario 1, BS2 represents what would have happened if the farmer was continuing the common agricultural practice of the region in the prevailing weather of the project year. This ensures that BS2 farmers are only generating ERRs based on their practices, not on weather condition changes from one year to another.

Monitoring will be conducted on each farm on an annual basis, drawing on farmers reporting their practices and supported by a comprehensive range of data records. Remote sensing will be used throughout the growing season to monitor practices that are more difficult to audit ex-post, such as tillage practices or cover cropping. Direct soil analysis is required at the beginning of the Project (see requirements in Annex I) to provide an independent source of verification for the baseline soil organic carbon content, which is required by the DNDC model and again at the end of the crediting period to provide calibration data for Regrow working to continuously improve the DNDC model.

Following an annual verification by an independent auditor, including visits to a sample of farmers, verified emission reductions and removals (VERRs) will be generated, with each equating to one tonne (t) of CO_2. Furthermore, 20% of verified removals generated will be held in a pooled buffer for 10 years and only released for sale if remote sensing confirms that the farmer has not been at significant risk of causing a loss event during the retention period. Buffer and loss events management is explained in detail in Section 2.10.2 about permanence risk.

Other than climate change mitigation, Soil Capital's Beyond Carbon metrics present a holistic approach that ensures more than just GHG emissions reductions and removals are quantified, but a range of socio-economic and environmental co-benefits as well.

Our Beyond Carbon metrics address the key environmental services linked to agriculture across five domains: Soil Health, Biodiversity, Water Management, Climate, and Farm Socio-Economics, each further divided into specific subdomains and indicators. Farm performance is measured annually, with expected long-term outcomes including:

- Enhancing soil health while preventing erosion and land degradation.
- Protecting and fostering biodiversity within ecosystems.
- Improving water management, reducing the risk of contaminated watersheds.
- Contributing to better air quality and climate change mitigation through lower GHG emissions.
- Reducing risks associated with extreme weather events by fostering climate adaptation.
- Securing long-term yield and profitability for farmers.

1 ISO 14064 principles

Soil Capital has chosen to use the ISO standard 14064-2 (initially published in 2006 and updated in 2019) for this Project. The ISO 14064 standard provides governments, businesses, regions and other organisations with a complementary set of tools to quantify, monitor, report and verify GHG emissions. The ISO 14064 standard supports organisations who participate in both regulated and voluntary programmes such as emissions trading schemes and public reporting, using a globally recognised standard.

This section documents how the Project meets the core principles of ISO 14064-2.

1.1 Relevance

1.1.1 GHG emissions and removals

The Project uses the combination of an activity-based, globally applicable empirical model called the CFT (Hillier et al., 2011), and a process-based model, calibrated and validated for the specific conditions of the Project area, called DNDC for the quantification of changes to net GHG emissions and removals from farming practice changes. The CFT is a third-party tool, which was developed and is being continuously improved by a consortium of leading European Universities including Edinburgh, Cambridge, Aberdeen, Wageningen and Oxford, who work together through a non-profit organisation called the Cool Farm Alliance. As an empirical model, it uses a set of mathematical equations and default emission factors that was built on life cycle assessment (LCA) principles and variable datasets (e.g. DEFRA[4] for direct fuel use or Fertilizers Europe[5] for synthetic fertilisers production) .

The CFT's main feature is a GHG calculator that enables crop-level calculations of GHG emissions for individual crops produced on a farm[6]. The CFT requires a range of input data including soil characteristics, operational practices and yields.

The DeNitrification-DeComposition model (DNDC) is a process-based model that simulates, at field level, the carbon (C) and nitrogen (N) processes within agro-ecosystems. It is a Tier 3 model, representing the IPCC's highest level of accuracy for capturing variability through space and time of GHG fluxes, and was originally developed by the University of New Hampshire. Regrow now has the exclusive worldwide licence for its commercial use. It has the capacity to simulate crop growth, soil organic carbon stocks and trace gas emissions including N_2O and CH_4 from the soil. Model simulations are reflective of soil type, initial SOC stock, climate (temperature and precipitation) and management inputs including those included within the Project boundary such as tillage and nitrogen inputs from organic or synthetic fertilisers. To date, DNDC has been extensively applied on cropland and grassland systems in both the USA and Europe and has been published in over 500 peer reviewed academic journals.

By combining the outputs from CFT and DNDC, assessments of the GHG emissions and removals for individual crops can be aggregated into emissions calculations across farm rotations, as outlined in this Project.

After a comprehensive review, the CFT has been identified as the best option for calculating the non soil-based GHG emissions from the Project activities in a cost-effective and practical manner. In the same way, DNDC has proved itself as the best option to quantify soil-based GHG emissions and removals.

While other activity-based models have been developed for individual country contexts around the world, the CFT is the only activity-based model of its type that has been designed to be globally applicable and therefore can be used consistently across France, Belgium and UK.

[4] DEFRA. Greenhouse gas reporting: conversion factors 2021. 2021. URL: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021.
[5] Fertilizers Europe. Fertilizers europe CFP calculator. 2013. URL: http://www.fertilizerseurope.com/.
[6] Cool Farm Alliance https://coolfarmtool.org/coolfarmtool/

As a process-based model, DNDC uses on-field data and local climatic and weather conditions to feed complex equations simulating the biogeochemical processes that are happening at soil level. Furthermore, DNDC has been applied across a wide range of agro-ecosystems globally, extensively validated and peer reviewed in over 200 peer-reviewed publications while being constantly improved by Regrow.

In the development of DNDC version 12.1.0, Regrow maintained the default parameter set from version 11.0.0, with no additional calibration conducted beyond the calibration of the two DNDC input crop growth parameters, maximum potential biomass (max_biomass) and total degree days to maturity (TDD) to better reflect growth and productivity in regions outside the USA. This has been done following an IPCC zones approach whereby they have calibrated and validated the IPCC zones 5, 6, 7, and 8 (including France, Belgium and UK), and that for the different combinations of emission source (ES), practice category (PC), and crop functional group (CFG) included in the Project boundary. For the specific case of the crop growth parameters, none of the dSOC and N_2O data in the observational database of peer-reviewed literature (CALVIN) are used in this calibration. Instead, these crop growth parameters were calibrated using country or similar level yield data reported by government agencies in the country of interest. These parameters were selected following a sensitivity analysis. The calibration consisted of a latin hypercube sampling over the parameter space and final parameter selection based on minimizing normalized root mean square differences between country/similar level yields and modeled yield at representative field locations, with qualitative checks for simulated crop stressors to reduce overfitting risk and a bias towards retaining default parameters by requiring parameter convergence and at least a 5% error reduction for new parameter selection.

For this Project, both calibration and validation of the DNDC model are needed. In this case, each study-site within the database is assigned to either the calibration or validation pool. This split is not done at random and is intended to result in complete coverage of the target validation domain by both the calibration and validation pools. This means that only data from the calibration pool was utilised for calibration and model improvement purposes. The study-sites in the validation pool were used exclusively for model validation.

With this in mind, the CFT and DNDC represent the best available combination of GHG calculation methodologies aligned to the needs of this Project and is considered to be the most relevant methodology to date.

1.1.2 Beyond Carbon metrics

The Project addresses the most pressing challenges facing the agricultural system in its transition to a regenerative model that is adapted to climate change. Designed in line with this goal, Soil Capital's Beyond Carbon metrics aim to quantify the outcomes of regenerative farming practices every year during this transition. To enable a holistic analysis, this quantification is conducted across five domains: Soil Health, Biodiversity, Water Management, Climate, and Farm Socio-Economics.

The domains and their further subdomains and indicators are described in the technical description provided in Annex II. They were chosen because they are highly relevant to regenerative agriculture. The ambition is for the collected data to directly support farmers and the companies that incentivise them to make meaningful progress towards established targets. The categories were developed using a bottom-up approach, placing the farmer at the centre to ensure alignment with on-the-ground realities and to avoid additional administrative burden for the farmer.

Soil Capital's Beyond Carbon metrics were developed by structuring the five key domains into logical subdomains, using the MECE framework[7] (Mutually Exclusive, Collectively Exhaustive) as a guide. For each subdomain, indicators were selected based on their direct relevance to quantifying the outcomes of regenerative farming practices and because they are

[7] https://en.wikipedia.org/wiki/MECE_principle

well-established, credible, scientifically and agronomically anchored and at the same time capturing spatial and temporal variations at scale. Care was taken to carefully evaluate the risk of any specific metric being misleading or misapplied, selecting only those metrics where such risks were absent.

The challenge ultimately addressed by Soil Capital's Beyond Carbon metrics is twofold: first, how to objectively measure farm performance in a holistic context; and second, how to assess farms in such a way that they can be compared. Anchoring our methodology in science, as mentioned, leads to accuracy and robustness of the measurement. For instance, we chose the widely used and continuously improved computation method for soil erosion "USLE" (Universal Soil Loss Equation)[8] and its variants "RUSLE" (Revised)[9] and "MUSLE" (Modified - targets a rain event)[10].

Soil Capital's Beyond Carbon metrics strive to calculate high-quality proxy outcomes that go beyond simply recording practices. The metrics represent detailed data from the fields that can be used to provide relevant information in farm management decision-making processes. For example, if the metric for Soil Humic Balance for the domain of Soil Health is unpacked:

- Simply applying organic amendments does not guarantee soil health improvement. Carbon mineralisation rates, which determine the transformation of compounds into plant-available forms, can vary significantly between soil types (for example the clay content) and with different soil management practices. Considering that, and for evaluating the state of a soil and its fertility, we need to know the exact quantity and type of any organic amendments with their specific humification potential, as well as the location of the farm (for soil type and weather conditions).
- The humic balance then takes all the organic input to the soil, including aerial and root dry matter returned to it (cash crops, cover crops, companion crops, organic products), and balances that against the mineralisation rate, which combines those specific soil characteristics and management practices. In other words, the humic balance is the balance between humification and mineralisation. It offers insights on nutrient dynamics, specifically on nutrient retention and availability.
- The measurement for humic balance used in Soil Capital's Beyond Carbon metrics is based on primary data on inputs of organic material, combined with modelled crop values and modelled soil carbon mineralisation. The latter are taken from the best scientific references, namely SIMEOS-AMG[11] from Agro-Transfer Ressources et Territoires; SoilGrids[12], a system for global digital soil mapping using machine learning developed by ISRIC; and Agroenvgeo[13] by INRAE.

Soil Capital's Beyond Carbon metrics are also relevant because they align with EU regulations. The Corporate Sustainability Reporting Directive (CSRD)[14], for example, mandates the disclosure of corporate impacts on biodiversity, water and climate, with an emphasis on using primary data. The upcoming Carbon Removal Certification Framework (CRCF)[15] will require companies seeking to make carbon removal claims with an EU certification to also demonstrate improvements in soil health and biodiversity.

Moreover, Soil Capital's Beyond Carbon metrics have been designed to be compatible with key voluntary frameworks and standards in the private sector, such as SAI, SBTi and SBTN, TCFD

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[8]Wischmeier, W., & Smith, D. (1978). Predicting Rainfall Erosion Losses: a Guide to Conservation Planning Agricultural Handbook. No. 537, US Department of Agriculture, Washington, DC (1978).
[9]Renard, K., Foster, G., Weesies, G., McCool, D. & Yoder, D. (1997) Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). *US Department of Agriculture, Agriculture Handbook No.703USDA, USDA, Washington DC.*
[10]Williams, J.R. (1975). Sediment-yield prediction with universal equation using runoff energy factor. *Present and prospective technology for predicting sediment yield and sources (1975), pp. 244-252*
[11]https://simeos-amg.org/
[12]https://soilgrids.org/
[13]https://agroenvgeo.data.inra.fr
[14]https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en
[15]https://climate.ec.europa.eu/eu-action/carbon-removals-and-carbon-farming_en

and TNFD, currently used by many organisations and companies to track progress on sustainable practices. Their main focus is to provide guidance for corporates on science-based targets for climate and nature impacts, to be consistent with corporate sustainability reporting global references.

The Sustainable Agriculture Initiative Platform (SAI) is a corporate-driven network focused on advancing sustainable agriculture globally. Both Soil Capital's Beyond Carbon metrics and SAI's Regenerating Together Framework (RTF) aim to quantify the outcomes of regenerative farming practices. All four RTF impact areas — water, soil, biodiversity, and climate — are addressed by Soil Capital's Beyond Carbon metrics. Throughout their development, Soil Capital has actively exchanged with SAI to ensure alignment and continues to explore further opportunities for integration.

In terms of environmental impact and natural resources, the Science-Based Targets Network (SBTN) and the Taskforce on Nature-related Financial Disclosures (TNFD) offer frameworks that complement the established Science-Based Targets initiative (SBTi) and the Taskforce on Climate-related Financial Disclosures (TCFD) for climate. SBTN cover the domains of climate, water quality and quantity, ocean, land protection and restoration of terrestrial ecosystems, and biodiversity. Very similar to those, the topics covered by TNFD are climate change, land and water use, pollution, resource management (including water), and invasive species control. Once again, Soil Capital's Beyond Carbon metrics align with and encompass all the major topics, relevant to agriculture, proposed by those frameworks.

Regarding scalability, Soil Capital's Beyond Carbon metrics have been designed to be used consistently across France, Belgium and the UK, as well as in future geographies with appropriate adaptations to local contexts. Finally, as evident from the above, the relevance of the entire approach, of its domains and related indicators, ensures that Soil Capital's Beyond Carbon metrics are actionable for farmers but also for corporations, with valuable data that drive positive impact across the value chain.

1.2 Completeness

1.2.1 GHG emissions and removals

The CFT and DNDC calculate the emissions of all three main GHGs associated with the production of agricultural products: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

In both the baseline and Project scenarios used in this Project, all these GHGs are included in scope, including CO_2 emissions and removals associated with soil carbon stock change (as a result of, for instance, changes to tillage practices, cover cropping or residue management), changes to the biomass of trees, fuel and energy use and synthetic fertiliser and pesticide production. It also includes CH_4 emissions from livestock via manure management and enteric fermentation via IPCC emission factors. Also, N_2O emissions from crop residue management, synthetic and organic fertiliser use and livestock via manure management. Section 4 details the overall inventory of sources, sinks and reservoirs for the Project, while subsection 2.10.3 addresses leakage issues associated with livestock emissions.

1.2.2 Beyond Carbon metrics

A variety of approaches for impact quantification for regenerative agriculture are under development globally. The complexity of assessing environmental and socio-economic outcomes together means that many actors are continuously refining and improving how to capture and interpret relevant data. In this context, Soil Capital's Beyond Carbon metrics can be considered a pioneering approaching, leading the way in integrating these evolving methods into a cohesive system and anchoring the approach in methods that are already feasible.

Up to now, carbon performance, environmental improvement, and farm socio-economics have often been treated as separate issues. By integrating them within the same framework, a more complete and meaningful evaluation of farm sustainability can be generated. Soil Capital's Beyond Carbon metrics collect data across arable farming contexts, with 23 fully finalised indicators already in use and a total of 32 shortlisted for future development.

As noted, the MECE framework was used for selecting the indicators, so all fundamental topics are covered. Summarising the points outlined in the section above on relevance, the completeness of Soil Capital's Beyond Carbon metrics is delivered by the following design principles. Indicators were selected on basis of the following criteria :

- are highly relevant to regenerative agriculture;
- together enable a holistic analysis, covering all the fundamental areas;
- directly support meaningful progress in the field;
- align with field realities also to avoid additional administrative burden for farmers;
- are well-established, credible, scientifically and agronomically anchored, at the same time capturing spatial and temporal variations at scale;
- present no risk of being misleading or misapplied; can be used consistently across different geographies with appropriate adaptations to local contexts;
- align with EU regulations;
- align with relevant voluntary frameworks and regulations in the private sector and so are actionable for corporations.

This commitment to completeness allows for a comprehensive understanding of the regenerative transition as a process, with a carefully selected set of metrics that reflect real on-field conditions and improvements. By valuing different aspects of sustainability, we also open up multiple pathways for meaningful change.

1.3 Consistency

1.3.1 GHG emissions and removals

All farmers enrolled in the Project must use the same dedicated farm diagnostic tool, mySoilCapital[16], for analysis of their net GHG emissions in both the baseline and Project scenarios.

mySoilCapital uses a farm's operational and practice data to calculate its net GHG emission reductions and removals, and other key agronomic, soil, economical and environmental metrics on a per crop and whole farm basis. mySoilCapital was developed by Soil Capital and is the first farm-level tool for analysis of performance across carbon, soil health, water, biodiversity and farmer livelihood indicators and benchmarks one farm's performance against relevant local peers (see Annex III for screenshots of this tool and the database it feeds). This allows farmers to quickly understand where there are practical and relevant opportunities for them to improve their environmental impacts that will also improve their economic performance. Until this point, environmental improvement has always been presented as a separate topic to the economic performance of a farm.

When analysing a farm's net GHG emission reductions and removals, mySoilCapital draws on the functionality of the CFT and DNDC via bespoke APIs developed by Soil Capital, the Cool Farm Alliance and Regrow[17].

Therefore, via the mySoilCapital tool, the CFT and DNDC methodologies are implemented consistently and accurately throughout the Project. The coupling of GHG analysis with other

[16] English version: https://www.soilcapital.com/farm-diagnostic; French version: https://www.soilcapital.com/fr/diagnostic-ferme.

[17] These APIs operate on a 'push-pull' basis, meaning that farmer data collected by Soil Capital is pushed to the CFT and DNDC and the CFT/DNDC's calculations are automatically pulled back to Soil Capital's systems without further human intervention.

economical and environmental metrics for farmers ensures that this is the most appropriate methodology, especially considering the Project's aim to deliver farming practice changes.

In line with the Verified Carbon Standard (VCS) requirements from Verra, if a new version of the CFT is released during a Project's five-year duration and is deemed by a qualified auditor to produce materially different results to previous versions, the CFT version that was used at the beginning of the Project will be valid throughout the duration of that Project, since variations in GHG estimates could otherwise be attributed to a change in the methodology, rather than a change in farmer practices.

On Regrow's side, they state that the observational database (CALVIN) and computational code (model source code, processing scripts, uncertainty model code) necessary to fully reproduce the entirety of the modelling is permanently archived and versioned for posterity. Regrow has demonstrated that such an archiving procedure is the best method to ensure reproducibility of prior simulations. Documenting a list of model parameters that are influenced by (or in some way derivative to) a set of user inputs does not, in itself, ensure reproducibility because there may be various updates to the model base. Regular updates of the model source code are intended to improve skill or performance, to update process-representation (e.g., a new N_2O emission pathway), add simulated events (e.g., fire, erosion), or provide bug fixes. For these reasons, Regrow regularly versions and archives to ensure reproducible results and transparency of the model code base. Archived versions associated with Validation Reports or Projects are available upon request.

1.3.2 Beyond Carbon metrics

To ensure consistency, Soil Capital's Beyond Carbon metrics employ standardised metrics and methodologies across all farms of a region.

Furthermore, when using third-party sources like global geospatial datasets, uniformity in data collection and analysis is maintained as much as possible. Variations will occur only for different regions that are not covered by the same databases, or that present specificities which are important to take into account. For example, there are some topics around agricultural practices that are not currently relevant for European countries, such as GMOs and some groups of pesticides that are forbidden; those could become targeted topics in other geographies. In any case, all the potential changes to adapt to local contexts occur without contradictions. It implies maintaining the same standards for data verification, as well as the same principles for the adjustments, for example in making new assumptions for a specific metric.

Besides the fact that it ensures coherence in actions, results, and communication about results, this consistency allows for comparability: while indicators cannot be compared across too large an extent of geography, by design comparisons can be made for a group of farms in the same context. This aligns with regulatory and corporate requirements by bringing together insights on a farm's performance against relevant local peers through time. Ultimately, it also allows farmers and corporations to understand where there are practical and relevant opportunities for them to improve.

1.4 Accuracy

1.4.1 GHG emissions and removals

There are two main sources of possible bias and uncertainty considered in this Project: input data uncertainties and parametric uncertainties. Input data uncertainties are driven by the accuracy of the input data applied to the CFT and DNDC with respect to representing the true situation on the ground. Parametric uncertainties are driven by the applicability of the CFT and DNDC to the modelled scenario.

In line with ISO 14064-2, the Project has quality management procedures in place to manage input data uncertainties, this includes the assessment of input data uncertainty, which is relevant to both the Project and baseline scenario. Section 6 describes these quality management procedures in more detail, as well as the approach to evaluating uncertainty.

With respect to parametric uncertainties, it is important to note that the CFT incorporates the IPCC Tier 1 and Tier 2 methods for crops. Rather than considering geographic location as a proxy for soil and climate conditions, the CFT requires elementary climate, soil and farm management information.

Hence, for non soil-based GHG emissions, taking both input data uncertainty and parametric uncertainty into account, this means that bias and uncertainties on estimations in the Project have been reduced as much as possible.

For soil-based GHG emissions and removals, Regrow has developed an empirical uncertainty model that estimates the lack of fit between DNDC model estimates and measured values of differences in a given emissions source (ES) between two paired scenarios from literature data. For this Project, Regrow will estimate uncertainty separately for both soil organic carbon (SOC) sequestration and direct N_2O emissions. Uncertainty deductions are then calculated individually for each DNDC pool included within the Project boundary and the selected approach to estimate uncertainty is representative of the quantification approach used.

1.4.2 Beyond Carbon metrics

Soil Capital's Beyond Carbon metrics use primary data from participating farmers that is necessary for calculating the GHG impacts of their operations and is anyway verified independently by a third-party verification body. This data is collected through the mySoilCapital platform, encoded by farmers in a procedure that not only includes automated checks but also close support of Soil Capital's agronomists.

Most indicators are measured annually at the smallest relevant unit: field level, with some exceptions at the farm level. The values are then aggregated to farm level, using a weighted average.

For secondary data, the use of reliable, trusted sources is essential to maintain data integrity. For instance, for measuring the "high nature value farming" indicator, within the Biodiversity domain, the CORINE Land Cover (Coordination of Information on the Environment) tool[18] is used. This is a European Commission tool that offers a pan-European land cover and land use inventory with 44 thematic classes. Various benchmarks that are used are accessed annually, such as for crop sales prices and yields. For national data, recognised bodies that conduct surveys on agriculture, such as Agreste[19] for France, are used.

1.5 Transparency

1.5.1 GHG emissions and removals

This document discloses all sources of information, calculations, types of data and assumptions required for easy understanding and/or reproduction of the Project's GHG emission reduction and removals calculations.

At each verification, all the data necessary to replicate the GHG emission reduction and removals calculations are made available to the appointed auditor. For each farm enrolled in the Project, this includes:

- analysis of the soil organic matter of its soils for the baseline assessment;
- proof of the managed arable area enrolled in the Project

[18]https://land.copernicus.eu/en/products/corine-land-cover
[19]https://agreste.agriculture.gouv.fr/agreste-web/

- data records accounting for crop management at field level, including synthetic and organic fertilisers inputs;
- remote sensing information (i.e., tillage practice, cover crop use).

Also provided are the databases developed by Soil Capital to calculate the emission reductions and removals for each farm, containing all raw data from the farmers and relevant formulae.

1.5.2 Beyond Carbon metrics

Soil Capital's Beyond Carbon metrics place a strong emphasis on transparency by clearly communicating the methods, data sources, and results of the assessments. All the domains with their respective indicators and metrics can be found in technical description, Annex II.

Both farmers and corporations receive performance metrics from primary data that has been verified, presented in a clear and accessible format. The data generated by Soil Capital's Beyond Carbon metrics is used to support transparent communication, with careful attention paid to ensuring the accuracy and integrity of any claims made.

1.6 Conservativeness

1.6.1 GHG emissions and removals

Two key conservative approaches and assumptions are used in the Project to ensure that GHG emission reductions and removals are not over-estimated.

1.6.1.1 Construction of the regional common practice baseline for baseline emissions scenario 2

The methodology used to calculate the common practice baseline for each region includes a number of specific steps so as to adopt a conservative approach (see subsection 3.2):

i. variance analysis, to ensure that the data collected from relevant experts is sufficiently aligned to be reliable;
ii. upper and lower bound analysis, to ensure that where ranges exist for the data used to represent common practice for a region, the end of the range that is conservative and results in a lower GHG balance at farm level is selected;
iii. apply the common practices to a set of combinations of soil characteristics and rotations to avoid reducing farming heterogeneity to a unique scenario. This approach reduces the risk of rewarding farmers based on its soil characteristics instead of the practices he implemented;
iv. apply an uncertainty deduction on the final common practice baseline result to account for the DNDC model prediction error for soil-based emissions.
v. the average SOC content of each net sequestering farmer will be rounded down to the nearest SOC range bucket used for the GHG assessments of common practice baselines (see section 5.1.1.2.6) to finally calculate the VERRs generated.

1.6.1.2 Uncertainty deduction at verification

At each verification event, for soil-based GHG emissions and removals, uncertainty deductions are calculated individually for each pool included within the Project boundary based on the DNDC model prediction error, as explained in the section 5.1.4.

In addition to that, if, during any verification event, the verification body deems that a farmer cannot provide any reasonable evidence (noting, for instance, that manure is sometimes traded informally) to satisfactorily account for at least 75% of their inputs (by volume), then the farm will not be permitted to generate VERRs for that season. This is equivalent to an uncertainty deduction.

1.6.2 Beyond Carbon metrics

Soil Capital's Beyond Carbon metrics follow a conservative approach to avoid overestimating environmental benefits. This approach has various components, such as the use of the most rigorous methods available for each indicator, combined with conservative assumptions being taken during the calculations, as described below.

When conducting calculations for Soil Capital's Beyond Carbon metrics, making assumptions refers to the process of establishing certain conditions, values, or parameters that are not explicitly given, but are necessary to proceed with the calculation. This allows for (1) simplifying complex problems by reducing variables or the scope of analysis; (2) using reasonable estimates when specific inputs that are not directly observable are required; (3) standardising, by creating a consistent baseline for repeated analyses. Best practices for making robust and conservative assumptions include the following procedures:

- Ground assumptions in field experience and relevant data;
- Explain and justify the rationale behind each assumption, documenting it to ensure transparency and replicability;
- Adjust when necessary, i.e. refine assumptions based on new information or changing circumstances;
- Before a final decision, consider and test how different assumptions might affect results and conduct sensitivity analyses if appropriate.

One example can be seen in the STIR (Soil Tillage Intensity Rating) calculation within the Soil Health domain, which assesses the extent of mechanical disturbance to the soil from machinery use. Scientific evidence underscores the need to minimise soil disturbance for optimal soil health. STIR quantification takes into account not only the surface area affected but also variables such as speed, depth, and the type of tillage, i.e. information about the machinery used. Each machine has guideline values for working speed, depth and the proportion of soil disturbed. However, these values can be adjusted based on actual usage of the machine. Where assumptions are required, the best practices outlined above are consistently followed. Since speed has a high impact, we use average speeds per operation. Secondary data about machine performance comes from widely-used datasets such as Bareme d'entraide for France.

The same conservativeness conditions that are applied to GHG emissions reductions and removals are also applied to Soil Capital's Beyond Carbon metrics. For example:

- If, during verification, the auditor determines that a farmer cannot provide sufficient evidence to account for at least 75% of their inputs, the farm will not be remunerated for its results on carbon or Soil Capital's Beyond Carbon metrics for that season. This is equivalent to an uncertainty deduction.
- Variance analysis is conducted to assess discrepancies between expected and actual values for specific indicators, helping to identify the underlying causes and providing insights into the calculation itself.
- Additionally, upper and lower bound analysis is used to ensure that, when ranges are present, the most conservative value is selected.

Finally, this conservative approach is also underpinned by other principles, such as transparency about the methods used and assumptions made, reinforcing the integrity of the data, the results and consequently of the entire approach.

2 Project description

This Project targets arable farmers in France, Belgium and the UK who are committed to both adopting and maintaining regenerative agriculture practices. Each farmer commits to a five-year crediting period, which can be repeated a maximum of four times, followed by a 10-year retention period. The duration of the Project is, therefore, a maximum of 30 years. The purpose of the Project is for these farmers to benefit from technical support and earn financial rewards for farming practice changes that result in the reduction and removal of GHG emissions.

The Project builds on the design of an earlier project initiated by Soil Capital for farmers in the same geographies, but includes various design features intended to align the Project with the European Union(EU)'s Carbon Removal Certification Framework (CRCF). Full alignment with the EU CRCF was not possible at the time this Project was designed (2024) because the CRCF's detailed methodology - to be presented in a Delegated Act - was still forthcoming at the time. However, the overarching CRCF regulation had been adopted into law[20] at the time and makes clear four fundamental quality criteria for carbon removals to be certified by the EU in the future:

1. Quantification - the combination of soil analysis and modelling, using Tier 3 approaches
2. Additionality - the use of standardised baselines, not least to accommodate the efforts of early adopters, or individual baselines if data does not allow
3. Permanence - ongoing monitoring to confirm long-lasting removals
4. Sustainability - quantification of co-benefits of practices implemented on domains like soil health and biodiversity alongside carbon impacts

While differences with Soil Capital's earlier project are aimed at integrating the above EU CRCF quality criteria in this Project's design, its fundamental purpose remains unchanged.

The Project has been developed by Soil Capital, an independent agronomy firm whose headquarters are in Belgium. Soil Capital's mission is to enable farming professionals to convert 1 M ha of farmland to more profitable, regenerative agriculture by 2025. To achieve this mission, it has built a team of agronomists (experts in the science of soil management and crop production) who have a great deal of experience of direct farm management around the world, along with finance and business professionals. Since the firm was established in 2013, the team has managed, or advised, on nearly 200,000 ha of farmland under transition to regenerative agriculture across at least five continents.

Regenerative agriculture does not have a single, globally adopted definition. One helpfully succinct attempt from Carbon Underground[21] (2017) is, "farming and grazing practices that reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity – resulting in both carbon drawdown and improving the water cycle".

In general, regenerative agriculture differentiates itself from other sustainable agriculture practices by focusing on more than the reduction of negative impacts of farming practices and instead ensures that agriculture has a net positive effect on a range of environmental issues, ranging from climate change to soil erosion to overuse of pesticides.

While a wide range of on-farm practices can be combined to achieve this goal, Soil Capital has determined that all these practices fall under six universal principles, which remain true and applicable across geographies, soil types, climatic zones and farm types:

1. reducing soil disturbance (tillage), with a view to its ultimate elimination;
2. reducing use of synthetic inputs (pesticides and fertilisers) via increased use efficiency and/or their replacement by organic sources, with a view to their ultimate elimination;
3. maximising soil coverage over time with living roots, e.g. via increasingly systematic implementation of cover crops (including catch crops, intercrops);

[20] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202403012
[21] https://thecarbonunderground.org/our-initiative/definition/

4. maximising organic matter restitution the soil via an increase use of organic amendments and a greater incorporation of crop residues into the soil post-harvest;
5. maximising the functional role of biodiversity (moving beyond monocultures, livestock integration);
6. adapting design to local context, so that the farmers that know their land best can adapt practices according to local soil, climate, topography, market and other realities.

Soil Capital has formed business partnerships with a range of entities that aggregate large groups of farmers and who share an interest in Soil Capital's mission to convert 1 M ha to more profitable, regenerative agriculture by 2025. These include independent agronomists and cooperatives across Europe.

- Each independent agronomist provides professional advice to a portfolio of up to 80 farmers in a given region. At the time of validation, at least seven independent agronomists were participating in this Project. They all have long-term relationships with their farmer clients and collectively provide advisory services to more than 200 farmers, operating across more than 20,000 ha of land. Each of their businesses has its own profile; the most visible is probably Regenacterre[22] in Belgium.
- Cooperatives vary in size and structure, but all have long-standing relationships with farmers in their region, many of whom retain some ownership of the cooperative's business.

The Project aims to enrol more than 3,000 farmers in its first five years in Belgium, France and the UK. Farmers will be able to enrol each year, and this process has already started. The distribution of the 600 farmers who have already enrolled at the time of validation is shown in the below map (Figure 2).

[22] https://www.regenacterre.be/

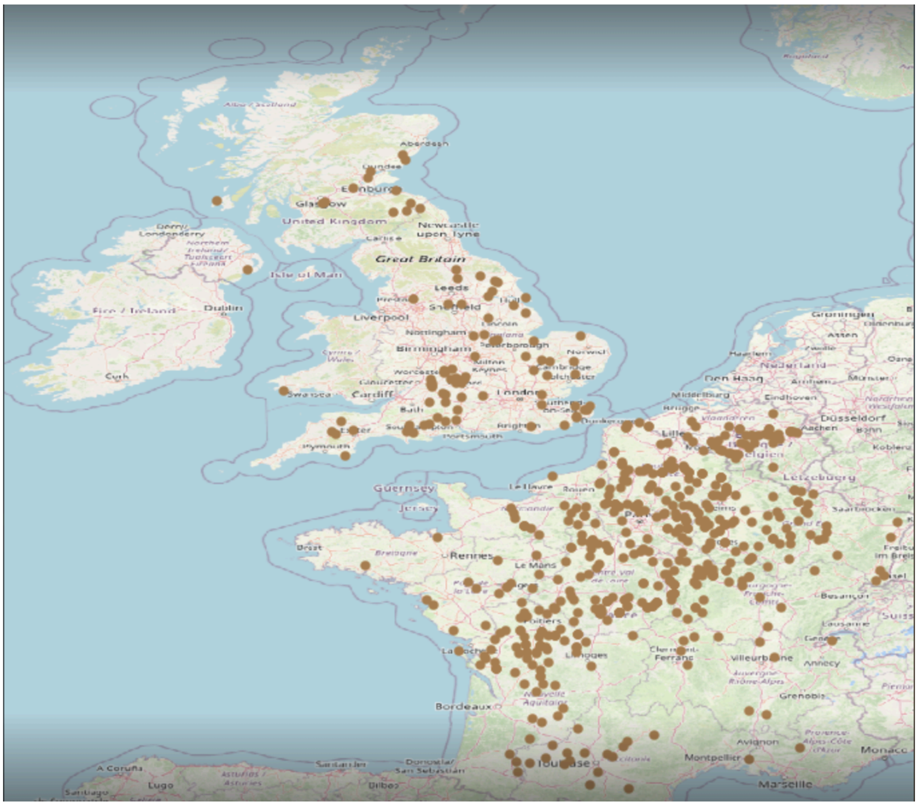

Figure 2 : Locations of the farmers who have already enrolled in France, Belgium and UK to date.

(Source: Soil Capital data mapped via Google Maps 2024)

The number of farmers participating in the Project will expand each year. Table 1 presents Soil Capital's current forecast of enrolments to be expected each year for the first five years, which will be monitored at each yearly verification.

Table 1 Actual and forecast of the number of farmers enrolling in the Project over its first five years

	New farmers enrolling the Project (France, Belgium and UK)	New French farmers per year (%)[23]	New Belgian farmers per year(%)[21]	New British farmers per year (%)[21]	Total cumulative
2023–24[24]	600	71	19	10	600
2024–25[25]	600	Data not available			1200
2025–26	600	Data not available			1800
2026–27	600	Data not available			2400
2027–28	600	Data not available			3000

(Source: Soil Capital, 2024)

[23] Rounded to nearest 5%
[24] Actual information from the first monitoring period 1/09/2023 to 31/08/2024;
[25] Forecast of the number of enrolled farmers to the Project;

2.1 Project title

Soil Capital Climate Change Mitigation Project for Arable Farming: Operational Framework for EU CRCF alignment ('the Project').

2.2 The Project's objectives

The objective of the Project is for eligible farmers to benefit from technical support and earn financial rewards for adopting regenerative agriculture practices and maintaining them.

The duration of the Project is a maximum of 30 years, starting on September 1st 2023. The Project contains a maximum of four consecutive 5-year crediting periods, plus a retention period of 10 years. Individual farmers can enter into the Project each year on September 1st where, in order to align with the Project schedule, the following requirements for each individual farmer shall be met: (1) Individual crediting periods shall be 5 years starting with their year of enrolment; (2) The retention period following the individual crediting periods must be 10 years; (3) The retention period cannot exceed the end of the Project lifetime (August 31st, 2054) so if there is insufficient time for four whole consecutive 5-year crediting periods to be completed, only the number of whole consecutive 5-year crediting periods that can be completed within the Project lifetime may be completed.

By becoming a part of this Project, it is believed that farmers would encourage many more farmers to follow suit and adopt regenerative practices themselves. The regenerative agriculture practices that contribute the most to emission reductions and removals in this Project are the reduction of synthetic fertilisers use and/or their substitution with organic fertilisers, the use of innovative products or additives to decrease on-field N_20 emissions due to the use of synthetic fertilisers, the incorporation of nitrogen-fixing legumes into crop rotations, the reduction of full inversion ploughing practices, tillage depth and number of tillage operations, the maximisation of organic matter restitution to soils via the management of crop residues, the increase of systematic use of diversified cover crops between cash crops and the introduction of trees and perennial tree crops into arable fields using agroforestry techniques.

Alongside the climate change mitigation benefits of these farming practice changes, numerous outcomes are envisaged and will be quantified through Soil Capital's Beyond Carbon metrics. Soil Capital's Beyond Carbon metrics present a holistic approach that ensures more than just GHG emissions reductions and removals are quantified, but also a range of socio-economic and environmental co-benefits as well.

Our Beyond Carbon metrics address the key environmental services linked to agriculture across five domains: Soil Health, Biodiversity, Water Management, Climate, and Farm Socio-Economics, each further divided into specific subdomains and indicators. Farm performance is measured annually, with expected long-term outcomes including:

- Enhancing soil health while preventing erosion and land degradation.
- Protecting and fostering biodiversity within ecosystems.
- Improving water management, reducing the risk of contaminated watersheds.
- Contributing to better air quality and climate change mitigation through lower GHG emissions.
- Reducing risks associated with extreme weather events by fostering climate adaptation.
- Securing long-term yield and profitability for farmers.

2.3 Expected lifetime of the Project

The lifetime of the Project is a maximum of 30 years, comprising up to four individual five-year crediting periods, followed by a 10-year retention period. For each monitoring period, a start and end date for all farms is implemented. The start date is set to September 1st and the end date is set to August 31st of the following year. However, growing cycles for individual crops can sometimes extend beyond this 12-month period. For practical purposes, if a growing cycle begins prior to September 1st, it will be included in the monitoring period starting September 1st of that year. If a growing cycle ends after the 31st of August, it will be included in the monitoring period starting on the previous September 1st.

This approach diminishes the risk of cutting through the different on-farm operations associated with individual crops across a whole farm rotation, while also allowing for yearly monitoring periods. It represents the most pragmatic way to deliver farmer reporting in sync with the reality of their farm's timelines.

The start of the Project was set at the beginning of the 2023–2024 growing season, the first monitoring period, i.e. 1st of September 2023. The emissions reductions and removals (ERRs) that will be generated over the first monitoring period, will be verified by a third-party auditor, which will result in their first VERR issuance in Spring 2025. Each individual crediting period for a farmer lasts five years, e.g., for the farmers joining for the 2023–2024 growing season through to the 2027–2028 growing season, the end date of the first crediting period is 31 August 2028. Farmers may participate in a maximum of four consecutive, whole crediting periods as can be completed, together with their respective retention periods, before the date of Project termination. The end date of the Project is 31 August 2054.

The requirement for landowners and tenants to commit to a 10-year retention period is necessary so as to ensure that farmers demonstrate that they have the ability to deliver the commitment to no loss events, whereby carbon that has been stored in soils is subsequently released, during the retention period (i.e., that they can manage non-permanence risk). The typical initial duration of a farmland tenancy agreement in France and Belgium is 18 years. In the UK, about one-third of tenancies ('Full Agricultural Tenancies') offer lifetime security,[26] while the other two-thirds ('Farm Business Tenancies') do not have a set duration and are negotiated between landlord and tenant, though land agents have reported a structural shift towards longer term agreements, with over 25% lasting for over 20 years.[27] To check how the length of the tenancy agreement at the point of enrolment compares to the one crediting period plus the retention period (i.e. 15 years), Soil Capital requests the farm operator to confirm the amount of years remaining on their current tenancy agreement as part of the onboarding process. Depending on the duration left on the tenancy, different actions are then required by the farm operator (see subsection 2.6 below for more information).

[26] https://www.gov.uk/government/statistics/farm-rents/farm-rents-england-2020#full-agricultural-tenancies

[27] https://www.savills.co.uk/insight-and-opinion/savills-news/176713/fbt-rental-levels-becoming-increasingly-diverse-as-sustainability-grows-in-importance

2.4 Type of GHG emission reduction or removal Project

In this Project, regenerative agriculture practices result in the following emission reductions and removals (please refer also to Section 4 which details the overall inventory of sources, sinks and reservoirs (SSRs)):

Emission reductions:

- Carbon dioxide (CO_2),
  - Reduced need for, and use of, synthetic fertilisers via incorporation of nitrogen-fixing legumes into crop rotation design and increasing substitution with organic fertilisers (e.g., manure); and
  - Use of synthetic fertilisers produced with innovative low-emitting processes; and
  - Reduced pesticide usage and therefore emissions associated with pesticide production; and
  - Reduced use of full inversion ploughing, replacing this instead with reduced tillage and direct drilling (zero tillage) practices; and
  - Reduced fossil fuel and energy use (e.g., for irrigation).

- Methane (CH_4)
  - Improved crop residue management;

- Nitrous oxide (N_2O):
  - Reduced need for, and use of, synthetic fertilisers via incorporation of nitrogen-fixing legumes into crop rotation design and increasing substitution with organic fertilisers (e.g., manure); and
  - Use of innovative synthetic fertilisers or additives (e.g coated urea) decreasing direct on-field N_20 emissions; and
  - Improved crop residue management;

Removals

- Carbon dioxide (CO_2):
  - Increased systematic use and complexity (i.e. number of species and duration) of cover crops between cash crops; and
  - Increased organic matter restitution to the soil via an improved residue management; and
  - Reduced use of full inversion ploughing, replacing this instead with reduced tillage and direct drilling (zero tillage) practices; and
  - Increased use of organic fertilisers, resulting in organic matter being added to the soil and the carbon incorporated within it helping to build more soil organic carbon; and
  - In some cases, introduction of trees and perennial tree crops into arable fields using agroforestry techniques.

2.5 Legal land description of the Project or the unique latitude and longitude

The Project includes farms located throughout France, Belgium and the UK (see Figure 1 for the approximate locations of farmers already enrolled at the time of validation).

Soil Capital is the Project owner and accesses farmers via its direct relationships with independent agronomists and cooperatives. Soil Capital is the lead on the design and delivery of the Project, including the development of a monitoring protocol for farmers.

Soil Capital either contracts directly with the farm operator on each farm or via a cooperative. Being a farm operator is confirmed during the contracting process. In either model, the farm operator takes full responsibility for any operations performed by subcontractors or other agents. Upon enrolment, all farmers (regardless of country) confirm if they are the landowner or not. If they are a tenant, the action required of them by the terms and conditions by which they are bound varies depending on how many years remain on their current tenancy agreement at the point of enrolment.

- If that period is less than five years (i.e., the length of the first crediting period), the tenant is required to confirm the explicit support of the landowner via them signing an Assignment of Beneficial Interest form.
- If that period is between 5 and 15 years (i.e., more than the first crediting period but less than its subsequent 10-year retention period), the tenant is required to confirm their intention to renew their lease immediately upon its cessation.
- If that period is greater than 15 years (i.e., the sum of the first crediting period and its 10-year retention period), the tenant is not required to take any further action.

Soil Capital is the Project owner and subsequently the owner of the achieved emission reductions and removals. It has developed the Terms of Use for the Soil Capital Climate Change Mitigation Project for Arable Farming Project and outlines the ownership of the GHG emission reductions or removal enhancements (document available upon request).

As part of the management of non-permanence risk, data about the remaining years of tenancy arrangements at the point of enrolment will be retained and analysed, so a future decision about whether different risk ratings should be applied to farmers with different contract lengths can be made.

2.6 Conditions prior to Project initiation

The farming practices that characterise conditions prior to the Project initiation will vary, depending on the baseline scenario that a given farmer will use within the Project.

The Project focuses on arable lands in France, Belgium and the UK. In France, there is an agricultural area[28] of 27.5 million hectares (i.e., 50% of the French national territory) of which 62% is arable lands, i.e., 17 million hectares (Sovran, 2022). In Belgium, 44.5% of land area (~13 540 km²) is classified as agricultural land (Knoema, 2018). In the UK, around 4 million hectares of land is used for arable crop production (Bedford, 2023).

It is estimated that around 45% of soils in Europe “have low or very low organic matter content (0-2% organic carbon)”, this can be seen especially in France, the UK, Germany, Norway, and Belgium (Panagos et al., 2012; FAO and ITPS, 2015). In addition, soil loss due to crop harvesting is a globally occurring and underestimated process that promotes soil degradation. Therefore, this is important to explore soil conservation measures and strategies to reduce ongoing soil degradation especially in highly mechanized agriculture (Saggau et al., 2024). During the period 2000–2016, the total soil loss by crop harvesting is estimated at ca. 14.7 million tons yr^{-1} in the EU-28 (Panagos et al., 2019). Furthermore, in France, it is estimated that the decrease in carbon stocks in agricultural soils is about 6 million tonnes per year (Pointereau, et al., 2008, p. 17). In Belgium, the average soil loss due to crop harvesting is estimated to be 1.4 tonnes/ha/year (Gentile, et al., 2009). Future predictions indicate that climate change will have a more profound impact on soil organic carbon (SOC) losses than land use changes. By 2100, it is estimated that France could lose between 774 and 1221 million tonnes of SOC due to climate factors alone (Meersmans et al., 2016).

[28] The Useful Agricultural Area (UAA) is a statistical concept designed to assess the territory devoted to agricultural production. The UAA is composed of: arable land (field crops, market gardening, artificial grassland, etc.), areas still under grass (permanent grassland, mountain pastures), perennial crops (vines, orchards, etc.).
It does not include woods and forests. It does, however, include fallow land (included in arable land).

It is well documented that one of the main drivers for the loss of soil carbon and soil depletion is agricultural intensification and certain cropping activities (Pointereau, et al., 2008; Antoni, et al., 2013; Kopittke et al., 2019). The farming management practices often associated with conventional farming systems have been influenced or are rooted in the Green Revolution, and the subsequent agricultural intensification (McLaughlin et al., 1995; Geiger et al., 2010; Tal, 2018; European Environmental Agency, 2021). As a result of agricultural intensification, conventional farming systems tend to have higher use of synthetic pesticides, insecticides, fungicides, herbicides and fertilisers, and tend to employ mechanical tillage. The use of synthetic fertilisers has led to an increase in nitrogen and phosphorus into surrounding environments, resulting at times in water and soil quality deterioration. In Europe, the decrease in carbon in soils has been tied to "the excess nitrogen in the soil from high fertiliser application rates and/or low plant uptake" as a result of "intensive fruit and vegetable cropping, or cereal production" (p.10). Insecticide, pesticide, and fungicide drift or run-off into waterways and/or landscapes has also led to deterioration of water and soil (Biao et al., 2003; Devine et al., 2007; European Environmental Agency, 2021; Kopittke et al., 2019).

Intensive agriculture in France is predominantly situated in the North and South-West of the country. These areas have been associated with greater loss of soil organic carbon (Pointereau, et al., 2008). While intensive agriculture has resulted in high levels of productivity, this increase has come at the cost of biodiversity and soil quality (Abada-Simon, et al., 2022).

From the 1960s onward, the intensification of agriculture in Belgium, characterised by the increase in fertilisers, pesticides and mechanisation has given rise to among other negative environmental impacts (Gentile, et al., 2009, p.53). The majority of Belgian farms employ intense farming management practices (Van Hecket, et al., 2000; DG AGRI, 2015).

In the UK, the Government itself admits that "intensive agriculture has caused arable soils to lose about 40 to 60% of their organic carbon" (Environment Agency, 2019).

In Europe, more than 90% of fields are conventionally grown (RegAgri4 Europe, 2022). Organic and regenerative practices are adopted by a very small portion of farmers. In Belgium between 6.8 - 7.2 % of agricultural land has adopted organic farming practices, of which 90.2% is located in the region of Wallonia (STATBEL, 2021). In Belgium 0.03% of arable land is classified as conservation agriculture, and approximately 1% of farmers have adopted regenerative agricultural practices. In France, 7.3-9.5% of agricultural land is classified as organic, and only 1.55% is classified as conservation agriculture (ECAF, 2022; Agence Bio, 2021). Approximately 4% of French farmers have transitioned to regenerative agriculture. In the UK, 3.3% of arable land is classified as organic and 8% as regenerative (FiBL & IFOAM, 2019). Consequently, the agricultural soils in France, Belgium and the UK are considered as potential GHG sources due to the currently degrading SOC stocks.

Therefore, the conditions prior to the Soil Capital Project initiation are that the overwhelming proportion of farms apply conventional agriculture practices, with a small proportion of farms implementing regenerative agriculture.

2.7 Description of how the Project will achieve GHG emission reductions or removals

This Project is a European agricultural emission reductions and removals Project targeting all of the main GHGs linked to agriculture. The Project will achieve its goal by enrolling farmers who are committed to transitioning to regenerative agriculture practices and those committed to maintaining such practices. Such practices reduce GHG emissions from the agriculture sector and increase storage of carbon in soil organic matter and tree biomass.

Throughout the Project, Soil Capital will provide technical support, covering topics such as the reduction of use and GHG impact of synthetic fertilisers and/or their substitution with organic inputs, the minimisation of full inversion ploughing practices, reduction of tillage depth and number of tillage operations, the maximisation of soil cover and organic matter restitution to the soil by improving residue management or increasing of systematic use and complexity of cover crops between cash crops and the introduction of trees and perennial tree crops into arable fields using agroforestry techniques.

Farmers participating in this Project will implement these practices with support from local, expert agronomists, who are either working independently or for cooperatives, and who are partnered with, and receive support and training from, Soil Capital. Such support and training will take the form of online webinars, field tours for groups of agronomists, facilitated peer-to-peer knowledge exchange and events with local and international experts.

2.8 Project technologies, products, services and the expected level of activity

2.8.1 Regenerative agriculture practices

Soil Capital's mission is to enable farming professionals to convert 1 M ha of farmland to more profitable, regenerative agriculture by 2025, and maintain their efforts. Achieving and maintaining such a transition will result in conventional farmers implementing new farming practices resulting in net removals in farmland soils and tree biomass.

The regenerative agriculture practices promoted by the Project increase soil biodiversity, improve soil structure, increase plant diversity and promote soil health in addition to SOC benefits.

1. **Reduced or zero tillage**

High disturbance of the soil via deep ploughing that fully inverts the soil profile results in disruption to soil microbial activity and oxidation of soil carbon. When soils are left undisturbed, the abundance and diversity of life in the soil increases, driving improved soil biology and physical structure. These improvements provide both ecological benefits as well as resilience to crop stressors, improvements in plant health and, ultimately, yield. With improved soil structure, loss of soil due to both wind and water erosion is reduced, together with nutrient and pesticide run-off into watersheds. Crucially, it is well known that tillage reduction also leads to increased soil carbon content (Ogle et al., 2005; Labreuche et al., 2007; Angers & Eriksen-Hamel, 2008; Franzluebbers, 2010; Kravchenko and Robertson, 2011; Virto et al., 2012, Powlson et al., 2012). Minimum (reduced) tillage techniques typically leave 30-60% residue cover while no (zero) tillage techniques typically leave 60-100% residue cover.

2. **Increasing plant diversity**

Historically, areas that grew a variety of plants and crops built healthier soil naturally before modern industrial farming began to focus more on specialisation in a few crops, year in and year out. Crop rotation and plant diversity (e.g., techniques such as companion cropping, inter-cropping, relay cropping) play a critical role in mimicking the natural diversity of natural ecosystems and enabling the reduction of inputs, including synthetic fertilisers and pesticides which interrupt the life cycles of, and interactions between, soil microbes and plants (Yang et al., 2024).

3. **Cover cropping**

Promoting more continual plant and root growth in soils is also key to soil health and regenerative agriculture. Cover cropping systems in between cash crop cycles enables farmland to continue to sequester CO2 from the atmosphere in the soil via photosynthesis, whereby plants input carbohydrates into the soil via their root exudates (Poeplau and Don, 2015; Abdalla et al., 2019). Having living roots in place during a period where soil would normally be bare brings varied co-benefits, such as protecting soil surface from erosion, increasing soil biodiversity, etc (Jian et al. 2020). Cover cropping will also reduce potential fertiliser leaching into watersheds and groundwater, help to reduce agricultural run-off. Leguminous cover crops can be used to fix nitrogen from the atmosphere into the soil, reducing the need for synthetic nitrogen fertilisers next season.

4. **Improve residue management**

Conventional agriculture practices, especially in regions with a lot of livestock farming, often see crop residues (e.g. straw) that are left behind when crops are harvested, being collected, baled and exported from fields for sale to feed the neighbouring animals and/or to be used as bedding material. It is more often the case for winter cereals and in some cases, rapeseed. Such a practice can lead to periods with bare soils and decrease the dead plant materials restitution to the soil. Promoting the restitution of crop residues as such or in mulch results in higher carbon input for the soil, which not only increases soil organic carbon content after residues are broken down, but also lead to other key co-benefits, such as erosion control, improved water retention capacity, etc (United States Department of Agriculture Natural Resources Conservation Service, 2011; Arvalis, 2020 ; TerreOM, 2023).

5. **Synthetic fertiliser reduction and/or new organic fertiliser application**

Conventional agricultural practices rely on synthetic fertiliser for plant nutrition and productivity, resulting in significant GHG emissions and disruption of microbial activity in the soil that would otherwise be providing nutrition to plants. Reducing the use of synthetic fertilisers and/or maximising their substitution with low emitting innovative products (e.g. coated urea) or organic fertilisers such as compost, manure or slurry is therefore not only decreasing nitrogen run-off and leaching into groundwater (indirect N_20 emissions) or losses via volatilisation (NH_3) or nitrification/denitrification (direct N_20 emissions). It is also beneficial for soil biodiversity. Thus, optimising nitrogen inputs is both economically and environmentally beneficial (Miller, 2015; Deng et al., 2016). In addition, replacing synthetic inputs by organic products rich in organic matter will increase the restitution of organic carbon to the soil, leading to an increase in soil organic carbon stocks.

6. **Agroforestry**

When integrated into in-field cropping systems in a methodical and managed manner, trees help to increase plant diversity and soil health, reduce agricultural run-off, guard against soil erosion and provide habitat for native flora and fauna to thrive, they also sequester carbon in their biomass. Economically, these practices provide additional and diversified revenue streams.

The field experimental evidence that regenerative agricultural practices can significantly increase soil carbon stocks is unequivocal (Paustian et al., 2020).

2.8.2 Operation of the Project

Given these conditions prior to the Project initiation, and based on the selected methodology, the following eligibility criteria further defines whether farmers may join this Project.

1. This Project is for arable farms that are growing any range of combinable and horticultural crops.
2. Note that the Program targets arable farming, but to accommodate the market reality that arable farms do sometimes integrate livestock and genuinely mixed arable-livestock operations do exist, arable farms with livestock remain eligible. In this case, GHG emissions from those livestock are accounted for in the farm overall GHG balance and result from common practice in the region at the baseline assessment, as calculated using IPCC Tier 1 emission factors. Emissions related to livestock are then held constant from the baseline throughout the crediting period, unless there is an increase in heads of livestock during the Project, in which case the same equations are used to calculate the increase in emissions. This is further elaborated in Section 2.10.3 and Section 4.
3. Farms with livestock management must account for any leakage sources.
4. Cropland enrolled must only be on mineral soils (i.e., peatlands and wetlands are excluded from the Project).

5. Cropland enrolled must have been managing cropland or grassland for at least 10 years prior to the Project start date (i.e., no conversion of native ecosystems in the last 10 years).
6. Farm operators must only commit cropland to be enrolled in the Project that they reasonably expect they have operational control over throughout the first crediting and its retention period (i.e., 15 years).
7. Farms must be located in an area with access to fire services; if a farm has suffered a fire in its fields that destroyed more than 10% of the crops in the affected fields during the 10 years prior to enrolment, the farmer must confirm that they have a valid crop insurance policy covering the enrolled cropland.
8. Cropland enrolled must not be enrolled in any other GHG payment scheme deriving payments from the voluntary markets during the crediting period.
9. Since each farm commits to a crediting period that lasts five years, and the IPCC advises that mineral soils can continue to sequester carbon permanently after practice changes, on average, for 20 years, each farmer is eligible to participate in a maximum of four consecutive crediting periods. Hence, the Project's maximum duration is 30 years when the subsequent 10-year retention period is taken into account (IPCC, 2003).
10. Farms must not be part of another private sector carbon Project, rewarded for GHG emissions reductions or sequestrations.
11. Farms in Wallonia, Belgium must not be enrolled in the 'soil' agri-environmental scheme together with the 'long cover' eco-scheme.
12. Farms in Flanders, Belgium must not be enrolled in the "the high carbon content products pathway" of the eco-scheme related to soil organic carbon

2.9 Total GHG emission reductions and removals, stated in tonnes of CO_2e, likely to occur from the GHG Project (GHG assertion)

With the enrolment of new farmers into the Project each year, it is assumed that, in its first five years, the number of French and Belgian farmers will increase from just over 600 in the 2023–2024 growing season to more than 3000 in the 2027–2028 growing season. This growth rate is based on conservative and constant lead generation and conversion rates applied to a target market of farms over 50 hectares in size (data sourced from Eurostat for each country). Using these recruitment numbers, combined with an average farm size of around 200 ha, the total farm area enrolled by the 2027–2028 growing season is forecast to be over 600,000 ha.

The total cumulative emission reductions and removals potential in the first five years of the Project is likely to be around 900,000 tCO_2e, i.e. 0.5 VERR per hectare per year on average (counting VERRs held in the buffer), broken down into the contribution of annual vintages as in Table 2. This forecast is generated using the assumptions presented in Section 5.

Table 2 Total GHG emission reductions and removals likely from the Project

	2024 vintage	2025 vintage	2026 vintage	2027 vintage	2028 vintage	Total
Total emission reductions and removals (tCO_2e)	60,000	120,000	180,000	240,000	300,000	900,000
Buffer contribution @ 20% (tCO_2e)	6,000	12,000	18,000	24,000	30,000	90,000

(Source: Soil Capital 2024)

For more information about Buffer, refer to subsection 2.10.2.

2.10 Identification of risks

2.10.1 Performance risk

Agricultural Projects face several inherent risks that, if they occur, may affect the performance of a farm in the context of a Project like this. 'Performance risk' is defined here as any risk that would lead to lower GHG emission reductions and removals than expected. These risks need to be identified and managed according to the specifics of the Project. Table 3 sets out Soil Capital's analysis of performance risks and its proposed measures to manage them. For each potential performance risk to the Project, whether it is external or internal, its definition and management measures to mitigate the risk is provided.

Table 3 : Performance risk identification and management measures

Type of risk	Description	Risk management measures
Management risks (internal)		
Project management	Farmers without appropriate training or support perform poor management practices during their transition, delivering sub-optimal outcomes	As a condition of participation in the Project, farmers must confirm that they have access to suitable expert agronomic advice. As such, the risk that farmers undertake unwise or impractical practice changes, given their local circumstances, or lack suitable expert support to implement their plan appropriately is reduced. In addition, farmers are regularly in contact with our trained internal and external agronomists, during data collection meetings, results discussions or field tours, all those interactions being the opportunity to support farmers in their transition

Type of risk	Description	Risk management measures
Financial viability	Farmers find that implementing the Project activities is not financially viable for them over the duration of the Project, meaning they do not implement expected practices and deliver sub-optimal outcomes	As a condition of participation in the Project, farmers must confirm that they have access to suitable expert agronomic advice. As such, the risk that farmers undertake financially hinder practice changes, as their local circumstances are reduced
Alternatives to Project activities appear more attractive to farm operators	Conventional farming practices are the common practice in the Project region. During the Project, some farm operators may perceive these conventional practices to be more desirable and, consequently, they withdraw from the Project	As a condition of participation in the Project, farmers must confirm that they have access to suitable expert agronomic advice. Additionally, to further support farmers in their decision-making and track the progress of implemented practices, Soil Capital developed the **Beyond Carbon** metrics. These metrics quantify the outcomes of regenerative farming practices on an annual basis. The analysis covers five key domains: Soil Health, Biodiversity, Water Management, Climate, and Farm Socio-Economics, each broken down into relevant subdomains and indicators. These categories were selected for their strong relevance to Regenerative Agriculture. The goal is for the results to promote meaningful progress, providing additional incentives for farmers to sustain these practices, while reducing the temptation to revert to previous, less sustainable methods. The additional revenue available to farmers through the sale of their VERRs will serve as an additional incentive to maintain practice changes. Soil Capital will seek to secure advance market commitments from prospective buyers of VERRs to reduce the risk that the revenue secured turns out to be lower than expected. Finally, 20% of all VERRs generated will be held in the pooled buffer for 10 years and only sold if remote sensing has shown that the farmer in question has not been at risk of causing a loss event during the retention period. This creates a meaningful incentive for farm operators to maintain their practice changes during the retention period.

Type of risk	Description	Risk management measures
Landowner commitment	The farm operator is a landowner and they decide to withdraw their land from the Project	Upon enrolment, farm operators who are landowners will be required to sign a contract for the entire duration of the first crediting period and its subsequent retention period. The contract shall clearly state that, should a farm operator withdraw from the Project during these crediting or retention periods, they will no longer have a claim on future financial benefits
Tenant commitment	The farm operator is a tenant and they, or their landowner, decides to withdraw their land from the Project	In the scenario where the tenant decides to withdraw, the risk management measure is the same as above. In order to manage the risk that the landowner decides to withdraw, information about the years left on the tenancy is required from all tenant farmers prior to enrolment. A three-tier approach to risk management is in place, depending on this information. See Section 2.5 for full details.
MRV system approach used	An MRV system used to estimate reliable, credible and accurate net GHG emissions from the agricultural systems	The selection of the most appropriate MRV system is crucial to avoid any underestimation or overestimation of net emissions reductions and removals. The combination of DNDC (removals and soil-based emissions) and CFT (non soil-based emissions) is bringing a mix of default factors derived from global datasets (Tier 1 or 2) and a process-based model of GHG fluxes from agricultural soils. In addition to the modelling approach, the use of the remote sensing device from Regrow, called OpTIS, will verify that each year, the declared practices are well implemented on the fields. This combination of remote sensing with two complementary modelling approaches enables standardised, robust, reliable, cost-effective and easily applicable MRV systems as well as consistent estimation techniques over time to track SOC change , GHG removals and GHG reductions, applicable to different agricultural systems. The continuous improvement of the science used by the model providers will ensure that at any moment the best science available is used.

Type of risk	Description	Risk management measures
Natural risks (external)		
Fire	There is a fire in the fields of one or more participating farms (e.g., during harvest, following a lightning storm, etc), destroying a crop and its contribution to removals	As a condition of participation in the Project, farms must be located in an area with access to fire services. If a farm has suffered a fire in its fields that destroyed more than 10% of the crops in affected fields 10 years prior to enrolment, the farmer must confirm that a valid crop insurance policy covering the enrolled cropland is in place to show that adequate risk management measures have been taken
Pests and disease outbreaks	A pest or disease outbreak destroys a crop, affecting the biomass growth in a particular year and its contribution to removals	As a condition of participation in the Project, farmers must confirm that they have access to suitable expert agronomic advice
Extreme weather	Too much or too little rainfall leads to problems establishing or growing crops, respectively, affecting the biomass growth in a particular year and its contribution to removals	As a condition of participation in the Project, farmers must confirm that they have access to suitable expert agronomic advice
Geological events	Earthquakes or other geological instabilities render farmland unworkable	This is not deemed a material risk in France, Belgium and the UK, where the Project is located

(Source: Soil Capital, 2023)

2.10.2 Permanence risk

Permanence risk generally refers to the risk that GHG emission reductions and removals that have been credited in past periods will be reversed in future periods (following events known as 'loss events').

According to ISO14064-2, the Project shall establish and apply criteria, procedures and/or methodologies to assess and manage permanence risk.

However, specific sources of permanence risk in the agricultural sector and procedures for how to deal with them are not specified by ISO. Therefore, in this section, potential sources of permanence risk are identified, and a risk management procedure is outlined.

The first key risk management measure relates to GHG emission reductions (i.e., the avoidance of GHG emissions that would have otherwise occurred). In this Project, VERRs will only be generated once a verification has occurred. Verification will be timed to occur once a year after the growing season is complete, e.g., mid-December onwards, and will be completed by the following April at the latest. Verification will confirm, ex-post, the impact of the farmer's practices over the previous year on the farm's overall net GHG emission reductions and removals.

Since this Project deals with arable farming systems operating on annual cycles, it will be known at this point whether any of the above performance risks affecting the in-field practices and viability of the crops have occurred. Therefore, it will be clear whether all practices related to GHG emission reductions (e.g., fertilisation strategy, use of machinery) have been completed or not for that growing season. Since the GHG emission reduction activities in this Project all refer to farming practices associated with establishing, growing and harvesting annual crops, once the growing season is complete these GHG emission reductions have either been achieved or not, and any that have been achieved cannot be reversed. It will also be clear what level of above-ground dry matter growth exists, which is critical in pumping carbon into the soil, was achieved.

What remains as a permanence risk once this risk management measure is taken into account is the gains from removals, i.e., carbon that is stored in farmland soils or tree biomass. This sequestered carbon could indeed be released from these stores after the growing season by a future change of farming practice (e.g., reverting to more intensive tillage practices or cutting down trees). To manage this risk, such loss events are defined with a remediation process being established.

Defining a loss event

A 'loss event', in this instance, is defined in accordance with the following definition from the VCS: "in an AFOLU Project, any event that results in a loss of more than 5% of previous VERRs due to losses in carbon stocks in pools included in the Project boundary that is not planned for in the Project description (e.g. harvesting as set out in management plans and described in the Project description is not a loss event). Examples include catastrophic events as well as human-induced losses such as those caused by poor management, tillage, over-harvesting or encroachment by outside actors (e.g., illegal logging or fuelwood collection)" (Verra, Program Definitions, 2022, p.10). A catastrophic reversal is defined by the VCS as "a type of reversal caused by disasters, such as hurricanes, earthquakes, flooding, drought, fires, tornadoes or winter storms, or man-made events over which the Project proponent has no control, such as acts of terrorism or war)" (Verra, Program Definitions, 2022, p.5).

Furthermore, the VCS definition for reversal is "a situation where the net GHG benefit, taking into account Project emissions, removals and leakage, in any monitoring period is negative" (Verra, Program Definitions, 2022, p.16). In the Project, the above definition of human-induced loss events is taken to define a loss event. Specifically, a loss event is defined as a release of carbon previously sequestered in an enrolled farm's soils and/or in-field tree stocks during the crediting period, where the following three criteria apply:

1) the loss event was caused by practices not used in the previous seasons of the Project period (e.g., more intensive land preparation, except in the context of a transition to certified organic production);

2) the loss is quantified as representing more than 5% of the removals achieved already by the farm during the crediting period;

3) the loss event results from the farm operator's management decisions, rather than directly from natural weather events (e.g., flood, wildfire) or other man-made events over which the farmer has no control (e.g., terrorism, war).

The third criterion ensures that the definition of a loss event aligns with the Project's overall goal for farmers to earn financial rewards for farming practice changes that result in GHG emission reductions and removals. It means that loss events caused by farming practices do trigger consequences for the farmer, while loss events outside of their control – i.e., those defined as catastrophic events in VCS – do not. For the avoidance of doubt, if a period of intense rainfall leads to waterlogging of soils and a farmer subsequently decides to increase the intensity of tillage as a management practice response, it constitutes a loss event. This is because, in truth, with sufficient planning and proactivity, other solutions to increasing the water infiltration rate of soil could have been implemented.

It is worth noting that, even though a loss event caused by wildfire falls outside the scope of the definition of this Project, and therefore does not create a liability for the farmer, the IPCC guidance (IPCC, 2006) on how to understand the risk of carbon release from soils during a fire is that, for mineral soils, the release of carbon in this scenario is negligible. According to the IPCC, fire on organic soils such as peatland would result in a meaningful release of carbon into the atmosphere. However, such organic soils are ineligible for this Project.

Monitoring and reporting loss events

During the crediting period, farmers report each year on the tillage practice actually implemented in the previous years. In addition to farmer reporting, the Project uses remote sensing applications to monitor key risk factors that might lead to loss events, namely changes in tillage practice. See Section 6.2 for more information on this technique. Where either monitoring methodology indicates a suspected loss event, where operationally possible, the farmer shall have the right to challenge the suspected loss event by providing satisfactory evidence of the tillage practice actually implemented. Possible examples of satisfactory evidence include a combination of farm records such as proof of ownership of relevant machinery, invoices for sub-contracted operations, Farm Management Information System records of operations performed or data direct from farm machinery; geo- and time-stamped photographs).

If the loss event is confirmed and occurred during the crediting period, at the next verification a final calculation of the farm's net GHG emission reductions and removals will be performed, and an assessment will be made as to the quantified extent of the loss. A loss event report shall be prepared, including details of the loss event and the quantification of the impact on the net GHG emission reductions and removals of the farm calculated using DNDC. If the loss event occurred during the retention period, this assessment will be carried out at the end of growing season in which the loss event occurred.

Managing and remedying loss events

The ISO 14064-2 standard itself does not make prescriptive requirements in this regard. However, for the management of non-permanence risk, Soil Capital has elected to follow the VCS Standard v4.1, which requires an analysis of non-permanence risk and the establishment of a pooled buffer in line with other Agriculture, Forestry and Other Land Use (AFOLU) Projects.

In this approach, following the analysis of a Project's non-permanence risk, a determination is made as to the proportion of VERRs that must be held in a AFOLU pooled buffer.[29] To align with the detail of the Core Carbon Principles, published by the Integrity Council for the Voluntary Carbon Markets, in which the requirement is made to capitalise a buffer with 20% of removal VERRs, without any such requirement being made of emission reduction VERRs. This follows the broader logic that accounting for reversed removals should only be done with removal VERRs. The pooled buffer holds removal VERRs that are not traded to cover the non-permanence risk associated with the Project. In terms of contributions to the buffer, the Project aims to align with the VCS from Verra and other standards, like the United Kingdom's Woodland Carbon Code (WCC) and the Label Bas-Carbone. Therefore, it applies a standard requirement that 20% of all removal VERRs generated in the Project are held in a pooled buffer. Hence, at each verification, when removal VERRs are generated, 20% of each farmer's removal VERRs are set aside and reserved in the Project's pooled buffer to account for any reversals. These removal VERRs are not released or materialised until 10 years after the verification period in which they were created, provided ongoing monitoring by remote sensing has shown that the farmer in question has not been at risk of causing a loss event during the retention period.

Based on the experience of other Projects, a standardised contribution to the buffer by all farmers was selected instead of a customised contribution based on individual risk assessments to control setup costs. Should a loss event be confirmed after a verification event (i.e., during the crediting period) or at

[29] The buffer is managed by the Project proponent and the Project owner via a database that is reviewed by the independent auditor every year during the verification process.

the end of the five growing seasons after farmer enrolment (i.e. during the retention period), the number of removal VERRs required to compensate for the loss will be retired from the pooled buffer. If the loss occurs during the crediting period, the removal VERRs generated by the responsible farmer over the following years will first be used to replenish the buffer and, once this is done, the farmer's removal VERRs can then be sold again and will return to earning revenue. If the loss occurs during the retention period, the buffer cannot be replenished, earning and the farmer will stand to gain less once the retention period is complete.

The level of standardised contribution to the buffer is reviewed and may be adjusted over time based on the actual experience of reversals in the Project. In addition, other measures to manage non-permanence risk include: i) Soil Capital reserving the right to terminate a farmer's participation in the Project at its own discretion following a loss event during the crediting period; ii) terminating a farmer's participation in the Project if they end the crediting period while still owing removal VERRs to the buffer; and iii) terminating a farmer's participation in the Project if they cause a single loss during the retention period totalling 30% or more of the amount of removal VERRs they contributed to the buffer at the beginning of the retention period,[30] or if they cause more than one loss during the retention period.

Ten years after the removal VERRs have been created and have entered the buffer, i.e., the duration of the retention period, any removal VERRs that remain in the buffer may then be released and sold, provided ongoing monitoring by remote sensing has shown that there has been no significant risk resulting from the farmer causing a loss event during the retention period, as defined in iii) above.

This creates a clear financial incentive for farmers to manage non-permanence risk throughout the retention period. As neither the existence nor the length of the retention period is prescribed by the ISO standard 14064-2, the Project has selected a duration of 10 years based on careful analysis of the market context, including:

- Other standards in relevant European markets, such as the French Government's Label Bas-Carbone, that require only a five-year commitment period from farmers;
- The typical initial duration of a farmland tenancy agreement in France and Belgium of 18 years. In the UK, about one-third of tenancies (Full Agricultural Tenancies) offer lifetime security,[31] while the other two-thirds (Farm Business Tenancies) do not have a set duration and are negotiated between landlord and tenant. Land agents have reported a structural shift towards longer term agreements, but still around 50% of Farm Business Tenancies are around 5 years.[32] If the retention period was much longer than 10 years, the total time commitment expected from tenants enrolling in the Project would far exceed the typical length of many standard tenancy agreements, raising fundamental questions about the credibility of the retention period.

As a final risk management measure, the contract signed by the farm operator indicates that the right to payments generated by the sale of removal VERRs from the buffer accrues to the operator of that land specifically. Thus, if the land happens to be sold during the Project's retention period, the seller can incorporate the value of the remaining payments into the price of that land. Selling this right to the new owner increases the likelihood that loss events are avoided, an important mechanism for ensuring further non-permanence risks are minimised.

[30] This approach ensures that, even if there is one modest loss during the retention period, farmers still have a positive financial incentive to achieve permanence with the rest of the carbon they have stored during the crediting period. Without this threshold, the smallest of loss events during the retention period would result in the elimination of this positive financial incentive, thereby creating a much weaker permanence regime.

[31] https://www.gov.uk/government/statistics/farm-rents/farm-rents-england-2020#full-agricultural-tenancies

[32] https://www.savills.co.uk/insight-and-opinion/savills-news/176713/fbt-rental-levels-becoming-increasingly-diverse-as-sustainability-grows-in-importance

2.10.3 Leakage risk

A full assessment of leakage risks from the project activities has been conducted resulting in identification of three potential sources of leakage from these SSRs, together with monitoring and mitigation approaches for them. This assessment is summarised below.

1) Leakage resulting from yield reduction.

   A common concern regarding similar projects is that the project activities will result in lower yields. Since food demand continues to grow, the concern is that such projects would displace food production to other areas, potentially leading to increased GHG emissions if the GHG intensity of production in those areas was higher than in the project area. Section 5.1.3 presents an analysis that this risk is not material, but nevertheless presents a monitoring and quantification approach for this potential source of leakage.

2) Leakage resulting from the substitution of synthetic for organic fertiliser.

   From a single farm point of view, this activity results in an increased demand for organic manure. In theory, it is possible that this could result in an increase in the production of farmyard manure in response, via expansion of livestock farming elsewhere. If this was the case, it would result in increased GHG emissions from livestock. In practice, manure is a waste product from livestock production whose value is immaterial to a livestock producer compared to the value of meat or livestock products. An increase in demand therefore does not lead to an increase in supply. The other possible effect is that manure could be diverted from other activities that are more beneficial to the climate. In Europe, the vast majority of manure is used to fertilise farmland (Andurand et al. 2018), rather than being used in bioenergy, for example. Therefore, this is also not considered to be a material risk. Finally, depending on the volumes of synthetic fertilisers being avoided, it is theoretically possible that the Project could lead to a reduction in price for such fertilisers and subsequently an increased consumption by other farmers (i.e. a 'rebound effect'). However, the synthetic fertiliser market is a global commodity market. In the EU alone, there were over 10 million different farms in 2016 (Eurostat – Agriculture statistics, 2016). So, the behaviour of 2,000 farmers in this Project is highly unlikely to have a material impact on fertiliser pricing. The risk of leakage via this mechanism is negligible.

3) Leakage via displacement of livestock.

   For those arable farms that do have livestock (and are eligible), all relevant emissions from enteric fermentation and manure management are included as SSRs for the Project. It is plausible that farmers would respond to this by selling livestock, which would result in simply moving their associated emissions outside of the project area, leading to leakage. To manage this risk, for those arable farms that do have livestock (and are eligible), the GHG emissions calculated during their baseline assessment are held constant throughout the Project Years, irrespective of changes to livestock management practice or reductions in livestock numbers. Thus, if livestock displacement does occur and livestock numbers go down during the project years, the GHG emissions calculated during the baseline will continue to be applied to the farm's GHG analysis, thus ensuring no leakage

2.10.4 Roles and responsibilities

Soil Capital, local expert agronomists and farmers are the key entities to implement the Project, see Table 4.

Table 4 : Roles and responsibilities

Party	Role and responsibilities	Key contact
Soil Capital	'Project Proponent' Oversees the development of appropriate Project design and monitoring techniques in line with carbon standard requirements and timely implementation of validation and verification; responsible for registration of Project with relevant standards and for ultimate sale of VERRs generated	Andrew Voysey Chief Impact Officer Rue du Buisson, 19, 1360 Thorembais-Les-Beguines, Belgium a.voysey@soilcapital.com
Soil Capital	'Project Owner'. Leads the conception and implementation of the Project, including the development of implementation and monitoring protocols for farmers, via its direct relationships with expert agronomists and their farmer clients	Andrew Voysey Chief Impact Officer Rue du Buisson, 19, 1360 Thorembais-Les-Beguines, Belgium a.voysey@soilcapital.com
Agronomists	Advisers to farmers Agronomists are responsible for: i) advising farmers who are participating in the Project on how to achieve emission reductions and removals in a prudent manner for their farm; ii) assisting farmers implementing the requirements of this Project Document; and iii) supporting farmers in submitting relevant data for monitoring, reporting and verification (MRV) purposes	A mixture of independent agronomists and employees of cooperatives, each with portfolios of farmer clients in France, Belgium and the UK
Farmers	Farmers Individual farmers will implement changes to their practices in line with agronomic advice and this Project Document, providing MRV data and submitting loss event reports so that they ultimately benefit from the sale of VERRs.	At least 116 farmers in the first growing season, rising to around 5,000 by 2024–2025 in France, Belgium and the UK.
Intended users	Project stakeholders of the Project, such as the buyers of VERRs, the participating farmers and Soil Capital	Various

(Source: Soil Capital, 2023)

2.10.5 Any information relevant for the eligibility of the GHG Project under a GHG Project and quantification of emission reductions and removals

This Project is eligible to create emission reductions and removals in accordance with the ISO standard 14064-2 (2019) guidelines and principles.

In the assessment in Section 3, there is a small chance that in certain, narrow circumstances, the Common Agricultural Policy (CAP) may offer an overlapping incentive with this Project in France and Belgium, as well as Countryside Stewardship (CS) and the Sustainable Farming Incentive (SFI) in the UK. The way this risk is managed is described in Section 3.

The emission reductions and removals are quantified using the best available approaches, i.e. combining DNDC and CFT. Monitored data and parameters at field level and emission factors used in the CFT methodology are described in Section 6.[33]

The Project is eligible under the CSA GHG CleanProjects® Registry. Emission reductions from the Project are solely registered under the GHG CleanProjects® Registry.

The Project did not receive any additional public funds in exchange for the emission reductions.

2.10.6 Social-economic and environmental impact

The Project results in no net harm to the surrounding environment or local communities. Alongside the climate change mitigation benefits, the Project's Beyond Carbon metrics present a holistic approach that ensures that the Project delivers more than just GHG emissions reductions and removals, but also a range of socio-economic and environmental co-benefits as well.

Our Beyond Carbon metrics address the key environmental services linked to agriculture across five domains: Soil Health, Biodiversity, Water Management, Climate, and Farm Socio-Economics, each further divided into specific subdomains and indicators. Farm performance is measured annually, with expected long-term outcomes including:

- Enhancing soil health while preventing erosion and land degradation.
- Protecting and fostering biodiversity within ecosystems.
- Improving water management, reducing the risk of contaminated watersheds.
- Contributing to better air quality and climate change mitigation through lower GHG emissions.
- Reducing risks associated with extreme weather events by fostering climate adaptation.
- Securing long-term yield and profitability for farmers.

Relevant outcomes from stakeholder consultations and mechanisms for ongoing communication

Since the Project promotes the adoption of regenerative agriculture practices, it is not expected to have negative impacts on local stakeholders, and only positive ones. For instance, a reduction in synthetic fertiliser and pesticide use will lead to less air and groundwater pollution for surrounding communities.

Therefore, even if no specific local stakeholder consultation has been organised before the start of the Project, Soil Capital conducted a range of consultations directly with farmers to inform the development of this Project Document. This includes events on 7 July 2020 (Belgium), 3 September 2020 (Belgium), 11 September 2020 (France) and 16 September 2020 (France). Relevant outcomes from these consultations were compiled and integrated into the development of this document.

The two most important outcomes that led to changes in the Project were:

[33] Assessment of the Label Bas Carbone (French Standard), Methodology for Improved Agricultural Land Management from Verra, Soil Enrichment Protocol from the Climate Action Reserve, Nori.

- **livestock integration** – earlier versions of the Program did not allow for any livestock integration on arable farms at all. Farmer feedback stated that this exclusion, in effect, penalised those arable farmers who had started to find ways to achieve more regenerative farming systems by integrating small numbers of livestock. As a result, on-farm livestock was made permissible with controls for leakage from displacement of livestock, as introduced in Section 2.10.3;
- **landowner approval** – earlier versions of the Project set a fairly stringent requirement for landowner approval of tenants participating in the Project. It was noted by many tenant farmers that they simply do not have direct relationships with their landowners and that they may, in practice, rent land from a large number of small landowners. This resulted in more stringent requirements for landowner approval, creating significant practical barriers to participation. As a result, the requirement for landowner approval was redesigned to be risk-sensitive, as explained in Section 2.5.

In addition to the consultations mentioned, Soil Capital establishes and maintains various channels for ongoing communication mainly with farmers, but also with development partners, regional experts agronomists, organisations like the *Chambres d'Agriculture* in France, companies within the agricultural sector, representatives of regenerative agriculture frameworks, and other. These efforts serve as important feedback mechanisms and are equivalent to a continuous stakeholder consultation process.

2.10.7 Detailed chronological plan

Table 5 provides information on the Project implementation, including the date of initiating the Project, the end date of the Project, frequency of monitoring and reporting, and the Project period, including relevant Project activities at each step of the GHG Project cycle.

Table 5 : Key timing details for the Project

Category	Project Detail
The date of the initiating Project activity	1 September 2023
Deadline for enrolment of farmers each year	28 February every year
Duration of each farmer's crediting period	Five growing seasons after farmer enrolment
Duration of each subsequent retention period	10 growing seasons after the end of each monitoring period
Maximum number of consecutive crediting periods	Up to four. Farmers may commit to as many consecutive whole crediting periods as can be completed, together with their respective retention periods, before the date of Project termination.
End date of the first crediting period	Five years after the start date of the crediting period, e.g., if a farmer's start date is 1 September 2023, the end year is 31 August 2028, noting that the last date for the end of the first crediting period is 31 August 2044.
End date of the last retention period	e.g., if a farmer's start date is 1 September 2023 and only one crediting period is undertaken, it is 31 August 2038
Date of Project termination	31 August 2054
Time period of GHG baseline	The 3 completed growing seasons directly preceding enrolment, e.g., for a farmer enrolling for the 2023–24 growing season, the 2020–21, 2021-22 and 2022-23 growing seasons
Frequency of monitoring and reporting	Annual
Frequency of verification	Annual

(Source: Soil Capital, 2023)

3 Selection and justification of the baseline scenario and additionality assessment

As per the VCS Improved Agricultural Land Management (IALM) methodology, the baseline assumes the continuation of pre-Project agricultural management practices. The baseline determination is central to the concept of additionality because it provides the reference point against which net GHG emission reductions and removals generated by the Project are assessed, to conclude whether they go beyond what would have happened in the absence of the Project.

Each farmer that enrols in the Project will provide historical practice data from the three complete growing seasons directly preceding enrolment.[34] This is known as their individual historical practice assessment. This data is collected via mySoilCapital, and the net GHG emissions and removals are calculated using the combination of DNDC (soil-based emissions and removals) and CFT (non soil-based emissions) for each farm individually.

Under the Soil Capital Project two baseline scenarios can apply:

- Baseline scenario 1 – continuation of the current situation, i.e., common practice of the individual farm;
- Baseline scenario 2 – common practice of the region.

Most of the farmers will have a net emitting profile, ie their practices will result in net emissions of GHGs. This type of farming profile could be characterised by at least one of the following :

- Input and disturbance intensive farming practices including full inversion ploughing for land preparation, systematic use of synthetic fertilisers, short rotations of mono-cultured crops and use of cover crops only as the law requires, or;
- Being early in a transition towards regenerative farming practices where the increase of soil organic carbon stocks does not compensate fully the soil and non soil-based GHG emissions, or;
- Farming practices on soils rich in soil organic carbon where the high mineralisation rate is not entirely compensated by the farming practices implemented

The GHG balance of a typical net emitting farm for the Project region, as calculated by DNDC+CFT, ranges from 1 to 5 tCO_2e per ha of net emissions per year, depending on the practices, soil characteristics and weather conditions. Farmers enrolling on the Project with practices that result in net emissions will use their own individual GHG inventory, as calculated via the yearly construction of a counterfactual baseline scenario, as their baseline throughout the crediting period, i.e., baseline scenario 1. This counterfactual baseline represents, for each project year, what would have happened in the absence of the project. Therefore it represents the continuation of the 3-year historical practices in the prevailing weather of the project year. This methodology ensures that only practice changes lead to ERRs for BS1 farmers, not the weather conditions.

The rest of the farmers will demonstrate net removal of GHGs from the atmosphere. Their style of farming aims to systematically increase the soil organic carbon stock and biodiversity in farmland soils and see synthetic inputs use and GHG impact reduced and or substituted with organic inputs (with a view to their elimination), tillage reduced (with a view to its elimination), soil kept covered with living roots (cover crops) or dead plant materials (crop residues) for as much of the year as possible and rotations lengthened to include a diversity of crops, including legumes. The GHG balance of such farms for the Project region, as calculated by the DNDC + CFT, ranges from 1 to 4 tCO_2e per ha of net removals per year, depending on the level and type of implemented regenerative agriculture practices, soil characteristics and weather conditions. Farmers enrolling on the Project with practices that result in net removals will use a regional

[34] For example, a farmer enrolling in 2024 for the 2023–24 growing season provides historical data for the 2020–21, 2021-22 and 2022-23 growing seasons.

common practice baseline under baseline scenario 2 as their baseline throughout the crediting period. This baseline is constructed from the modelling of what are considered 'common practices' for a specific region in the Project area by a group of independent experts. A conservative approach to this modelling is applied in a number of ways, as explained in subsection 3.2. This approach is used to reflect the EU Carbon Removals Certification Framework, CRCF, desire to reward first movers by setting standardised baselines at EU level, defined as the standard performances of comparable activities in similar social, economic, environmental and technological circumstances and geographical locations. Still as depicted by the CRCF, a standardised baseline should reflect the statutory and market conditions in which the carbon removal activity takes place.

As is the case for baseline scenario 1, BS2 represents what would have happened if the farmer was continuing the common agricultural practice of the region in the prevailing weather of the project year. This ensures that BS2 farmers are only generating ERRs based on their practices, not on weather conditions changes from one year to another. Even if the full process of establishing the common practices (detailed in Section 5.1.1.2) will only be performed for a given region every five years while the Baseline Expert Group (BEG) of each region, will be consulted each year to check whether material changes to common practice that would affect the common practice baseline have occurred or not. This approach ensures that a relevant common practice baseline is always used for an individual farmer whenever they join the Project. For each region, Annex IV provides a comprehensive overview of the key characteristics of the two baseline scenarios of the Project, while Table 6 provides a summary.

Table 6 : Brief summary of the two baseline scenarios

Characteristic	Baseline scenario 1	Baseline scenario 2
Description	Continuation of the current situation, i.e., common practices of the individual farm	Common practices of the region
Farmer's GHG balance following individual historical practice assessment	Net emissions	Net removals
Baseline emissions	GHG inventory from counterfactual baseline built on basis of individual historical practices	Regional common practice baseline

(Source: Soil Capital, 2023)

The farmers transitioning from conventional to regenerative agriculture practices face clear barriers to doing so (see subsection 3.1.2). Meanwhile, market data shows that the farmers who have already adopted regenerative agriculture practices remain part of a niche group. They are typically motivated by increasing the long-term fertility and health of their soil or by a growing awareness that societal expectation is pushing them towards reducing the environmental impacts of farming. However, these intentions will remain a niche market if barriers to maintaining these practices are not tackled – and these barriers are numerous and significant.

To summarise these barriers, most farmers today do not have the knowledge nor financial incentive to take the steps towards regenerative agriculture practices and maintain them over time. Both these financial and technical types of support to sustainably keep applying the regenerative measures are key for these farmers. Since the Project aims to enable the transformation of farming so that regenerative agriculture is more than a niche, both the barriers that prevent conventional farmers from transitioning and those that prevent regenerative farmers from maintaining their practices must be tackled at once.

3.1 Baseline scenario 1: individual historical practice

For farmers whose practices result in net emissions, their own GHG inventory, as calculated via a counterfactual baseline built on the basis of individual historical practices, will be used as the baseline against which their net GHG emission reductions and removals during the Project are compared. Consequently, any changes to an individual's farming practice during the Project that result in an improvement in that farmer's net GHG emissions and removals will be considered additional. Since the farming practices most likely to occur in the Project region today are those which result in net emissions, this individual historical practice baseline and definition of additionality serves as the default for the Project.

3.1.1 Alternative baseline scenarios

The baseline scenario is the hypothetical reference case that best represents the conditions most likely to occur in the absence of the proposed GHG Project. An analysis of the alternative baseline scenarios has been conducted to assess what is most likely to occur in the absence of the Project activity.

Conventional agriculture

Currently, approximately 88.7% of French farms are classified as conventional farming systems, 7.3% are classified as organic farming systems and 4% are classified as regenerative (see Table 7). In Belgium, 92.2% of farms are conventional, 6.8% are organic and 1% are regenerative (see Table 7). In the UK, 88.7% of the farms are classified as conventional, 3.3% are classified as organic and 8% are classified as regenerative (see Table 7).

Conventional farming is characterised by the applicability of tillage; the use of mineral and synthetic fertilisers; the use of chemical pesticides, herbicides and fungicides; a low variety of crops; and employing fewer to no crop rotations compared to other farming systems. Furthermore, Table 7 shows that neither organic nor regenerative agriculture (here, the proxy classification of 'conservation agriculture' is used) pass the common practice threshold of 20% market penetration established by the VCS IALM, either individually or collectively. Therefore, conventional farming is considered the most common agricultural system and the most plausible baseline scenario that is likely to occur, here defined as baseline scenario 1.

Table 7 : Adoption of alternative farming types by arable farmers in Project area

Farming type	Adoption: France	Adoption: Belgium	Adoption: UK
Organic[35]	7.3%–9.5%	6.8%-7.2%	3.3 %
Regenerative[36]	4%	1%	8%
Conventional[37]	88.7%	92.2%	88.7%

(Source: Soil Capital, 2023)

[35] https://www.organicseurope.bio/about-us/organic-in-europe/;https://agriculture.gouv.fr/infographie-lagriculture-biologique; https://statbel.fgov.be/en/themes/agriculture-fishery/organic-farming; FiBL& IFOAM, 2019

[36] Per country adoption of Conservation Agriculture in 2015/16, taken from Kassam A. et al., 2018, calculated as a percentage of per country arable land in 2016, sourced from Eurostat, https://ec.europa.eu/eurostat/web/agriculture/data/database; UK country adoption of Conservation Agriculture in 2015/16 at 362,000 hectares, taken from Kassam A. et al., 2018, calculated as a percentage of UK per country arable cereals and general cropping land in 20169, sourced from EurostatDefra (ibid),

[37] This represents an absolute minimum, since much regenerative farming is also technically classified as conventional.

Regenerative agriculture

The conversion from conventional to regenerative agriculture represents an alternative scenario. Farmers may choose to transition from conventional to regenerative agriculture for a number of reasons. Conventional agriculture practices often result in soil degradation, leading to fewer nutrient-rich and infertile soils, which can negatively impact yields. Transitioning to regenerative agricultural practices can lead to soil fertility improvement and better climate resilience (Gish, 2022; Abram, 2022). Moreover, with the increasing costs of synthetic fertilisers, regenerative agriculture is becoming more attractive, as it requires fewer inputs (Baffes & Koh, 2022). However, the transition from conventional to regenerative agriculture is challenging and includes numerous barriers (see Annex V). Thus, farmers are more likely to continue implementing conventional practices.

Land use changes

In addition to conventional and regenerative agriculture, two additional alternative scenarios have been identified. The alternatives to competing land use changes to agricultural land in France, Belgium and the UK are urbanisation and increased forest cover.

Urbanisation

Urbanisation involves the "conversion of natural physical landscape to more economic land uses" (Aswathy & Sindhu, 2013, p.75), including the conversion of arable land to urban land. This is because "the natural vegetation is removed and replaced by non-evaporating and non-transpiring surfaces such as metal, asphalt and concrete" (Aswathy & Sindhu, 2013, p.75). Urbanisation is a common phenomenon in Europe, whereby land (e.g., agricultural, forest and abandoned land) is converted into urban areas. Over "the last decades, the transformation of Western European landscapes has mainly been characterised by an expansion of the built-up area at the expense of fertilised arable land and natural areas'' (Beckers et al., 2020, p.1). This trend can also be observed in France, Belgium and the UK and is expected to continue (Beckers et al., 2020). For example, over the last 40 years, the urban areas in France have expanded, through the urbanisation of agricultural and natural soils, a trend that seems to be continuing due to increasing populations and the need for housing among other factors. Since 1982, 65,900 ha of agricultural land has been lost in France (Abada-Simon et al., 2022). In France, 88% of new urban areas are a result of conversion of agricultural land (Angusseau et al., 2018).

In Belgium urban expansion is the dominant driver for agricultural land conversion, which is partly driven by "high rent and the lack of space in the city centres" which leads to certain industrial and commercial activities to find new locations, often on peri-urban farmland (Beckers et al., 2020 p.2). In the last 20 years, 20% of the farms in Flanders "are now being used for activities such as storage of building material, garages for car repair, restaurants, and catering, wellness centres and farm tourism" (Beckers et al., 2020, p.2; Verhoeve et al., 2015). Moreover, in recent years, the price per ha of agricultural land in Belgium has increased. In Wallonia, the average price per ha ranges from EUR 24,744 per ha to EUR 41,000, while in Flanders the average price can range from EUR 42,600 per ha to EUR 60,500 per ha (Notaire BE, 2019). In the UK, between 1990 and 2015, there has been a decrease in arable farmland of 782 km^2 while the urban areas have increased by 3,376 km^2. Moreover, 2,502 km^2 of grassland and 1,121 km^2 of arable farmland were converted to urban use (UK Centre for Ecology & Hydrology, 2020).

Urbanisation usually results from the conversion of abandoned land, forest land, and/or agricultural land usually located in the fringes of urban areas, as illustrated above. Thus, in the absence of the Project, a plausible alternative baseline scenario is the sale of agricultural land for the purpose of urbanisation, particularly in times of economic uncertainty or hardship.

Forestry

Currently, approximately 31% of the total land use in France is forest area. Tissot and Kohler found that "since the beginning of the 19th century the forest area in France has expanded to about 15 M hectares, mainly due to land abandonment in mountainous areas and afforestation on former agricultural land" ((Tissot, et al. 2013, p.1). Moreover, over the last 20 years, the size of French forests has increased by 7% (Colagrossi, 2019). The growth of French forests can be attributed to reforestation efforts promoted by the government and "the intensification and concentration of domestic agriculture" which has led to "increases [in] domestic agricultural production while freeing land for first recovery" (Gingrich et al., 2021, p.2). In Belgium, most forests are located in the Wallonia region. In the last 16 years, Belgium has experienced an increase in forest cover from 22.03% of total land use to 22.52% (Jaganmohan, 2021). More generally, in the EU, forest area has increased continuously since the 1950s. Part of this increase has been attributed to the increase in protected forest areas due to the establishment of the Natura 2000 framework. Another driver for this forest area increase is the afforestation efforts of both public and private actors following World War II (Mauser, 2022). Moreover, various models suggest that there will be a continued increase in forest cover in Western Europe.

In England, forest area has expanded from 1.26 M ha in 2002 to 1.32 M ha in 2022 (Forest Research, 2022). Since 1990, European forest cover has increased by 9% (Raši, 2020).

Most plausible alternative scenario to baseline scenario 1

When analysing the plausibility of the alternative scenarios, urbanisation is a more likely scenario in comparison to changing land use to forest area, as it is unlikely that governments would seek to convert arable land to forest areas, unless the land was previously abandoned. Moreover, when given a choice, farmers are more likely to sell their land than to abandon their land. However, the conversion of arable land to urban areas is less likely than farmers continuing business as usual (i.e. conventional farming), unless they are experiencing economic hardship or uncertainty. In conclusion, the most likely plausible alternative scenario for farmers is conventional agriculture.

3.1.2 Barrier analysis for farmers whose practices result in net emissions: analysis confirming significant barriers in adopting regenerative practices

In a study of 1,381 French farmers by Groupe BPCE (2019), farmers identified the following barriers that prevented them from transitioning to regenerative agriculture. Since soil, climate and market conditions do not vary significantly in neighbouring countries, these results can apply to farmers in Belgium and the UK:

- investments needed are considered too large (25%);
- uncertainty about the economic benefits (24%);
- technical difficulties (17%);
- lack of information and knowledge (11%);
- other (23%).

The first two barriers are financial and economic, and essentially amount to a fear of loss. They are put into context by the reality that 50% of French farmers on medium or large farms earned less than EUR 14,000 per year in net income in 2016.[38] In the UK, the majority of arable farmers were only able to return a positive net margin per hectare on three crops between 2017 and 2020 (winter wheat, winter oats and potatoes).[39] The third and fourth barriers are prevailing practice and socio-cultural barriers. Shifting from conventional to regenerative agriculture is not trivial (Gosnell et al., 2019), as it questions some fundamental practices of conventional farmers. It requires the application of five key principles: (1) maximisation of soil cover with living plants; (2) minimisation of soil disturbance; (3) maximisation of biodiversity; (4) minimisation of agrochemical use; and (5) context-specific design. Farmers mostly receive advice from farm advisers employed by input providers, which has resulted in the input-dependent agriculture

[38] https://www.lemonde.fr/economie-francaise/article/2018/02/24/dix-chiffres-cles-sur-l-agriculture-francaise_5261944_1656968.html
[39] https://ahdb.org.uk/news/top-of-the-crops

model that is prevalent today. Shifting practices require more on-farm knowledge that is independent from input producers.

The importance of these prevailing practice and socio-cultural barriers is identified in the academic literature where it is noted that, alongside economic motivations, changes in farmer behaviour to adopt different farming practices is also influenced by social, cultural and personal factors (Thamo & Pannell, 2015).

In combination, these financial and prevailing practices and socio-cultural barriers justify that it is most likely for conventional farmers not to change their practices; therefore any practice changes during the Project can be considered additional.

3.2 Baseline scenario 2: Regional common practices

If the individual historical practice assessment for a farmer enrolling in the Project shows that their practices result in net removals, an alternative baseline is used, specifically a regional common practice baseline. This baseline is constructed from the modelling of what are determined as ‘common practices’ for a specific region in the Project area by a group of independent experts. A conservative approach to this modelling is applied in a number of ways, as explained in subsection 5.1.1.2. For a farm using this baseline, any difference between that farm’s net GHG emissions and removals and the regional common practice baseline will be considered additional.

3.2.1 Alternative baseline scenarios

As mentioned previously, there are farms in the Project that have already begun implementing regenerative farming practices. Market data shows that farmers who have already adopted regenerative agricultural practices remain part of a niche group. Farmers with a regenerative agricultural profile face numerous barriers in maintaining and expanding these practices. As such, it is possible for farmers to revert to conventional agricultural practices when facing these barriers, particularly as conventional agricultural systems can be viewed as common practice in France, Belgium and the UK.

Challenges of maintaining practices

There are many barriers to maintaining regenerative agricultural practices, indicating that farmers can be tempted to revert to conventional agriculture to overcome these barriers. A trend has been observed in Western European countries (France, Germany and Denmark) in which farmers implementing organic agriculture revert to conventional agriculture due to the challenges in maintaining organic practices (Kaltoft et al., 2006; Sanders et al., 2014; Madelrieux et al., 2013). The main motivation for reverting to conventional agriculture is economic, more specifically “unsatisfactory farm incomes, marketing problems, low price premiums for organic products and low or reduced organic support payments” (Sanders et al., 2014, p.439). A lack of experience and knowledge in organic farming practices is another motivation for farmers to revert to conventional agriculture, as they are unable to make a sufficient living (Kaltoft et al., 2006).

Given that regenerative agricultural farmers face even greater obstacles than organic agricultural farmers, and do not benefit from dedicated subsidies, it is plausible to envisage that many regenerative agricultural practices may consider reverting to conventional agriculture for economic and technical reasons, particularly if their yields have been negatively impacted (e.g., due to bad weather conditions, increasing prices for organic fertiliser, etc.). Furthermore, the lack of a premium pricing and low level of financial subsidies for regenerative practices (e.g. through public subsidies like EU CAP or SFI payments in the UK) indicates they have less economic security than organic farmers or conventional farmers. Given that economic concerns are one of the main reasons organic farmers reverted to conventional agriculture, economic hardship may motivate regenerative farmers to revert as well. Similarly, farmers who have transitioned from conventional to organic agriculture, may lack experience and knowledge in implementing regenerative agricultural practices and may equally contribute to regenerative farmers considering reverting to conventional agriculture, especially because regenerative agriculture is more complex and knowledge-intensive for the farmer to implement in comparison to conventional agriculture.

By rewarding pioneer farmers that had implemented regenerative agriculture ahead of the time via additional financial revenues, the Soil Capital Project supports regenerative farmers in not reverting to conventional agriculture.

Regenerative farming is nascent and niche market

There is a very limited uptake of regenerative agricultural practices in Europe. In the UK and Germany, the regenerative agriculture movement is considered nascent, as there is limited "movement among brands, retailers, investors and policymakers to help farmers transition toward and build consumer awareness around regenerative agriculture" (Alpha Food Labs, 2021, p.29). Similar trends can be observed in France and Belgium. In France, it is estimated that only 4% of farmers implement regenerative agriculture, while in the UK it is estimated that 8% of farmers implement regenerative agricultural practices. In Belgium, the percentage is even lower, with only 1% of farmers adopting regenerative agriculture (Livelihoods Funds, n.d.). Moreover, market data shows that the farmers who have already adopted regenerative agricultural practices remain part of a niche group. Thus, regenerative agriculture can be considered a niche and nascent market.

To summarise, most farmers today do not have the knowledge nor financial incentive to take the steps towards regenerative agriculture practices and maintain them over time. Both financial and technical support are key for farmers to sustainably keep applying the regenerative measures. Since the objective of the Project is the mitigation of GHG emissions from agricultural practices in France, Belgium and the UK by implementing regenerative agriculture practices, the Soil Capital Project aims to reward regenerative farmers to maintain their practices and efforts.

Land use changes due to urbanisation and forest expansion

Section 3.1.1 outlines possible alternative scenarios to a business-as-usual scenario (i.e., conventional agriculture) related to urbanisation and forest areas that can apply to regenerative farmers. Hence, the scenarios previously identified can be seen as alternatives to maintaining regenerative agricultural practices. This is because the burden to maintain regenerative agricultural practices are numerous, and farmers may opt to either sell their land for urban expansion or to abandon their lands.

Most plausible alternative scenario to baseline scenario 2

Prior to selling or abandoning the land, farmers struggling in the implementation of regenerative agricultural practices may be more tempted to revert to conventional agriculture, which is more common, familiar and easier to implement, before considering the other alternatives. However, it is more likely that farmers may choose to continue maintaining regenerative agricultural practices, than converting to conventional agriculture. This is because many of the challenges and barriers of implementing regenerative agriculture occur in the earlier years of the transition, as farmers must learn and become acquainted with new practices and implement them correctly, and where the likelihood of temporarily lower yields is higher (Annex V). As such, the most plausible alternative scenario to baseline scenario 2 is maintaining regenerative agricultural practices.

3.2.2 Barrier analysis for farmers whose practices result in net removals: analysis confirming significant barriers to farmers in their efforts to maintain regenerative practices

The following is a list of common, mainstream barriers that all regenerative farmers face each season. These barriers are widely understood amongst farming communities, and each of them represents challenges to maintaining regenerative agriculture practices.

3.2.2.1 A response to unfavourable weather conditions

a) Very wet weather leading to resumption of ploughing

As soil health is increased through a transition to regenerative agriculture practices, better soil structure leads to improved water infiltration and water retention rates, making soils more resilient in the face of droughts or floods.

However, it takes time for this improved soil structure to emerge, and during that period water logging following intense rainfall and flooding may still occur. This presents a direct threat to continued operations in affected fields, and to yields and revenue opportunities. Farmers will be easily tempted to resume ploughing in order to turn the soil profile and deliver drier soil to the surface in order to facilitate the seeding of winter crops. This has been seen far and wide in France and Belgium in recent years. Many examples have been listed on the Terre-net website.[40] In the UK, a similar trend can be observed, as illustrated by the records of Britain's most active farmer-only discussion forum.[41]

b) Weather conditions leading to abandoning of cover cropping

If the season post-harvest is very dry, or even in drought conditions, farmers will have little incentive to spend money trying to establish cover crops. Equally, if the weather conditions have led to a very late harvest, the available window for seeding and growing cover crops may appear too short to make it worthwhile. In both of these circumstances, the weather conditions incentivise farmers to abandon their plans for cover cropping (see the first reply from Arnaud Bouchat as an illustrative example[42] and discussion on Britain's most active online farmer discussion forum[43]).

c) Very wet conditions leading to resumption of synthetic fertilisation

Organic fertilisation requires greater volumes of fertiliser to be applied and, because more time is needed for manure to break down into the soil as compared to synthetic fertiliser, it needs to be applied after summer harvest. Synthetic fertiliser, on the other hand, is applied in lower volumes and is applied just before seeding.

Wet conditions delay the delivery of manure, since the conditions prevent the logistics needed to clear livestock barns and complete transport operations. This alone means farmers relying on organic fertilisation can be several weeks behind conventional farmers in seeding their crops.

[40] Des semis de céréales perturbés par la météo, retour au labour (terre-net.fr) https://www.terre-net.fr/observatoire-technique-culturale/strategie-technique-culturale/article/retour-au-labour-ou-non-des-semis-de-cereales-perturbes-par-la-meteo-217-163755.html
[41] https://thefarmingforum.co.uk/index.php?threads/when-to-plough-a-wet-field.202404/
[42] Dubois David on Twitter: "@bouchat_arnaud @Grabotte2019 @RemDumDum @Horizons_agri @fnseacvl @ChambagriCvl Ouais, donc les nappes d'accompagnement, le fonctionnement hydrologique des rivières, des zones humides ... c'est pas votre truc. Pour vous une rivière c'est un tuyau qui transporte de l'eau quoi ?!" / Twitter https://twitter.com/DuboisD40726334/status/1294747675406082049?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1294898360550334464%7Ctwgr%5E&ref_url=https%3A%2F%2Fwww.francebleu.fr%2Finfos%2Fenvironnement%2Fsecheresse-le-mois-de-juillet-2020-deuxieme-le-plus-sec-enregistre-en-indre-et-loire-1598887314
[43] https://thefarmingforum.co.uk/index.php?threads/is-it-too-dry-to-plant-cover-crops.132258/

Also, if conditions are wet and fields impassable, this can make application of organic fertiliser very difficult, if not impractical, if not illegal.[44]

In both of these circumstances, it is the lower risk and more practical option to resume synthetic fertilisation.

3.2.2.2 Control of pest pressures

In no-till farming systems, pressure from pests such as rodent populations can increase and sometimes even get out of control (Witmer et al., 2007). This is because burrow systems are not disrupted by annual ploughing and plant residues build-up on the surface, providing cover and insulation.

In addition, severe outbreaks of weeds such as blackgrass can be experienced in minimum or no-till farming systems if seeds from such weeds are allowed to accumulate in the soil (UK Soil Association, 2018).

In both cases, the resumption of ploughing is often seen as the quickest and most effective way to regain control of pest pressures, which directly threaten yields and therefore revenue from the farm. This signals a return to conventional farming practices.

3.2.2.3 Lack of premium pricing offers no new revenue to offset additional costs

Today, there is no market premium commonly paid for crops that are grown regeneratively. It is only if a farmer makes the additional step of becoming certified organic that they can access premium pricing. Therefore, regenerative farmers mostly continue to sell to conventional commodity markets.

Regenerative agriculture is more complex and knowledge-intensive for the farmer to implement. Since its underlying philosophy is to 'farm with nature rather than against it, it requires proactively managing the agricultural ecosystem to prevent problems arising, instead of relying on prescriptions of agrochemicals and other synthetic inputs in reaction to problems that have already emerged. Regenerative agriculture simply is not as easy as conventional farming (Bolongaro, 2019).

The lack of premium pricing to reward farmers for maintaining a more complex approach to farming is a powerful factor in a farmer's decision-making. If commodity prices have been low in a season, or yields have suffered because of bad weather, or both, the farmer is incentivised to look for opportunities to cut costs. Abandoning plans to establish cover crops is often an option farmers take in this situation.

3.2.2.4 Lack of access to organic fertilisation as demand grows

The more that farmers seek to undertake a transition to regenerative agriculture, the more challenging the access to organic fertilisation becomes. The absolute volume of supply of organic fertilisation is limited, and so whether through increased prices or simply lack of availability, farmers can find procurement of organic fertiliser increasingly challenging.

This, combined with the incentives outlined above, make for a powerful set of motives to resume synthetic fertilisation.

3.2.2.5 Loss of yield in a poorly managed transition

When a farmer transitions from conventional to organic practices (typically over a three-year period), the relatively sudden shift from synthetic fertilisation to relying more on the natural fertility of the soil can result in short-term declines in yield (Schrama et al., 2018).

[44]https://www.gov.uk/guidance/rules-for-farmers-and-land-managers-to-prevent-water-pollution#reduce-pollution-risks-when-you-use-manure-or-fertiliser

If the transition from conventional to regenerative agriculture is poorly managed and follows a similar speed and abruptness as the transition to organic – especially with regard to shifting from synthetic to organic fertilisation and a reduction in agrochemicals to control pests – a similar decline in yield, up to 21%, can be experienced. For the farmer, this would represent a decline in revenue in the short-term. Since 50% of French farmers on medium or large farms earned less than EUR 14,000 per year in net income in 2016 (Pflimlin, 2018), and the majority of UK arable farmers were only able to return a positive net margin on three crops between 2017 and 2020,[45] this is a powerful factor in tempting them to revert to conventional practices.

3.2.2.6 Social and peer pressure

Farming communities remain important sources of influence over a farmer's decision-making, a reality that is only enhanced by social media. Furthermore, the practices that a farmer implements on their fields are visible for all to see, perhaps leaving them more exposed to social and peer pressure than in many other industries.

Since conventional agriculture remains a common practice, those practising regenerative agriculture remain outliers, breaking with the tradition of social norms. Concretely, leaving crop residues ('trash') to be incorporated into the soil and feeding the soil biology stands in stark contrast to the common practice of removing them and ploughing the soil, leaving a 'clean' field. Therefore, regenerative farmers continue to be subjected to peer pressure from those practising conventional agriculture, and this is known from survey data across Europe to be a material factor in their decision-making (Europa, 2015).

3.2.3 Soil Capital Project's mitigation of barriers

Enabling regenerative farmers to access sufficient new financial incentives to maintain their practices in the face of these barriers is the most important step to mitigating these barriers.

The second is that, even if our internal and external agronomists may provide direct support through the data collection meetings, results discussions or field tours, as a condition of participation in the Project, farmers must confirm that they have access to suitable expert agronomic advice. Where necessary, Soil Capital can provide this advice directly from its community of independent agronomists, or it can provide training and ongoing technical support to farmers' agronomists directly and via an established partnership with a training provider, ICOSYSTEME.[46]

More broadly, Soil Capital believes that the marketplace for crops will evolve so that low/zero carbon produce does command a premium in the market in the future. When this happens, it will start to offer farmers a premium price for their crops. However, since it is beyond Soil Capital's ability to control directly if and when this happens, this barrier mitigation step cannot be relied upon at this stage.

3.3 Regulatory and other additionality

As explained in Section 5, certain elements of a typical arable farm, such as tree planting to form new hedgerows, woodland or forests, are excluded from the Project's scope in order to ensure regulatory surplus.

In order to satisfy additionality requirements, there must be confidence that the incentive offered to farmers by new revenues from the Project are what is driving changes to or maintenance of farming practices, rather than other regulations. Since these regulations change through time, a regular analysis of relevant laws or regulations needs to be performed to make sure the Project provides carbon reductions and removals beyond those required by law and continues to achieve regulatory surplus.

[45] https://ahdb.org.uk/news/top-of-the-crops
[46] https://icosysteme.com/

Governments of the different countries in which the Project operates have launched new regulatory requirements and public subsidy incentives for farmers in 2023, driven by the coming into force of the new EU Common Agricultural Policy (CAP) in 2023.[47] The CAP continues to offer public subsidies to farmers in the form of 'area payments', essentially subsidy payments on an area basis for land that is in active agricultural production. Those subsidies are provided on the basis of adhering to various conditions, referred to as 'conditionality'. Conditionality is therefore a set of rules to be respected by any farmer who receives one or more of the subsidies linked to their farmed area. Conditionality is therefore not a direct financial incentive per se but can be seen to have an influence over farmer decision-making. Conditionality rules have been updated in each country where the Project operates. In addition, further CAP payments can be accessed via new agri-environmental incentives called 'eco-schemes'.

In the UK, following Brexit, agricultural policy independent of the EU has now been confirmed. Area payments are still provided but are being reduced over time in the coming years. In addition, a new public subsidy was introduced in late 2022 called the Sustainable Farming Incentive (SFI).

The following analysis demonstrates the regulatory surplus over the new CAP 2023–2027 and the SFI for the Soil Capital Project.

3.3.1 France

France has updated its CAP policy by launching its 'National Strategic Plan for the CAP 2023–27'.[48] This strategic plan contains certain provisions that aim to improve the environmental impact of the implementation of the CAP in France. It does that by changing some of the conditionality requirements for the area-based payments, known as 'Bonnes Conditions Agro-Environnementale' (BCAE) meaning 'Good Agricultural and Environmental Condition (GAEC)', and introducing new 'eco-schemes'.

This analysis focuses on the most relevant changes to the French conditionality requirements from the perspective of the Project.

BCAE 6

The first is BCAE 6,[49] which seeks to protect soils during sensitive periods of the season. This requirement extends some of the provisions of the Nitrate Directive, which was already operational under the previous CAP and is still operational at EU level today.. That directive required farmers in areas classified by the government as vulnerable to soil erosion to plant cover crops or leave mulch for six weeks during long periods of bare soil between cash crops. This requirement for vulnerable areas remains under the new CAP and has now been extended for these areas from six weeks to at least three months. Since the fundamental requirement for covering the soil already existed under the previous CAP for land classified as vulnerable,[50] this is not a material change from the point of view of the Project. In addition, the new BCAE 6 will now require farmers in any area to plant a cover crop or leave residues on the soil for at least six weeks during long periods of bare soil between cash crops, i.e., between 1 September and 31 December. In summary, farmers with land classified as vulnerable must now keep soil covered for at least three months, and farmers with any other land must now keep soil covered for at least six weeks.

In practice, the vast majority of France's arable farmland was already considered vulnerable to soil erosion under the previous CAP,[51] so the requirement to keep soil covered by cover crops or

[47] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27_en
[48] https://agriculture.gouv.fr/pac-2023-2027-le-plan-strategique-national
[49] Ministère de l'agriculture et de la souveraineté alimentaire, "La conditionnalité des aides PAC, annexe 6 : Fiche technique de la couverture des sols et la BCAE 6". Retrieved 10/01/2023 from https://agriculture.gouv.fr/la-conditionnalite-des-aides-pac
[50] https://meuse.chambre-agriculture.fr/actualites/detail-de-lactualite/actualites/arbitrage-nouvelle-pac-2023-2027/
[51] Système d'Information sur l'Eau, "Zones vulnérables - Métropole". Retrieved 10/01/2023 from https://geo.data.gouv.fr/fr/datasets/11ba3cbd980e1f0307e089054a9f91548ec40912

mulch was already in place in the Soil Capital Project area when the Project was launched. The Project's baseline methodology and regulatory surplus analysis therefore is not affected by this change – there is no material overlap between the activities of the Soil Capital Project and this part of the new CAP.

BCAE 7

Another of the conditionality requirements under the new CAP, BCAE 7,[52] relates to crop diversification such that a given field must have at least two different crops over the course of three years. Farmers have multiple options to achieve this condition. The most obvious and likely is to ensure a good rotation of cash crops through every field. Introducing cover crops between cash crops is technically a further way to meet the condition, but it will incur extra costs for farmers. Since the CAP conditionality requirements do not result in any additional payments to farmers, just ongoing area-based subsidies that are deemed necessary to keep farms profitable, this is not likely to be the option farmers chose to meet the condition.

The risk of overlap between BCAE 7 and the Soil Capital Project is that this conditionality requirement is seen as a regulatory driver for more cover cropping. However, since the conditionality requirement results in no new payments to farmers beyond what they were already receiving, and the main way in which they can meet the conditionality requirement is to ensure sufficient diversity of cash crops, the risk of overlap with the Project is not material.

Eco-schemes

In addition to the reinforced conditionality requirements, the new French CAP will reward farmers for implementing environmentally friendly farming practices via eco-schemes.[53] Farmers can be rewarded through three mutually exclusive pathways; the one that is relevant to the Project is the 'practice' pathway. For the farmer, the way this works in France is by scoring the diversity of cash crops in a farm's rotation and offering payments for greater diversity of cash crops. However, there is no consideration given to cover crops and for management practices to produce those cash crops. The impact of the scheme is simply therefore to reward a greater variety of cash crops being grown on a given farm.

If this eco-scheme had been designed to incentivise the establishment of cover crops or specific management practices that this Project also rewards, deeper analysis would be required. However, since this is not the scope, there is no material risk of overlap with the Soil Capital Project.

3.3.2 Belgium – Region of Wallonia

As in France, Wallonia (Belgium) has updated its CAP strategic plan by changing some of its conditionality requirements and introducing eco-schemes.[54] In addition, new agro-environmental measures (called agri-environmental measures) related to soils ('Mesures agro-environnementales et climatiques' (MAEc Sol) have been created.

BCAE 6

The most relevant change to the conditionality requirements under the new CAP is also via the requirement known as BCAE 6.[55] The Nitrate Directive that already existed under the previous CAP and is still operational today at EU level requires farmers in areas classified by the government as vulnerable to soil erosion to cover 90% of their croplands during long periods of

[52] Ministère de l'agriculture et de la souveraineté alimentaire, "La conditionnalité des aides PAC, annexe 6 : conditionnalité BCAE 7 rotation". Retrieved 10/01/2023 from https://agriculture.gouv.fr/la-conditionnalite-des-aides-pac
[53] Chambre d'agriculture de la Marne, "Eco-régimes PAC". Retrieved 10/01/2023 from https://marne.chambre-agriculture.fr/gestion-de-lentreprise/aides-et-financements/pac-2023-2027/eco-regimes-pac/
[54] Portail de l'agriculture wallonne, "Pac 2023-2027 - Description des interventions", https://agriculture.wallonie.be/pac-2023-2027-description-des-interventions, retrieved on the 11/01/2023
[55] Portail de l'agriculture wallonne, "BCAE 6 Couverture des sols minimale en vue d'éviter les sols nus dans les périodes les plus sensibles", https://agriculture.wallonie.be/bcae-6-couverture-des-sols-minimale-en-vue-d-eviter-les-sols-nus-dans-les-periodes-les-plus-sensibles, retrieved on the 11/01/2023

bare soil between cash crops (i.e. between a crop harvested before 1 September and a crop sown after 1 January). The new CAP's conditionality rules require that 80% of any arable land be covered during this period, regardless of their vulnerability.

In practice, virtually all Wallonian croplands are classified as vulnerable under the CAP so there has been no material change in regulatory conditions as a result of BCAE 6 to farmers in the Project boundary, and there is no material overlap between the Soil Capital Project and this part of the new CAP regulation.

BCAE 7

As in France, another of the conditionality requirements under the new CAP, BCAE 7,[56] relates to crop diversification such that a farmer will have to change the main crop annually on at least 35% of the farm area. Intercrops and secondary crops (if other crop groups) are considered as a change of main crop if they are maintained for at least three months. After three years, all fields of arable land are supposed to be rotated or, in other words, there must always be a change of main crop after three years. Farmers have multiple options to achieve this condition. The most obvious and likely is to ensure a good rotation of cash crops through every field. Introducing cover crops between cash crops is technically a further way to meet the condition, but it will incur extra costs for farmers. Since the CAP conditionality requirements do not result in any additional payments to farmers, just ongoing area-based subsidies that are deemed necessary to keep farms profitable, this is not at all likely to be the option farmers chose to meet the condition.

The risk of overlap between BCAE 7 and the Soil Capital Project is that this conditionality requirement is seen as a regulatory driver for more cover cropping. However, since the conditionality requirement results in no new payments to farmers beyond what they were already receiving, and the principal way in which they can meet the conditionality requirement is to ensure sufficient diversity of cash crops, the risk of overlap with the Project is not material.

Eco-schemes

Of the Wallonian eco-schemes, the most relevant is the 'long cover' eco-scheme.[57] Here, farmers are rewarded for extending their soil coverage between 1 January and 15 February on more than 70% of their land. This scheme is clearly designed to extend the period in which existing cover crops are left in the ground, including those that will have been implemented after the summer harvest because of the above conditionality requirements. This can be seen by the fact that the financial reward offered (EUR 15 per 45/ha) is insufficient to cover the seeding, planting and destruction costs, as well as the agronomic risks for following cash crops, of planting new cover crops.

Therefore, because it is only related to extending the presence of cover crops already in the rotation, this eco-scheme does not affect the regulatory surplus status of the Project.

In addition to the eco-schemes, there is an agri-environmental measure related to soils (MAEc Sol[58]) which has been set to encourage farmers to maintain and/or increase soil carbon stocks in arable lands. Based on an initial direct measurement of the SOC:clay ratio, fields enrolled (which must be a minimum of 90% of the cropped area) are classified into three categories: 'unfavourable', 'transition' and 'favourable'. During the following four years, farmers are incentivised first to maintain their SOC:clay ratio category. In addition, a direct measurement in year five will determine if a field has moved upwards by a category. If this is the case, a premium incentive will be paid to reward this increase, but only if the farmer has also opted in to the above long cover eco-scheme for the same five years.

[56] Portail de l'agriculture wallonne, "BCAE 7 Rotation des cultures sur les terres arables", https://agriculture.wallonie.be/bcae-7-rotation-des-cultures-sur-les-terres-arables, retrieved on the 11/01/2023
[57] Portail de l'agriculture wallonne, "Eco-régime couverture longue du sol", https://agriculture.wallonie.be/eco-regime-couverture-longue-du-sol, consulted 11/01/2023
[58] Portail de l'agriculture wallonne, "MAEC sol", https://agriculture.wallonie.be/maec-sol, consulted 11/01/2023

Farmers only being paid to maintain their SOC:clay ratios present no challenge to regulatory surplus within the Soil Capital Project. Since it is a condition of the scheme that if a farmer wants to be paid to improve their SOC:clay ratio they must also enrol in the long cover eco-scheme, Wallonian farmers opting in to the MAEc sol measure but not opting in to the long cover eco-scheme are eligible for this Project.

However, for farmers who are hoping to be paid via the MAEc sol measure for increasing the SOC:clay ratio of their soil, this measure is directly challenging the regulatory surplus of this Project. Therefore, farmers opting in to both the long cover eco-scheme and the MAEc sol agri-environmental measure will not be eligible for this Project.

3.3.3 Belgium – Region of Flanders

As in Wallonia and France, Flanders (Belgium) has updated its CAP strategic plan by changing some of its conditionality requirements and introducing eco-schemes.

BCAE 6

The most relevant change to the conditionality requirements under the new CAP is via the requirement known as “GLMC 6 - Minimale bodembedekking[59]” (i.e., “Goede Landbouw- en MilieuConditie” (GLMC) meaning GAEC in Flemish. The Nitrate Directive that already existed under the previous CAP, and that is still operational at EU level today, requires farmers in areas classified by the Flemish Government as Type 1, 2 and 3 (Figure 3), which are not heavy clay soils, to sow a cover crop by the 15th of September at the latest when the previous cash crop has been harvested by the 31st of August. The exception is if a winter or a secondary crop is to be sown instead. The new CAP’s conditionality rules require that 80% of any arable land (incl. Type 0 areas) be covered during this period. Plant residues are allowed as soil cover if the main crop is harvested after the 31st of August.

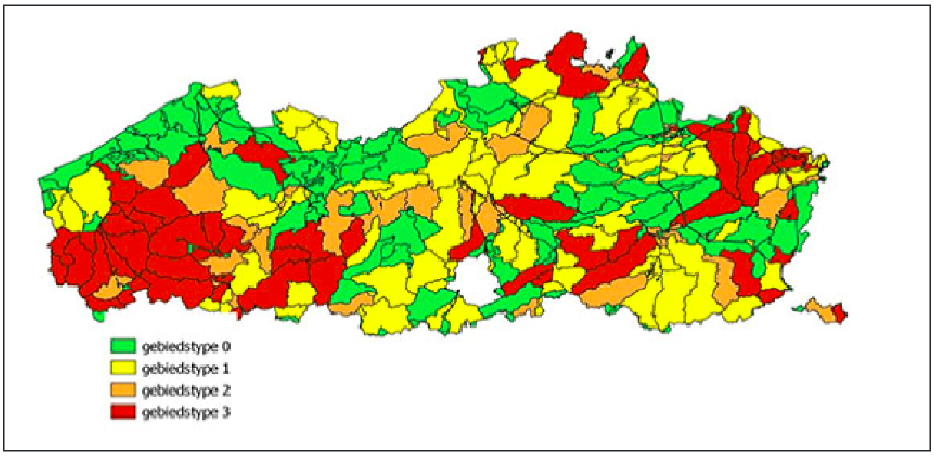

Figure 3 : Area type classifications in Flanders

(Source: Vlaamse Land Maatschappij, 2020)

In practice, the vast majority of croplands (see Figure 4) in Flanders is already covered by the Nitrate Directive under thes CAP. Therefore, there has been no material change in regulatory conditions as a result of GLMC 6 to farmers in the Project boundary and there is no material overlap between the Soil Capital Project and this part of the new CAP regulation.

[59] ”Minimal ground cover” in Flemish

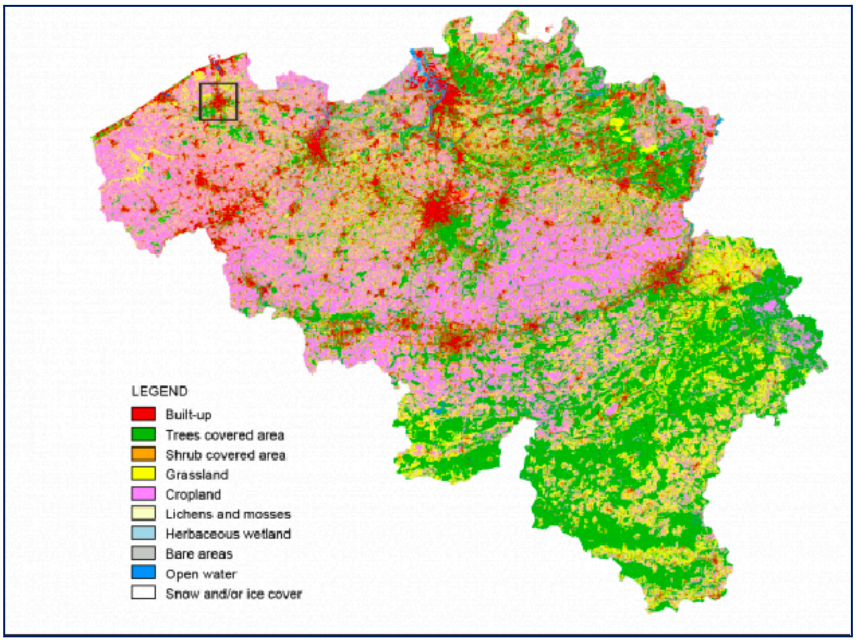

Figure 4 : Land use in Flanders

(Source: VITO, 2021)

BCAE 7

As in France and Wallonia, another of the conditionality requirements under the new CAP, "GLMC 7 - Gewasrotatie op bouwland[60]", relates to crop diversification such that a farmer will have to change the main crop annually on at least one third of the farm area. Cover crops and secondary crops (if from another crop group) are considered as a change of main crop if they are maintained for at least 12 weeks. On top of that, at field level, the same crop cannot be grown for 4 consecutive years unless that main crop belongs to perennial crops, grasses and other herbaceous fodder crops or fallow land. Farmers have multiple options to achieve these conditions. The most obvious and likely is to ensure a good rotation of cash crops through every field. Introducing cover crops between cash crops is technically a further way to meet the condition, but it will incur extra costs for farmers. Since the CAP conditionality requirements do not result in any additional payments to farmers, just ongoing area-based subsidies that are deemed necessary to keep farms profitable, this is not at all likely to be the option farmers chose to meet the condition.

The risk of overlap between GLMC 7 and the Soil Capital Project is that this conditionality requirement is seen as a regulatory driver for more cover cropping. However, since the conditionality requirement results in no new payments to farmers beyond what they were already receiving and the main way in which they can meet the conditionality requirement is to ensure sufficient diversity of cash crops, the risk of overlap with the Project is not material.

Eco-schemes

In addition to the conditionalities, there is an eco-scheme related to soil organic carbon ("Ecoregeling : het verhogen het organische koolstofgehalte van bouwland[61]") which has been set to encourage farmers to increase soil carbon stocks in arable lands. Three different pathways are subsidised by this eco-scheme: (i) crop rotation on the entire farm (including the use of cover crops); (ii) the use of products with high carbon content (e.g., manure, compost and woodchips) at field level; (iii) direct soil measurement (only if in combination with one of the two previous pathways). For the crop rotation pathway, an average effective soil organic carbon increase is assumed (there is no direct measurement) per hectare of arable land. To be eligible

[60] Crop rotation on arable land
[61] Eco-schemes: increasing the organic carbon content of arable land

for the payment for a given year, the farm has to have an average effective organic carbon increase of at least 1,250 kg/ha. For the high carbon content products pathway, each field receiving at least 10t per hectare per year of compost, or manure or 10t of woodchips per hectare every 5 years, is eligible. Finally, the direct measurement pathways require soil sampling proving that the soil is in good conditions (soil organic carbon above a determined threshold). This third pathway can only be claimed once every five years for a given field.

The crop rotation pathway is a crop diversification payment rather than a carbon payment, each crop having a determined effective soil organic carbon increase factor, regardless of the management practices implemented on the field. Therefore, this pathway presents no risk to the regulatory surplus of the Soil Capital Project.

However, for farmers who are hoping to be paid via the high carbon content products pathway, this measure is directly challenging the regulatory surplus of the Soil Capital Project because the application of organic fertilisation is one of the practices rewarded by the Project. Therefore, farmers opting in for the “Use of products with high carbon content” pathway will not be eligible for this Project.

Because the direct measurement pathway rewards a particular soil organic carbon content (via a threshold set per type of soil), rather than an increase, it presents no risk to the regulatory surplus of the Soil Capital Project.

3.3.4 United Kingdom

Sustainable Farming Incentive (SFI)

In the UK, following Brexit, the SFI was implemented in 2022 in place of the CAP. Its intention was to encourage farmers to deliver certain public goods such as healthy soils, clean water and climate action. It is a voluntary scheme (farmers opt-in) and its rollout has not been straightforward. In June 2023, less than a year into the formal rollout of the scheme, the UK Government abruptly terminated the contracts of farmers that had enrolled under the SFI 2022 offer and introduced a new scope, terms and conditions via an offer called “SFI 2023”. In August 2024 an expanded SFI offer was implemented, incorporating some new ‘actions’ or updated pricing[62].

The SFI 2024 offer for arable farmers is built upon the following core features:

- Farmers are offered a list of management practices with conditions and payment rates, ranging from integrated pest management (IPM), hedgerow management, nutrient management and soil health improvement to farm biodiversity uplift
- The updated offer for 2024 includes the original actions from 2023, with some updates reflective of feedback from the industry. Most notably however has been the expanded soil health offer section, and the bundling of Countryside Stewardship Mid Tier actions into the SFI.
- There is a system of audit to ensure practices are being implemented as required, but the scheme does not involve any quantification of the outcomes achieved for use in any Government reporting
- Upon annual review, the Government continues to make explicit that “the same area of land can be entered into SFI actions, for the expanded SFI agreement and a private sector scheme arrangement, such as carbon trading or payments for natural flood management.”, (Section 6.7 - Private sector schemes).

The SFI actions that Soil Capital expects to be most popular with farmers targeted by the Project and that present the greatest risk of overlap of payment include the following.

[62] https://www.gov.uk/government/publications/sustainable-farming-incentive-scheme-expanded-offer-for-2024/sfi-scheme-information-expanded-offer-for-2024

CSAM2: Multi-species winter cover crop £129/Ha

SOH4: Winter cover following maize crops £203/Ha

These actions require farmers to implement a winter multi-species cover crop that is present between harvesting a cash crop and establishing the next cash crop. The core rationale for this payment is to cover the costs of establishing, growing and terminating the cover crop. Since the SFI requirements prohibit farmers from using synthetic or organic manure to help their cover crop establish, farmers will need to rely on effective seedbed management and more conservative establishment techniques in order to meet their audit requirements.

The establishment and termination methods – and therefore costs – of cover crops will vary between farms, particularly as soil type, weather and crop conditions differ. For this reason, definitive cost estimates are difficult to come by. However, using the most conservative methods (i.e. lowest cost) indicated by UK Government Department for Environment, Food and Rural Affairs[63] and the AHDB[64] (the farmer-funded and Government-enabled agency providing UK farmers with technical advice and support to help make their businesses more competitive), **establishment and termination costs could be at least £276 per hectare**. This total cost estimate arises from:

- Establishment costs of £158 per hectare using a seed drill, disc harrow and ring roller – National Association of Agricultural Contractors Contracting (NAAC) Prices Survey 2024[65]
- Seed costs of £54 per hectare – Cotswold Seeds SFI Seed Mixes[66]
- Termination costs of £62 per hectare from the use of an arable sprayer (NAAC Prices Survey 2024) and relevant herbicide at recommended rate – Agrigem[67]

In addition, depending on their existing crop rotation, farmers face some important further barriers to implement CSAM2 or SOH4, whereby further indirect costs of establishing cover crops may arise, namely **loss of margin from reduced winter cash crops**. Neither action is compatible with winter seeding of cash crops, because the multi-species cover crop needs to be established in the field at the same time as a winter seeded crop would otherwise be established. Farmers who want to increase their land area under over-winter cover crop will therefore need to redesign their rotation to switch winter seeded crops for spring seeded crops. Since the latter typically produce lower yields, this will result in a gross margin decrease per hectare. Using average yield information from DEFRA[68] and prices from AHDB[69] it has been found that shifting from **winter barley to spring barley** could result in a gross margin reduction of around **£247** per hectare. Where rotation redesign is required for farmers to access CSAM2 or SOH4, the payment offered will rarely come close to covering even just the loss of margin that results, let alone the establishment and termination costs.

The SFI 2024 payment rate is clearly insufficient on its own to cover establishment and termination costs and overcome the above barrier with their possible indirect costs on their own (and certainly not in combination).

Other SFI 2024 options which could also be popular with farmers targeted by the Program and could present a risk of overlap are analysed below.

SOH1: No till farming £73/Ha

[63]https://www.gov.uk/find-funding-for-land-or-farms/csam2-multi-species-winter-cover-crop
[64]https://ahdb.org.uk/knowledge-library/how-to-establish-cover-crops
[65]https://www.naac.co.uk/wp-content/uploads/2024/04/NAAC-Contracting-Prices-Survey-2024.pdf
[66]https://www.cotswoldseeds.com/seeds/55/sfi-mixes
[67]https://www.agrigem.co.uk/product/gallup-biograde-360-5l/
[68]https://www.gov.uk/government/statistics/cereal-and-oilseed-rape-production/cereal-and-oilseed-production-in-the-united-kingdom-2023
[69]https://ahdb.org.uk/cereals-market-insight

The rationale for this level of payment is to cover the cost of risk associated with moving to a no till system, which as suggested by Defra includes crop yield decline, increased weed, disease and pest control coupled with crop establishment difficulty.

Since the SFI prohibits the use of any cultivation to include conventional or shallow min-till machinery, this severely limits the control options available to the farmer for successful crop establishment and yield.

The success of no till vastly differs from farm to farm, and therefore costs and income returned from the crop are highly variable. Defra highlights that no till is mostly suitable for drier, more stable and well-drained soils, and that often crop yields can decline during the first three years. Due to the nature of varying soil types, conditions and history on farms it is difficult to put a definitive opportunity cost on moving to no till.

By using the most conservative (i.e. low cost) and minimum recommendation methods indicated by Defra and AHDB, a move to no till will **cost at least £379 per hectare**. This arises from:

- Establishment costs of £276/ha for additional cover crops under guidance from DEFRA[70] for soil health and weed suppression reasons
- Weed control results in an increased cost of £33.22 split between physical spraying costs (NAAC) and additional herbicide purchase (Farm Marketplace)
- Pest (slug) control methods result in an extra £40.58 per hectare, again split between physical spreading cost (NAAC) and additional molluscicide purchase (Farm Marketplace)[71]
- For crop establishment, consistent straw raking is recommended at a cost of £29.96 per hectare (NAAC)

SOH2: Multi-species spring-sown cover crop £163/Ha

SOH3: Multi-species summer-sown cover crop £163/Ha

The rationale for this level of payment is to cover the direct cost associated with establishing, maintaining and destroying a spring or summer-sown cover crop. The action's aims are to implement a summer-sown/spring-sown multi-species cover crop, with at least 4 species, which is present between harvesting a cash crop, until the next one is established or either side of a winter cover crop being established or destroyed.

Given this SFI scheme requires farmers to not apply any fertilisers or manures in the establishment or maintenance of the cover crops, it becomes very important to appropriately prepare the seed bed for the successful establishment and growth of the cover crop.

By using a conservative (i.e. low cost) analysis, whilst considering the recommended methods of establishment and maintenance, indicated by DEFRA (Department for Environment, Food & Rural Affairs)[72] and Cover Crops Guide[73], the implementation of a spring or summer-sown cover crop will amount to **at least £219 per hectare**. This is considering a low cost, less reliable establishment method of 'not spraying' and 'broadcasting' and becomes a **more expensive £274 per hectare** using the more reliable direct drilling/spray method.

- Establishment costs (£/Ha) to set the seed (broadcast), ring roll and disc 115 - National Association of Agricultural Contractors (NAAC) prices survey 2024
- Seed Costs (£/Ha) 54 – Cotswolds Seeds

[70] https://defrafarming.blog.gov.uk/sustainable-farming-incentive-pilot-guidance-use-min-till-or-no-till-farming/
[71] https://www.marketplace.farm/inputs/crop-protection/molluscicides/sluxx-hp-3-ferric-phosphate-slug-pellets-20kg-clone/
[72] https://www.gov.uk/find-funding-for-land-or-farms/soh3-multi-species-summer-sown-cover-crop
[73] https://www.covercropsguide.co.uk/who-we-are/

- Destruction costs (£/Ha) 50 – Mowing – NAAC

The other possible areas of overlap between SFI 2024 and this Project are identified below, together with analysis of whether the SFI payment rate is material in the context of the choices farmers will need to make. These are less significant overlaps because they relate to less common management practices.

CAHL1: Pollen and nectar flower mix £739/Ha

CAHL2: Winter bird food on arable and horticultural land £853/Ha

CAHL3: Grassy field corners or blocks £590/Ha

AHW1: Bumblebird mix £747/Ha

AHW2: Supplementary winter bird food £732/t

AHW7: Enhanced overwinter stubble £589/Ha

OFA3: Supplementary winter bird food (organic land) £935/t

AHW9: Unharvested cereal headland £1,072/Ha

AHW10: Low input harvested cereal crop £354/Ha

AHW11: Cultivated areas for arable plants £660/Ha

CIPM2: Flower-rich grass margins, blocks or in-field strips £798/Ha

CNUM2: Legumes on improved grassland £102/Ha

CNUM3: Legume Fallow £593/Ha

CSAM3: Herbal Leys £382/Ha

The above-mentioned SFI actions prohibit the implementation of cash crops in the sense that the land that would need to be attributed to the schemes could otherwise be used to grow a cash crop. An analysis has been completed to determine this opportunity cost by using average cash crop (winter and spring) yields – DEFRA[13] and prices – AHDB[14] over the area cropped in the UK for 2023 harvest to determine an average weighted gross margin for a cash crop. This has been found to be **£1,319.80/Ha** and far exceeds any of the payments dedicated to the above SFI schemes.

CIPM3: Companion crop on arable and horticultural land £55/Ha

Farmers must grow another crop with their cash crop, such as to form a living mulch beneath the cash crop. Similar direct establishment and termination costs barriers as for CSAM2 will apply, as well as the second barrier related to possible yield loss, meaning the subsidy payment will be insufficient to cover these direct costs.

AHW6: Basic overwinter stubble £58/Ha

The rationale of this level of payment is to cover the cost of leaving arable land, with the previous crops' stubbles, over the autumn and winter months, inadvertently limiting the farmers' earning ability via a winter cash crop.

In the event the action restricts the drilling of a winter cash crop, the farmers will need to restructure their cropping rotation and switch the drilling of the cash crop to the spring. This typically incurs a yield reduction and a resulting gross margin reduction per hectare. An analysis has been completed on the opportunity cost of this transition using winter and spring barley yields – DEFRA – and prices – AHDB – for 2023. An average gross margin of £1,155/Ha was realised for winter barley compared with £908/Ha for spring barley – a differential of £247/Ha.

On the basis of the above analysis, it is concluded that the SFI 2024 offer does not present a material risk to the regulatory surplus of the Project.

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[1]https://www.gov.uk/government/publications/sustainable-farming-incentive-scheme-expanded-offer-for-2024/sfi-scheme-information-expanded-offer-for-2024

3.3.5 Conclusions to the regulatory additionality assessment

The above analysis demonstrates that the Soil Capital Project continues to achieve regulatory surplus over the new CAP: 2023–27 and the SFI because there are no material overlaps between the updated regulations and the Soil Capital Project's activities. The only exceptions are two eco-schemes in Belgium : one in Wallonia and one in Flanders, and so excluding participation in these eco-schemes have been added to the eligibility criteria for the Soil Capital Project (refer to Section 2.8.2).

4 Inventory of sources, sinks and reservoirs (SSRs) for the Project and baseline

As required by the ISO standard 14064-2, the GHG sources, sinks and reservoirs (SSRs) that are controlled by, related to or affected by the Project are identified, and each is listed as being included or excluded, together with a justification below in Table 8.

We use the following definitions from ISO 14064-2:

Controlled GHG source, sink or reservoir: GHG source, sink or reservoir whose operation is under the direction and influence of the GHG Project through financial, policy, management or other instruments.

Related GHG source, sink or reservoir: GHG source, sink or reservoir that has material or energy that flows into, out of or within the Project.

Affected GHG source, sink or reservoir: GHG source, sink or reservoir influenced by a Project activity, through changes in market demand or supply for associated products or services, or through physical displacement.

Table 8 : SSRs controlled by, related to and affected by the Project

Source		GHG	Whether controlled by, related to or affected by the Project	Included?	Justification/Explanation
Baseline	Emissions from soil organic carbon	CO_2	Controlled	Yes	Soil organic carbon is a major carbon pool controlled by the Program activities. While the overarching goal is to increase soil organic carbon under regenerative agriculture practices, there is also the possibility of CO_2 emissions (or CH_4 under anaerobic conditions) from soil organic carbon, mainly via increased tillage, which is material since soil disturbance is known, via oxidation, to result in CO_2 emissions.
		CH_4	Controlled	Yes	
		N_2O	Controlled	No	
	Emissions from fossil fuel and electricity use for field operations, e.g. mechanical operations, irrigation	CO_2	Controlled	Yes	Fuel use on farm, resulting in CO_2 emissions, is included in scope for this Program since it is a source of emissions directly controlled by the choice of farming practices. CO_2 is the relevant GHG. Note that fuel use off-farm (i.e. fuel used outside of field operations, for instance, for transport of inputs or crops) is not included in the Project because it is assumed to be largely unaffected by the Project activities.
		CH_4	/	No	
		N_2O	/	No	
	Emissions from the production and use of synthetic fertiliser	CO_2	Related	Yes	CO_2 emissions associated with the production of synthetic fertilisers, a key farming input, are known to be a material source of farm emissions. Synthetic fertiliser use is a practice that will be directly affected by the Program activities because of its relationship to soil health improvement.
		CH_4	/	No	
		N_2O	/	No	
	Emissions from the use of fertiliser	CO_2	Controlled	Yes	N_2O and CO_2 emissions associated with the in-field application of fertilisers, are known to be a material source of farm emissions. Fertiliser use is a practice that will be directly affected by the Program activities because of its relationship to soil health improvement.
		CH_4	/	No	
		N_2O	Controlled	Yes	

Source		GHG	Whether controlled by, related to or affected by the Project	Included?	Justification/Explanation
	Emissions associated with the production of synthetic pesticides	CO_2	Related	Yes	CO_2 emissions associated with the production of synthetic pesticides, a key farming input, are known to be a material source of farm emissions. Pesticide use is a practice that will be directly affected by Program activities because of its relationship to soil health improvement.
		CH_4	No	No	
		N_2O	No	No	
	Emissions from crop residue managemen t	CO_2	/	No	N_2O and CH_4 emissions associated with the management of crop residues are known to be a material source of farm emissions, both positive and negative. Residue management is a practice that will be directly affected by the Program activities because of its relationship to soil health improvement.
		CH_4	Controlled	Yes	
		N_2O	Controlled	Yes	
	Emissions from manure managemen t practices for livestock managed on participating farms	CO_2	/	No	If a participating farm has livestock, CH_4 and N_2O emissions from manure management are included in scope. This is because such emissions are known to be a material source of farm emissions and are under the direct control of participating farmers. Emissions related to the management of manure that is imported onto a farm participating in the Project are not included in the Project boundary, consistent with convention in that they are typically attributed to the livestock system where they were produced.
		CH_4	Controlled	Yes	
		N_2O	Controlled	Yes	

Source		GHG	Whether controlled by, related to or affected by the Project	Included?	Justification/Explanation
	Emissions from enteric fermentation of livestock managed on participating farms	CO_2	/	No	If a participating farm has livestock, CH_4 emissions from enteric fermentation are included in scope. This is because such emissions are known to be a material source of farm emissions and are under the direct control of participating farmers. Emissions related to enteric fermentation of livestock that have produced manure that is then imported onto a farm participating in the Project are not included in the Project boundary, consistent with convention in that they are typically attributed to the livestock system where they were produced.
		CH_4	Controlled	Yes	
		N_2O	/	No	
	Emissions from the construction of infrastructure and purchase of equipment	CO_2	Related	No	No infrastructure construction is required to implement the Project activities. Although some farmers may need to switch to alternative equipment to implement the Project activities, it is assumed that the production emissions associated with equipment manufacture are the same in the baseline and Project scenarios.
		CH_4	/	/	
		N_2O	/	/	
	Emissions related to loss of crops (biomass) due to exogenous factors	CO_2	Related	No	It is assumed that any such emissions would be equal under both the baseline and Project activities, i.e., they are unaffected by the Project activities and are unavoidable. Further details are provided below.
		CH_4	/	/	
		N_2O	/	/	
Inter-vention	Exactly as above	CO_2			
		CH_4			
		N_2O			

Sink		GHG	Whether controlled by, related to or affected by the Project	Included ?	Justification/Explanation
Baseline	Removals via build-up of soil organic carbon from organic matter inputs and tillage reduction	CO_2	Controlled	Yes	Soil organic carbon is a major carbon pool controlled by the Project activities. The overarching goal is to increase soil organic carbon under regenerative agriculture practices (i.e., towards net removals).
		CH_4	Controlled	Yes	
		N_2O	/	No	
	Removals via growth of biomass in trees planted within field boundaries to integrate with productive arable systems (e.g., following agroforestry techniques).	CO_2	Controlled	Yes	Sequestration of carbon in tree biomass is a material sink that can be directly affected by the Program activities. Tree planting to form new hedgerows, woodland or forests is excluded, as is the maintenance of existing hedgerows, woodland or forests, as these activities are the focus of existing public policy support.
		CH_4	/	No	
		N_2O	/	No	
Inter-vention	Exactly as above	CO_2			
		CH_4			
		N_2O			

Exogenous factors

Exogenous factors that could lead to crop destruction (such as flooding of farmland, fires, war and terrorism) or changes in the ability of farmland soil to retain sequestered carbon following changes in climatic conditions, are all excluded in the Project SSRs. This follows the VCS definition of catastrophic events as those which are "caused by disasters such as hurricanes, earthquakes, flooding, drought, fires, tornadoes or winter storms, or man-made events over which the Project proponent has no control such as acts of terrorism or war" (Verra, Program Definitions, 2022, p.5). The Project assumes such events to be extraordinary occurrences that are not created or influenced by the Project activities. Impacts that result from such exogenous factors would, therefore, be the same under the baseline and Project scenarios. Furthermore, since the Project is solely focused on incentivising farming practice changes, it is not considered appropriate to include exogenous factors in the Project SSRs.

Inclusion of livestock-related emissions

Although this Project is for arable farmers, the Project allows for participating farms to have livestock. While many arable farms in France, Belgium and the UK solely specialise in crop production, they do sometimes integrate livestock and genuinely mixed arable-livestock operations do exist. It would not be reasonable to exclude them from the scope of the Project, especially as they may not qualify for a Project aimed at livestock farmers. Therefore, arable farms with livestock remain eligible.

GHG emissions from these livestock are kept constant during the whole crediting period, unless livestock number increase, and are quantified on the basis of common practice in the region at the point of the baseline assessment, as calculated using the IPCC's Tier 1 emission factors (an approach that is in line with Verra's Improved Agricultural and Land Management methodology).

As a result of this, emissions related to this livestock population are included in the Project boundary as detailed above.

For both the baseline and Project SSRs, the quantification, monitoring and reporting of GHG emissions and removals are based on procedures developed by Soil Capital and are adherent to ISO 14064-2 in terms of Project design, baseline setting, additionality and risks to performance and permanence.

5 Quantification and calculation of GHG emissions/removals

5.1 Explanation of the methodology choice

The combining use of CFT and DNDC enables the calculation of the net GHG emissions and removals associated with each crop and management practice based on a comprehensive range of data inputs related to farm structure, location, soil conditions and management practices. The tools can be applied across all geographies and farm types and are not limited to just calculating emissions or focusing purely on carbon.

The CFT and DNDC incorporate a wide range of farming activities using farm management data. The major emission categories and methodologies for calculating emission reductions or removals are included in this Project (namely carbon stock changes in soils, emissions from managed soils from nitrogen inputs, plant residues and cover crops and emissions from synthetic inputs production, fuel and energy use) and are derived from the CFT for non soil-based emissions and from DNDC for soil-based emissions and removals.

5.1.1 Baseline emissions

5.1.1.1 Baseline emissions calculation process for baseline scenario 1

To inform the design of this Project, a summary of net GHG emissions and removals assessments conducted at farm level in 7 regions of France, Wallonia in Belgium, and the South East of England in the UK is represented in Table 9. For each region, the average net GHG balance is displayed together with the results of each quartile to give an overview of the variability of scenarios that is due to various parameters including weather conditions, soil characteristics and level of implementation of regenerative agriculture practices. Even though the number of assessments conducted is low in some regions, this table shows that the GHG balance is quite variable from a region to another and that, overall, arable farming practices for those regions result in net emissions.

Table 9 : Summary of average net GHG emissions and removals in regions of the Project area

Region	Number of assessments conducted	Average net GHG balance at farm level (tCO_2e per ha)	First quartile (tCO_2e per ha)	Second quartile (tCO_2e per ha)	Third quartile (tCO_2e per ha)
Bourgogne Franche Comte, France	34	+0.59	+0.18	+0.46	+1.40
Centre Val de Loire, France	46	+0.75	-0.26	+0.95	+1.53
Grand Est, France	39	+0.15	-0.30	+0.10	+0.94
Hauts-de-France, France	46	+0.44	+0.16	+0.58	+1.18
Ile-de-France, France	13	+0.44	-0.47	+0.27	+1.08
Normandie, France	13	+1.28	+0.34	+1.50	+2.05
Nouvelle Aquitaine, France	56	+1.82	+0.56	+1.66	+2.63
Wallonia, Belgium	11	+0.59	+0.42	+0.67	+0.78
South East of England, UK	13	+2.64	+1.63	+2.69	+3.50

(Source: Soil Capital, 2024)

Figure 5 depicts the GHG emissions reductions and removals generated by a typical conventional farmer in the region of Bourgogne Franche Comte in France, $BS1_{sc(t)}$.

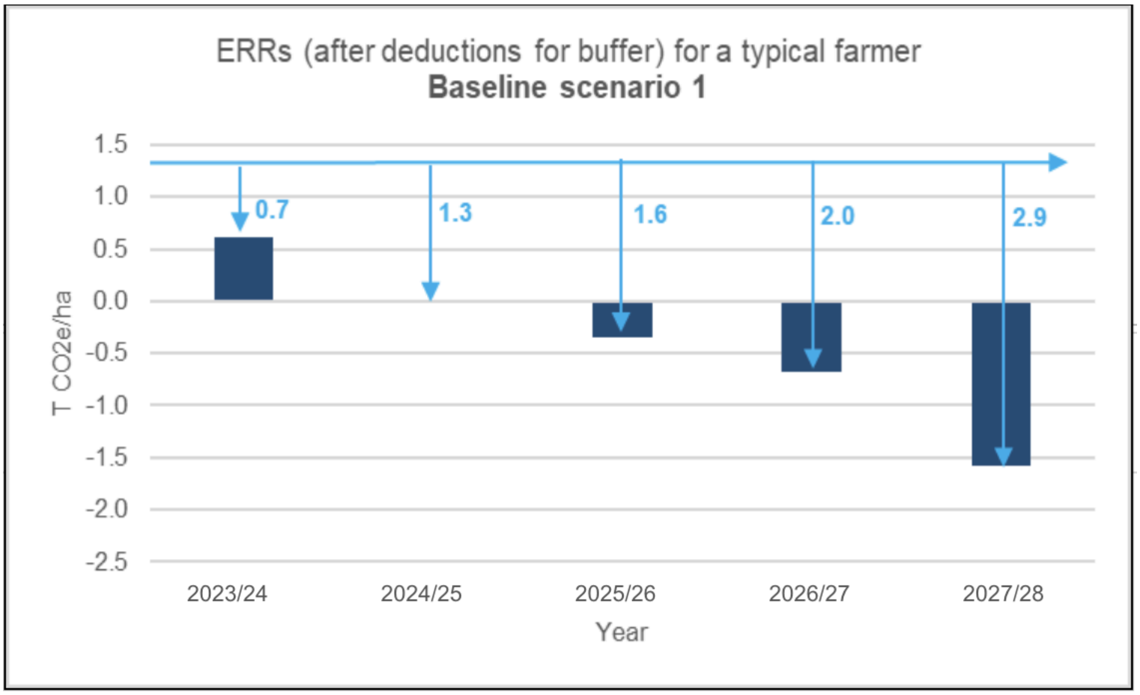

Figure 5 : Baseline scenario 1

(Source: Soil Capital, 2024)

The horizontal light blue line represents the baseline emissions as measured for the individual farmer, here at some 1.4 tCO_2e/ha, i.e. the GHG balance of the third quartile depicted in Table 9. Indeed the population depicted in the table is widely variable and includes farmers having input and disturbance intensive farming practices, being in early transition towards regenerative farming practices, or being more advanced on their path towards regenerative agriculture. The third quartile is therefore the best available approach to describe the situation of a typical net emitting farmer.

The dark blue bars represent the Project emissions in each year of the five-year crediting period for that same farmer. In the 2023/24 season they reflect a positive GHG inventory (+0.55 tCO_2e/ha), and by 2027/28 they reflect a negative GHG inventory (-1.65 tCO_2e/ha). The vertical light blue lines represent the ERRs calculated for each year, i.e. the difference between the baseline emissions and the annual project year emissions. This diagram is an illustrative simplification because in reality the light blue line, i.e. the baseline emissions as measured for the individual farmer, will be fluctuating from one Project year to the next due to the influence of weather. Indeed, as explained previously, each year, the historical GHG emissions and removals of a farm will be calculated by building a counterfactual baseline, representing, for each project year, what would have happened in the absence of the project. Therefore it represents the continuation of the 3-years historical practices in the prevailing weather of the project year.

5.1.1.2 Baseline emissions calculation process for baseline scenario 2 – implementation of regional common practices

A methodology for assessing the net GHG emissions and removals that reflects regional common practices has been developed for this Project. This methodology is designed to:

1. align with EU CRCF requirements for standardised baselines[74]. It is stated in that regulation that:
    a. "A standardised baseline should be representative of the standard performance of comparable practices and processes in similar social, economic, environmental and technological circumstances and take into account the geographical context, including local pedoclimatic and regulatory conditions".
    b. "In the context of carbon farming, only practices and processes that go beyond the common practice should be certified".
2. include in scope all soil-based removals and soil-based emissions, together with direct and indirect emissions associated with those removals.
3. avoid overestimating the GHG impacts of the adoption of those regional common practices by adopting conservative positions and adjusting for uncertainties at various points, as described below, during the assessment process.

This methodology is explained below. It is applied to each region (defined as no larger than a Nomenclature of Territorial Units for Statistics (NUTS) 2 region in France or a NUTS 1 region in Belgium and the UK) (Eurostat - RAMON, 2016).

5.1.1.2.1 Construct the common rotation

The most recent accessible official survey data about the proportion of land in that region dedicated to different arable crops is sourced. In France, data is sourced from the Ministry of Agriculture Statistics Department[75], in Belgium from the Government's Statistics Office[76], and in the UK from the Government's Department for Environment, Food & Rural Affairs[77]. Using this data, crops grown in the region are listed, starting with the one occupying the most land. When at least 80% of the arable land used in that region is covered, the process stops. This group of crops is taken to be representative of the region. Using the share of land taken by only these crops in reality, a common rotation for that region is then constructed. For instance, in the below examples, the calculation for the percentage of the region assumed to be under winter wheat in Hauts-de-France is (48/81) x 100 (see Table 10) and in the West Midlands is (41/80) x 100 (see Table 11).

Table 10 : Construction of the common rotation for Hauts-de-France, France

Crop	% of region by crop (2019)	% of region by crop, if these crops are assumed to be the whole rotation
Winter wheat	48%	59%
Sugar beet	12%	15%
Winter OSR	8%	10%
Winter barley	6%	8%
Potatoes	6%	7%
Total	81%	100%

(Source: Agreste, 2022)

[74] https://climate.ec.europa.eu/eu-action/carbon-removals-and-carbon-farming_en
[75] https://agreste.agriculture.gouv.fr/agreste-web/
[76] https://statbel.fgov.be/en
[77] https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs

Table 11 : Construction of the common rotation for the West Midlands, UK

Crop	% of region by crop (2019)	% of region by crop, if these crops are assumed to be the whole rotation
Winter wheat	41%	51%
Winter barley	9%	11%
Spring barley	6%	8%
Potatoes	4%	5%
Oilseed rape	12%	15%
Fodder maize	8%	10%
Total	80%	100%

(Source: DEFRA, 2019)

5.1.1.2.2 Form a Baseline Expert Group (BEG)

A BEG comprises a minimum of three professional agronomists, independent from Soil Capital, practising as farm advisers to at least 20 farmers in that region or having similar and equivalent experience that allows them to have a comprehensive knowledge of agricultural practice in the region. Each agronomist signs a declaration confirming their commitment to participate in the BEG in an objective, neutral and professional manner, and to declare any material personal conflicts of interest.

5.1.1.2.3 Collect expert judgement from BEG

Each agronomist is then presented with a data input table, into which they insert their expert judgement of current common farming practices for each of the crops in common rotation for the region. The parameters they are required to respond to are set out in Table 12. Where a definition is needed, common practice is defined as greater than 20% adoption, as per VCS IALM.

Table 12 : Parameters required for expert judgement and how they are analysed

Parameter for which expert judgement is sought	Upper or lower bound after variance analysis
Typical regional SOM, weighted average (%)	Lower
Typical yield, per crop (t/ha)	Lower
Typical residue management practice categorisation	N/A (mode used)
Typical number of land preparation passes after the preceding harvest	N/A (mean used)
Typical number of seeding or planting passes	N/A (mean used)
Typical number of agrochemical passes	Lower
Typical number of fertiliser passes	N/A (mean used)
Average synthetic nitrogen application (kg)	Lower

Typical proportion of cropped area under irrigation (%)	N/A (mean used)
Typical quantity of irrigation per year (millimetres [mm])	N/A (mean used)
Typical change in tillage practices, including:	
Type of change	N/A (mode used)
Proportion of cropland affected (%)	Upper
Typical change in cover crop practices, including:	
Type of change	N/A (mode used)
Proportion of cropland affected (%)	Upper

5.1.1.2.4 Variance analysis – conservativeness step 1

The coefficient of variation is then analysed for all the parameters for which this type of analysis is appropriate. The common reason for not applying variance analysis is due to the fact that the answers are not numeric or are typically very small integers. Analysis only proceeds if the coefficient of variation for relevant parameters is less than or equal to 30%. If this is not the case, additional agronomist input into the BEG is sought and the three views that do meet this condition are used instead. Setting this threshold for the coefficient of variation is subjective, but it was informed by academic opinion.[78]

5.1.1.2.5 Upper and lower bound analysis – conservativeness step 2

For the parameters to which variance analysis was applied, upper or lower bound analysis is then conducted. The upper bound is the mean plus one standard deviation. The lower bound is the mean minus one standard deviation. Table 13 indicates whether the upper or lower bound is used for each parameter. The common rationale is to select the bound that would result in the net GHG emissions and removals at farm level being closest to net removals, i.e., to deliver the more conservative outcome. For example, under identical agricultural practices, soils with lower SOC contents will have lower mineralization rates and therefore higher carbon removal potential. Therefore, for SOC content, the lower bound is used.

Once this step is concluded, the definition of farming practices that are considered to constitute regional common practice is complete.

5.1.1.2.6 Define soil characteristics and weather conditions for the common practice scenarios

In line with the EU CRCF, every farmer should be compared to a common practice baseline that takes into account their soil characteristics. Even though a process-based model like DNDC requires multiple soil parameters (pH, SOC content, clay content, etc.) as initial data inputs, it is more sensitive to initial SOC content because of its close link with mineralisation rate. If the lower bound of the BEG analysis is used as the sole input parameter for SOC in an entire region, it could lack relevance for farmers with a higher SOC content and be too generous (and therefore not conservative) for farmers with a lower SOC content. To take a concrete example: if two farms, one with 1% SOC and another with 4% SOC, are in a region with an average SOC content of 2% (lower bound), the 1% SOC farm could have a lower GHG balance than the 2% farm due to a lower mineralisation rate, even though its practices could be more conventional than the common practices of the region (and therefore considered as not additional). Conversely, the 4% SOC farm could have a higher GHG balance than the 2% farm due to its

[78] https://www.researchgate.net/post/What_are_the_acceptable_values_for_the_percentage_deviation_DEV_and_the_coefficient_of_variance_CV

higher mineralisation rate, even if it was implementing more regenerative practices than the common practices for the region (and therefore complying with additionality requirements). To minimise these discrepancies, for each region, the common practices set by the BEG are applied across a range of SOC contents, determined on the basis of the BEG expertise and available open data such as SoilGrids.

Regarding the clay content, pH and weather conditions, a representative field of the region is selected using SoilGrids as the data source for clay content and NASA Power Project[79] as the data source for weather conditions. For pH, given the fact that most agricultural soils in the Project regions have a pH between 5.5 to 8.5 and that it is the soil parameter having the least impact on soil GHG balance, a pH of 7 is used as standard.

5.1.1.2.7 Modelling analysis (CFT + DNDC)

A process-based model like DNDC is sensitive to the different interactions between crops, soil characteristics and weather conditions around a rotation. Therefore, to quantify the net GHG emissions and removals of a crop in a given year, the model requires at least 3 historical years previous to that crop to ensure that the crop*practices successions are taken into account. Consequently, several crop rotations are built based on the common rotation for the region described in Section 5.1.1.2.1 in order to have each crop at the end point of one rotation. This means that for example, in the “Hauts-de-France” region, the two following crop rotations are modelled, the first one to quantify the typical net GHG emissions and removals of sugarbeet in that region, and the second to quantify the typical net GHG emissions and removals of winter wheat:

- Winter wheat → Winter rapeseed → Winter wheat → **Sugarbeet**
- Winter barley → Winter wheat → Winter rapeseed → **Winter wheat**

The net GHG emissions and removals for each of those crop*SOC content combinations are then calculated using the combination of CFT and DNDC. This analysis results in per ha net GHG emissions and removals for each crop*SOC content combination, produced under conditions of regional common practice. Finally, for each SOC content combination, these individual crop net GHG emissions and removals are then summed into a weighted average, representing the common rotation by multiplying the individual crop net GHG emissions and removals by the proportion of land occupied by that crop in the representative rotation set in Section 5.1.1.2.1. If we take the example above, it means that the net GHG balance of sugarbeet will be multiplied by 15%, while the GHG balance of winter wheat will be multiplied by 59%.

5.1.1.2.8 Aggregated GHG balance with uncertainty deduction – conservativeness step 3

The above analysis results in an average annual GHG balance at the whole farm level for each SOC content, taking all sources of emissions and removals into account. The soil component of those GHG results, i.e. soil-based emissions and removals as quantified by the DNDC model, are accompanied by a model prediction error calculated by the Regrow uncertainty model. In order to be conservative, this uncertainty level is deducted from the calculated GHG balance obtained in section 5.1.1.2.7. The total aggregated GHG balance is then used as the point against which farms being in the same SOC content range, using this baseline, are assessed.

5.1.1.2.9 Choice of SOC reference to compare individual farmer to – conservativeness step 4

Given the fact that, for the same set of agricultural practices, a lower SOC leads to a lower GHG balance, the average SOC content of each net sequestering farmer is rounded down to the nearest SOC reference used for the GHG assessments of common practice baselines (see section 5.1.1.2.6) to finally calculate the VERRs generated.

[79] https://power.larc.nasa.gov/

In Figure 6, the horizontal light blue line represents the common practice baseline. The dark blue bars represent the Project emissions in each year of the five-year crediting period for that same farmer. They reflect a negative GHG inventory throughout the crediting period, The vertical light blue lines represent the ERRs calculated for each year, i.e., the difference between the common practice baseline and the annual Project emissions and removals.

It is important to note that, since new farmers are enrolled in this Project on a yearly basis, the crediting period is individual for each enrolled farmer. As above, whenever a farmer enrols in the Project, an individual historical practice assessment is performed, which results in that individual farmer being allocated to a Baseline Scenario at the point of their enrolment, which is the start of their own crediting period. This applies to BS1 as it does to BS2. To be consistent to all farmers throughout the Project and to take annual weather conditions into account, it is therefore important that the common practice baseline for a given region represents what would have happened if the farmer was continuing the common agricultural practice of the region in the prevailing weather of the project year. It is also important from a climate point of view, because it ensures that ERRs are only based on additionality of practices and not on weather conditions changes through years. . In addition to that, as described above, for a given region, the common practice baseline is set across a range of SOC contents and will therefore vary depending on the initial soil characteristics of a specific farm. Therefore Figure 6 is an illustrative example to show how the concept of BS2 works.

Having said this, practice change across a population of farmers is slow and so it is neither practical nor meaningful to do a full re-assessment of common practice in a given region each year. Therefore, within this Project, the full process detailed above is performed for a given region every five years and the Baseline Expert Group (BEG) for each region is consulted each year to check whether material changes to common practice that would affect the common practice baseline have occurred in the previous year or not.

In practice what this means is that all three members of each BEG are presented by email, each year, with the analysis of common practice that they originally produced. They are asked if there have been any material changes to common practice in their professional view, with materiality defined as in 5.1.1.2.3, that would affect the common practice baseline. If not, and their written responses are collated as evidence of this view, the common practices are maintained for that year and the common practice baseline is reassessed adapting the weather conditions only. If so, it is recalculated using both the revised view of the BEG and the weather conditions of that given year.

Since it is not always possible to reach the same individuals year after year, responses from the majority of BEG members for a given region are taken to be sufficient. Equally if for some reason, and after repeated efforts, it is not possible to re-establish contact with any members of the BEG for a given region, if the majority of regions in the same country have already been contacted and have confirmed that the common practices remain relevant without further changes, this majority view is applied to the other regions. If other regions have seen changes to their common practices, then a common practice baseline in a region where it was not possible to re-establish contact with the BEG members must be re-done.

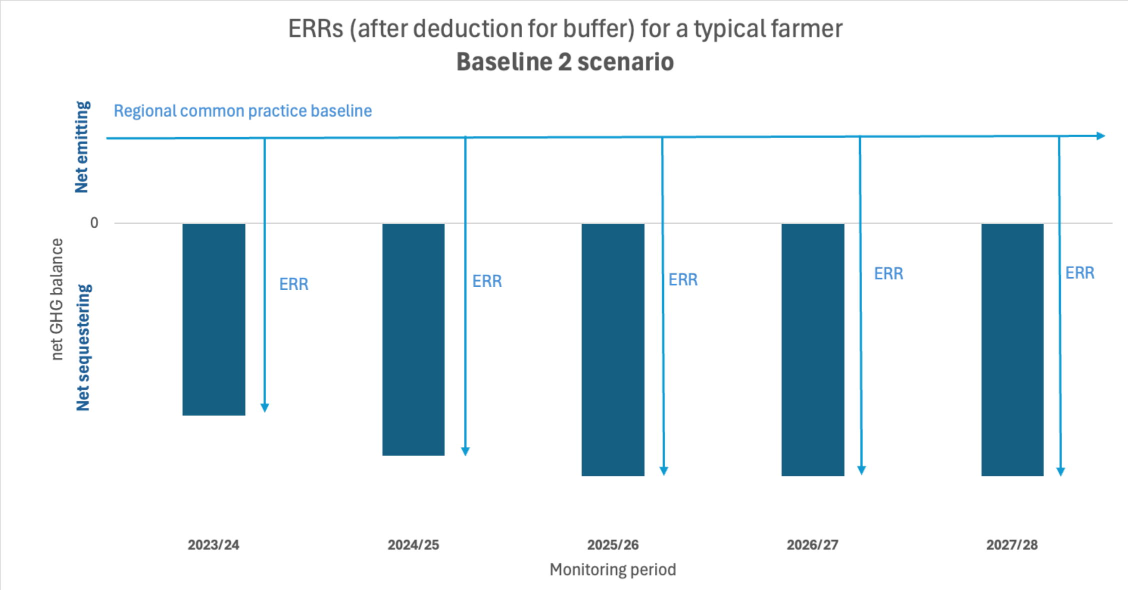

Figure 6 : Baseline scenario 2

(Source: Soil Capital, 2024)

5.1.1.3 Baseline emissions calculations

The emissions resulting from the individual historical practice assessment (tCO_2e) = BE_{SC}

BE_{SC} =Total (tCO_2e) non soil-based emissions in the individual historical practice assessment related to crops (CFT equation number 2.3.1 + 2.4.1 + 2.6.1a + 2.6.1b) + Total (tCO_2e) soil-based emissions in the individual historical practice assessment related to crops (DNDC equation number 1 + 2 + 3) + Total (tCO_2e) emissions in the individual historical practice assessment related to livestock (10.20 + 10.22 + 10.25 + 10.27). In baseline scenario 1, the same equation is used to calculate baseline emissions. In baseline scenario 2, the common practice baseline is used, as explained and calculated above.

$BE_{SC} = BS1_{sc(t)} + BS2_{sc(t)}$

Annex VI provides a complete list of equations extracted from the CFT and IPCC that are used to calculate the non soil-based baseline emissions of the Project. Annex VII provides a complete list of equations extracted from the DNDC model that are used to calculate the soil related baseline emissions of the Project. Annex VIII presents the list of default emission factors used.

5.1.2 Project emissions

The Project emissions (tCO_2e) = PE_{SC}

PE_{SC} = Total (tCO_2e) non soil-based emissions in the Project scenario related to crops (CFT equation number 2.3.1 + 2.4.1 + 2.6.1a + 2.6.1b) + Total (CO_2e) emissions from SOC stocks from tree planting with agroforestry techniques (equation number 2.9.8a) + Total (tCO_2e) soil related emissions in the Project scenario related to crops (DNDC equation number 1 + 2 + 3) + Total (tCO_2e) emissions calculated in the Project scenario related to livestock (10.20 + 10.22 + 10.25 + 10.27). Note that emissions related to livestock are held constant from the baseline throughout the Project, unless there is an increase in heads of livestock during the Project, in which case the same equations are used to calculate the increase in emissions.

Annex VI provides a complete list of equations extracted from the CFT and IPCC that are used to calculate the non soil related Project emissions of the Project. Annex VII provides a complete list of equations extracted from the DNDC model that are used to calculate the soil related

Project emissions of the Project. The Project emissions are determined in the same way for all farms.

5.1.3 Deduction for leakage

The description of all leakage risks for this Project can be found in Section 2.10.3. As explained and contextualised, and under the methodology applicability conditions, leakage risks could be assumed as being negligible and therefore leakage deduction is considered as being zero. However, in order to ensure conservativeness and align with widely accepted methodologies for IALM Projects, the market leakage risk linked to short-term productivity decline identified for this Project is monitored.

Productivity or yield impacts from land use change are a common consequence of Projects such as this one. However, this Project does not allow for land use change that would change the use of land from arable farming during the Project and cropland must have been managed as cropland for at least 10 years prior to the Project start date.

On the other hand, observers and farmers alike share fears that changes to land use practices in line with the Intervention activities of this Project can lead to productivity or yield reductions. We observe that there is no single truth here and that, in fact, the impact of implementing the intervention activities on productivity or yields is a function of the nature and implementation strategy of an individual farmer's transition to adopt the project activities. It is noted, for example, that there are many long-term experiments which demonstrate the capacity of improved crop rotations and cover crop adoption to increase soil organic matter levels, while maintaining or increasing yields, without requiring additional nitrogen inputs compared to conventional management (e.g. Dick et al., 1998; Abdalla et al., 2019).

The Climate Action Reserve's Soil Enrichment Protocol (CAR SEP)[80] adopts the position that soil enrichment Projects like this Project are unlikely to cause such productivity declines, provided the Project area remains in commodity crop production. According to CAR SEP, the Project activities should not negatively impact long-term crop yields, and they develop this argument by showing several factors limiting the likelihood of significant yield declines, such as:

- Farmer risk aversion: Farmers are highly risk-averse. Yield declines immediately impact their income. Carbon revenues are designed to cover the costs of adopting new practices, not to replace crop income. Significant yield declines would likely result in farmers exiting the Project, reverting to previous practices, avoiding market-shifting leakage.
- Quantification of emission reductions: Process-based models, such as the one used in this Project, link productivity to soil organic carbon (SOC) increase. Lower yields result in reduced SOC, leading to fewer emission reductions. Thus, maintaining yields directly incentivises better performance in emission reductions, which is one of the main goals of such Projects.

Nevertheless, yield is monitored routinely during the Project for all farmers. Data already collected in this way substantiates the above. For instance, for data collected from 1 September 2020 to 31 August 2021 as part of the Soil Capital Climate Change Mitigation Project for Arable Farming, i.e. previous quantification methodology validated in 2023, yields for six crops in the baseline and Project intervention ("Year 1") were compared (Figure 7). A positive difference means that the Year 1 yield was higher than the baseline yield.

[80] https://www.climateactionreserve.org/wp-content/uploads/2020/10/Soil-Enrichment-Protocol-V1.0.pdf

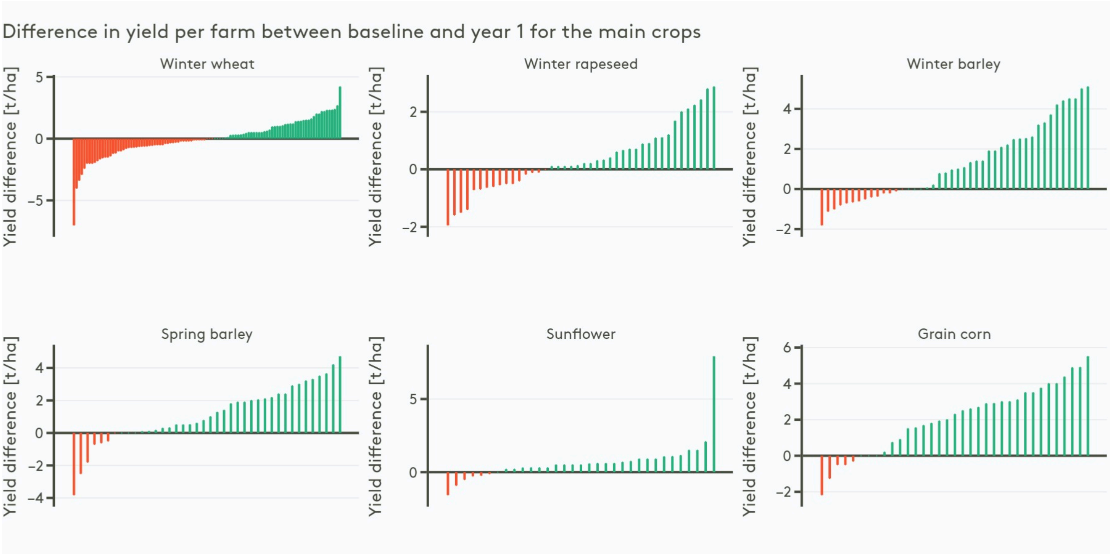

Figure 7 : Difference in yield per farm between baseline and year 1 for the main crops

(Source : Soil Capital, 2024)

To control for the extent to which the intervention activities were implemented, this analysis was supplemented by comparing yield change between the two years with the change in the GHG footprint of the crop in question, as per the Figure 8 below, where the green quadrant highlights both yield improvement and GHG footprint improvement. This highlights that, indeed, productivity or yield reductions are by no means guaranteed as a result of implementing the intervention activities, but rather the opposite can be achieved with a prudent and appropriate approach to execution.

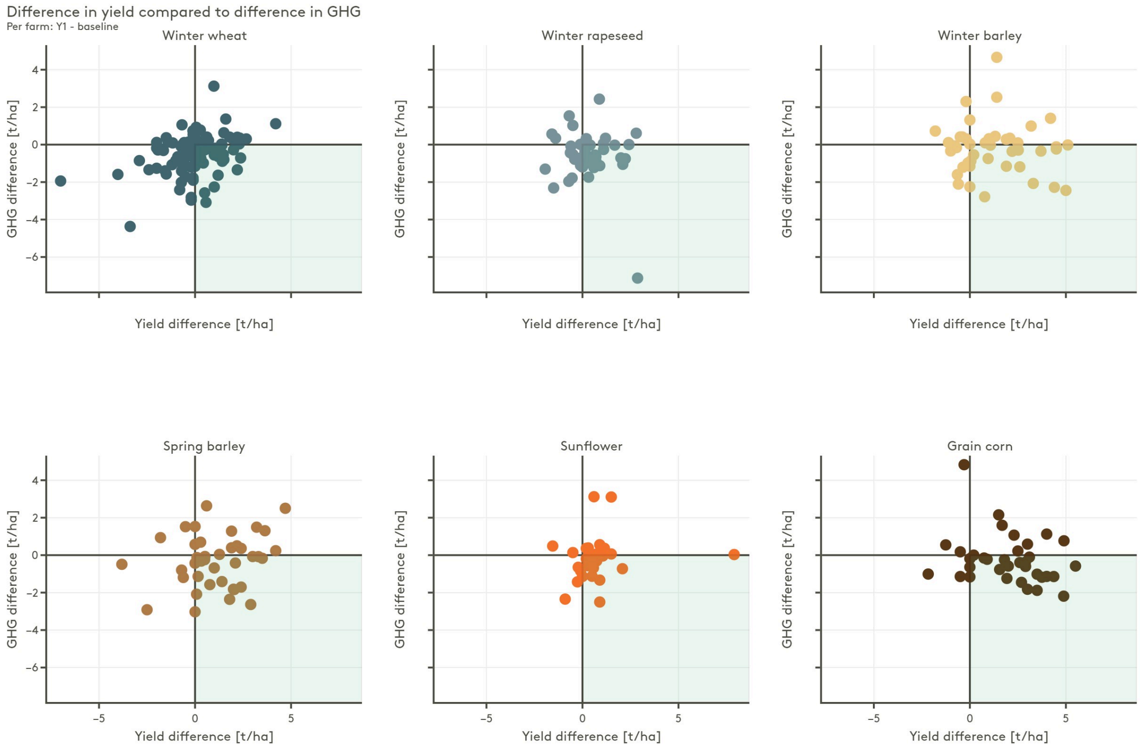

Figure 8 : Difference in yield compared to difference in GHG

(Source : Soil Capital, 2024)

A final control was performed by comparing the yields of farmers in the Project to average yields in their local regions using publicly available Government data. The Figure 9 focuses on barley yields as an illustration, whereby Agreste is the regional average yield and farmers in the Program are categorised into those that net sequester or net emit GHGs. As above, we observe that it is by no means a guarantee that implementing the Intervention activities leads consistently to any measurable yield reduction – sometimes (e.g. North of France & Belgium) to a marked increase.

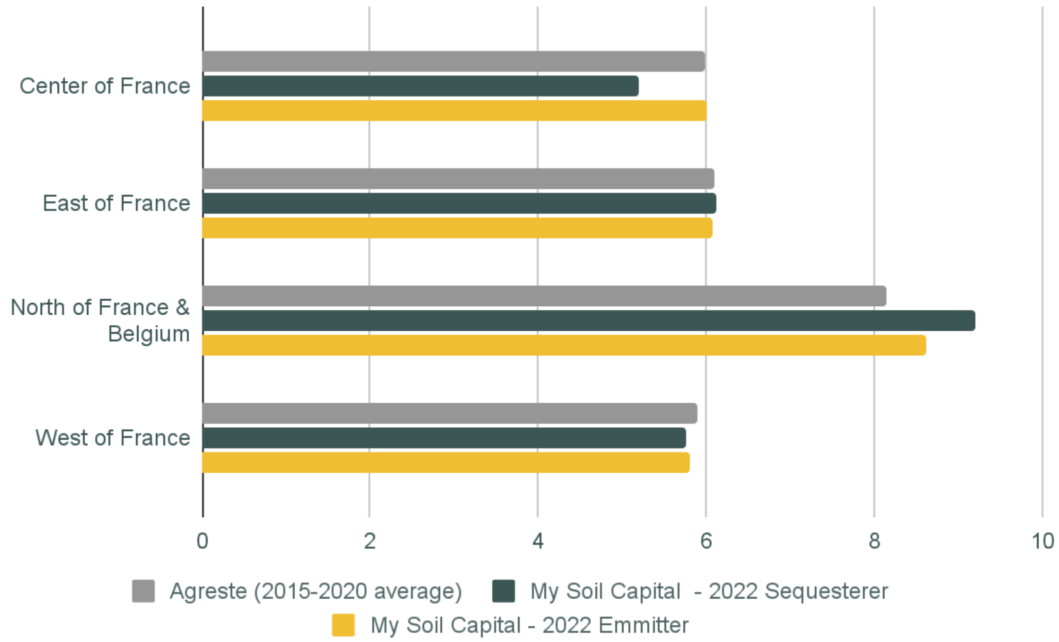

Figure 9 : Comparison of barley yields of farmers in the Project to average barley yields in their local regions

(Sources : Agreste, 2022 ; Soil Capital, 2024)

Despite all of the above, the Project implements a process for comparing yields between the baseline and Project scenario and for quantifying GHG leakage where service equivalence is not met (i.e. when yield has decreased as a result of the Project). This approach is based on the CAR SEP methodology, as follows.

Data on actual achieved yields is collected systematically across all hectares of major crops in the Project, for each cultivation cycle, through the mySoilCapital digital platform. Using this data, annual yield ratios between farmers in the Project and regional averages, per crop and weighted by field area, are calculated in order to derive “relative yield ratios”. The data sources on annual regional yields used are authoritative and reliable based on what is available in each country and area of activity. Relative yield ratios for farmers within the Project during Project years are then compared with those from the baseline period each year. The area-weighted difference in relative yield ratios, multiplied by the proportion of crop area, determines the leakage value. If the difference exceeds the threshold of 5% in the fifth year of a group of farmers being in the Project, leakage is deemed non-negligible and the difference with this 5% threshold is the quantified GHG leakage deduction. The equation for calculating leakage deduction in the Project is provided below. As explained above, projects like ours are unlikely to cause such productivity declines, provided the Project area remains in commodity crop production. Therefore, in this project, leakage deduction has been set to 0 for the time being and if the monitoring performed as described in this section demonstrates a material leakage over multiple years, the leakage deduction will be reviewed.

$$LEt = MAX\left(0, \sum (YRc{,}bsl - YRc{,}t) \times (Ac{,}t / \sum Ac{,}t) - 0.05\right)$$

Where,

LEt = Leakage deduction due to yield decline of crop c during cultivation cycle (year) t , ratio

$YRc{,}bsl$ = Average yield ratio for crop c during the historical baseline period

$YRc{,}t$ = Project-specific yield ratio for crop c during cultivation cycle t

$Ac{,}t$ = Area of fields growing crop c during cultivation cycle t

This equation can be further broken down as:

Project-Specific Crop Yield Ratio in the Project Scenario

$$YRc, t = PPc, t / RPc, t$$

Where,

$YRc{,}t$ = Project-specific yield ratio for crop c during cultivation cycle t

PPc, t = Project production reported by field growing crop c during cultivation cycle t

RPc, t= Regional production yield for crop c during cultivation cycle t

Average Yield Ratio During the Historical Baseline Period

$YRc, bsl = \sum IPHc, bsl / \sum RPHc, bsl$

Where,

$YRc{,}bsl$ = Average yield ratio for crop c during the historical baseline period

$IPHc, bsl$= IPH by fields growing crop c during cultivation cycle of the historical baseline period

$RPHc, bsl$ = Regional production for crop c during cultivation cycle of the historical baseline period

Average Annual Crop Yield During the Historical Baseline Period

$IPHc, bsl = \sum PPc \times Afc) / \sum Afc$

Where,

$IPHc, bsl$ = IPH by fields growing crop c during cultivation cycle of the historical baseline period

PPc= PP for field f growing crop c during cultivation cycle

Afc = Area of field f growing crop c during a historical cultivation cycle

5.1.4 Uncertainty and model prediction error

If during any verification event the verification body deems that a farmer cannot provide any reasonable evidence (noting, for instance, that manure is sometimes traded informally) to satisfactorily account for at least 75% of inputs (by volume), then the farm is not permitted to generate VERRs for that season. This is equivalent to an uncertainty deduction.

Beyond this, uncertainty deductions are calculated individually for each pool included within the Project boundary and the selected approach to estimate uncertainty is representative of the quantification approach used. For all GHGs modelled, the key sources of error that are included within this Project are discussed separately in the sections below.

Regrow's uncertainty model is an empirical model that estimates the lack of fit between model estimates and measured values of differences in a given emissions source (ES) between two paired scenarios from literature data. For this Project, Regrow will estimate uncertainty separately for both soil organic carbon (SOC) sequestration and direct N_2O emissions.

This shall be completed following the use of the statistical model (i) below

(i) $$y_i = \eta_i + \delta_i + \epsilon_i$$

where

yi = The measurements of treatment-pair level differences (offsets) from the validation dataset,

ni = The DNDC model estimates of the treatment-pair level differences,

δi = A single bias/model discrepancy estimate,

εi’s = The independent random normals centred at 0 with the same single variance

parameter σ,. This captures both the observational error and other random variability such as within field variability.

For this Project model uncertainty is estimated using a Bayesian framework to simplify the model’s parameter uncertainties along with its prediction uncertainty to new modelling units. A half-Cauchy distribution with location parameter 0 and scale parameter 1 will be used for the non-informative prior distribution of σ following Gelman et al (2006). A normal distribution centred at 0 with a large standard deviation of 100 will be used as the prior distribution for □. Posterior probability distributions for both parameters are sampled using Markov Chain Monte Carlo (MCMC) methods. This is a standard Bayesian sampling method that iteratively draws samples from approximate distributions called transition distributions, which through the use of a Markov Chain are improved with each iteration until the chain converges to the target posterior distribution (Gelman et al., 2013). Sampling is done in Stan software (Carpenter et al., 2017) using the No-U-Turn Sampler (for definition see appendix 5) developed by Hoffman and Gelman (2014). Initial warm-up samples from each MCMC run (the so-called “burn-in”) are discarded therefore yielding a final distribution of 1000 samples. Convergence is evaluated using the Gelman-Rubin statistic, which approaches 1 as the model converges (Gelman & Rubin, 1992). Once sampled, the posterior distributions of δ and σ are used to propagate the structural uncertainty in the validation dataset to DNDC estimates of differences in SOC or N_2O between the baseline and Project scenario of new fields via Monte Carlo integration.

Histograms showing the model discrepancy parameter’s posterior distribution for SOC, and Direct N_2O emissions are shown in Figure 10, and histograms of the model’s posterior distribution of the sigma parameter are shown in Figure 11.

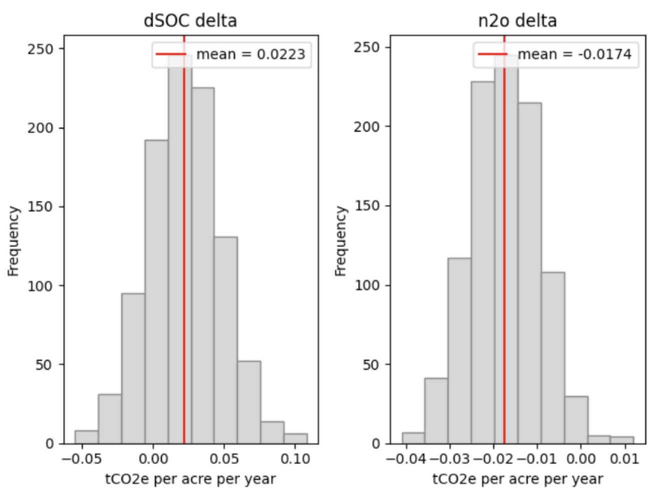

Figure 10 : Posterior distributions of the model discrepancy/bias parameter of the uncertainty model by emission type based on the validation set.

(Source : Regrow, 2024)

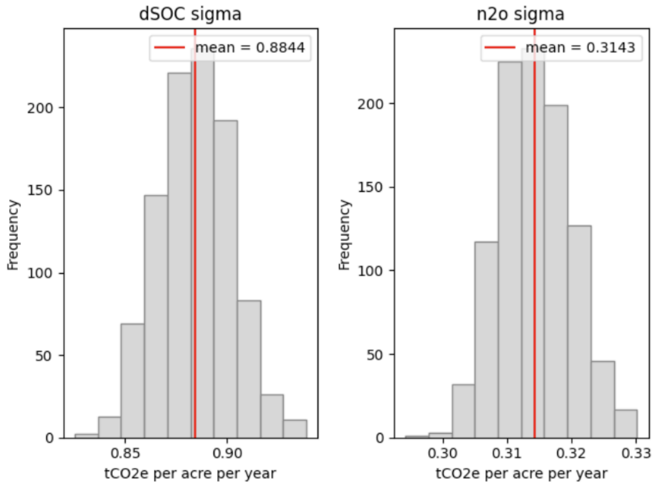

Figure 11 : Posterior distributions of the sigma parameter of the uncertainty model by emission type based on the validation set.

(Source : Regrow, 2024)

5.1.4.1 Model prediction error

Model prediction error is defined as the standard error of the posterior predictive distribution based on the uncertainty model described in the previous section. The posterior predictive distribution is the distribution of differences in emissions for a given Emissions Source (here SOC and N_20) over time and between paired treatments (baseline and practice) at a new modelling unit not in the validation data conditional on the uncertainty model. To demonstrate the coverage probability of the 90% prediction intervals derived from these distributions, 90% prediction intervals will be generated based on an approximate leave-one out (LOO) cross-validation procedure (Vehtari et al., 2017) for the modelled values in the validation dataset. From this, 1000 samples will then be obtained from this distribution using Monte Carlo (MC) integration. The number of corresponding measured validation values that fall within the 90% prediction intervals will then be reported for each emission source, practice category, and crop functional group combination.

5.1.5 Net emission reductions and removals (ERR)

To calculate the overall project emission reductions or removals each year, the following equation is applied:

Equation 1:

$$\mathbf{ERR_{sc(t)} = (ERR\_BS1_{sc(t)} + ERR\_BS2_{sc(t)}) \times (1 - LE_t)}$$

Where:

$ERR_{sc(t)}$ = Estimated net GHG emission reductions and removals for the project in year t [t CO_2e]

$ERR\_BS1_{sc(t)}$ = Estimated net GHG emission reductions and removals calculated using baseline scenario 1 for the project in year t [t CO_2e]

$ERR\_BS2_{sc(t)}$ = Estimated net GHG emission reductions and removals calculated using baseline scenario 2 for the project in year t [t CO_2e]

$LE_{d,t}$ = Leakage deduction in year t, considered as 0 [ratio]

5.1.5.1 Net GHG emission reductions and removals calculated using baseline scenario 1

To calculate the overall Project soil-based emission reductions and removals each year for all farms in BS1, the following equations are applied:

Equation 2 :

$$\Delta N_2O_{soil,t} = \Sigma (N_2O_{soilbsl,i,t} - N_2O_{soilp,i,t}) \times A_i$$

where:

$\Delta N_20_{soil,t}$ = Total nitrous oxide emission reductions from nitrification/denitrification in year t for all farms in BS1 (t CO_2e)

$N_2O_{soilbsl,i,t}$ = Mean nitrous oxide emissions from nitrogen inputs to soils in the baseline scenario for sample unit i in year t, at field level (t CO_2e/ha)

$N_2O_{soilp,i,t}$ = Mean nitrous oxide emissions from nitrogen inputs to soils in the Project scenario for sample unit i in year t, at field level (t CO_2e/ha)

A_i = Total area in the Project in year t for all farms in BS1 (ha)

Equation 3 :

$$E_{soilred,t} = \Delta N_20_{soil,t} \times (1 - UNC_{t, \Delta N2O\_soil})$$

where:

$E_{soilred,t}$ = Estimated net GHG soil-based emissions reductions in year t for all farms in BS1 (t CO_2e)

$\Delta N_20_{soil,t}$ = Total nitrous oxide emission reductions from nitrification/denitrification in year t for all farms in BS1 (t CO_2e)

$UNC_{t,\Delta N2O\_soil}$ = Uncertainty deduction in year t for all farms in BS1 from nitrous oxide emission reductions from nitrification/denitrification (fraction between 0 and 1)

Equation 4 :

$$\Delta CO_{2soil,t} = \Sigma (((SOC_{p,i,t} - SOC_{p,i,t-1}) - (SOC_{bsl,i,t} - SOC_{bsl,i,t-1})) \times 44/12) \times A_i$$

where:

$\Delta CO_{2soil,t}$ = Total carbon dioxide emission removals from increasing the SOC pool in year t for all farms in BS1 (t CO_2e)

$SOC_{p,i,t}$ = Mean carbon stocks in the SOC pool in the Project scenario for sample unit i at the end of year t, at field level (t CO_2e/ha)

$SOC_{p,i,t-1}$ = Mean carbon stocks in the SOC pool in the Project scenario for sample unit i at the end of year t – 1, at field level (t CO_2e/ha)

$SOC_{bsl,i,t}$ = Mean carbon stocks in the SOC pool in the baseline scenario for sample unit i at the end of year t, at field level (t CO_2e/ha)

$SOC_{bsl,i,t-1}$ = Mean carbon stocks in the SOC pool in the baseline scenario for sample unit i at the end of year t – 1, at field level (t CO_2e/ha)

A_i = Total area in the Project in year t for all farms in BS1 (ha)

Equation 5 :

$$E_{rem,t} = \Delta CO_{2soil,t} \times (1 - UNC_{t,\Delta CO2})$$

where:

$E_{rem,t}$ = Estimated net GHG removals in year t for all farms in BS1 (t CO_2e)

$\Delta CO_{2soil,t}$ = Total carbon dioxide emission removals from increasing the SOC pool in year t for all farms in BS1 (t CO_2e)

$UNC_{t,\Delta CO2}$ = Uncertainty deduction in year t for all farms in BS1 associated with modelling SOC stock changes (fraction between 0 and 1)

Equation 6 :

$$ERR_{soil,t} = E_{soilred,t} + E_{rem,t}$$

where:

$ERR_{soil,t}$ = Estimated net soil-based GHG emissions reductions and removals in year t for all farms in BS1 (t CO_2e)

To calculate the overall non soil-based emission reductions each year for all farms in BS1, the following equations are applied:

Equation 7 :

$$ER_{nonsoil,t} = ER\_BS1_{nonsoil,t} \times (1 - UNC_t)$$

Where:

$ER_{nonsoil,t}$ = Estimated net non soil-based GHG emission reductions for the Project in year t for all farms in BS1 [t CO_2e]

$ER\_BS1_{nonsoil,t}$ = Estimated net non soil-based GHG emission reductions for the Project in year t for all farms in BS1 [t CO_2e]

UNC_t = Uncertainty deduction in year t, considered as 0

Equation 8 :

$$ER\_BS1_{nonsoil,t} = \sum ER_{nonsoil,BS1}$$

Where:

$ER\_BS1_{nonsoil,t}$ = Estimated net non soil-based GHG emission reductions for the Project in year t for all farms in BS1 [t CO_2e]

$ER_{nonsoil,BS1}$ = Estimated net non soil-based GHG emission reductions for an individual farm using BS1 in year t [t CO_2e]

Equation 9 :

$$ER_{nonsoil,BS1} = (BE_{nonsoil,t} - PE_{nonsoil,t})/1000$$

Where:

$ER_{nonsoil,BS1}$ = Estimated net non soil-based GHG emission reductions for an individual farm using BS1 in year t [t CO_2e]

$BE_{nonsoil}$ = Baseline non soil-based GHG emissions for an individual farm using BS1 in year t calculated with CFT equation number 2.3.1 + 2.4.1 + 2.6.1a + 2.6.1b presented in Annex VI [kg CO_2e]

$PE_{nonsoil,t}$ = Project non soil-based GHG emissions for an individual farm using BS1 in year t calculated with CFT equation number 2.3.1 + 2.4.1 + 2.6.1a + 2.6.1b presented in Annex VI [kg CO_2e]

Unless $PE_{nonsoil,t}$ is greater than $BE_{nonsoil}$, in which case the farmer has not generated any improvement over the baseline, this calculation is always performed to identify the absolute difference between $BE_{nonsoil}$ and $PE_{nonsoil,t}$, including when the latter is a negative integer.

To calculate the overall emission reductions and removals each year for farms in BS1, the following equation is applied:

Equation 10 :

$$ERR\_BS1sc_{(t)} = (ERR_{soil,t} + ER_{nonsoil,t})$$

Where:

$ERR\_BS1sc_{(t)}$ = Estimated net GHG emissions reductions and removals in year t for farms using BS1 [t CO_2e]

5.1.5.2 Net GHG emission reductions and removals calculated using baseline scenario 2

To calculate the farm level Project soil-based emission and removals each year, the following equations are applied:

Equation 11 :

$$E_{farm,soil,t} = \Sigma\ (N_20_{soil,i,t} \times (1 - UNC_{t,\ N2O,soil,i})) \times A_{farm,i}$$

where:

$E_{farm,soil,t}$ = Estimated net GHG soil-based emissions in Project year t at individual farm level using BS2 [t CO_2e]

$N_20_{soil,i,t}$ = Total nitrous oxide emission from nitrification/denitrification in Project year t for sample unit i, at field level [t CO_2e/ha]

$UNC_{t,N2O,soil,i}$ = Uncertainty deduction in Project year t from nitrous oxide emissions from nitrification/denitrification for sample unit i, at field level (fraction between 0 and 1)

$A_{farm,i}$ = Total individual farm area using BS2 in the Project in year t (ha)

Equation 12 :

$$E_{farm,rem,t} = \Sigma\ (((SOC_{p,i,t} - SOC_{p,i,t-1}) \times 44/12) \times (1 - UNC_{t,SOC,i}) \times A_{farm,i}$$

where:

$E_{farm,rem,t}$ = Estimated net GHG removals in Project year t at individual farm level using BS2 [t CO_2e]

$SOC_{p,i,t}$ = Mean carbon stocks in the SOC pool for sample unit i at the end of Project year t, at field level [t CO_2e/ha]

$SOC_{p,i,t-1}$ = Mean carbon stocks in the SOC pool for sample unit i at the end of year t – 1, at field level [t CO_2e/ha]

$UNC_{t,SOC,i}$ = Uncertainty deduction in Project year t associated with modelling SOC stock changes for sampling unit i, at field level (fraction between 0 and 1)

$A_{farm,i}$ = Total individual farm area using BS2 in the Project year t (ha)

Equation 13 :

$$\mathbf{ERR_{farm,soil,t} = E_{farm,soil,t} + E_{farm,rem,t}}$$

where:

$ERR_{farm,soil,t}$ = Estimated net soil related GHG emissions and removals in Project year t at individual farm level using BS2 [t CO_2e]

To calculate the common practice baseline soil-based emission and removals each year, the following equations are applied:

Equation 14 :

$$\mathbf{E_{cpbaseline,soil,i,t} = N_20_{cpbaseline,soil,i,t} \times (1 - UNC_{t,\ N2O\_cpbaseline,soil,i})}$$

where:

$E_{cpbaseline,soil,t}$ = Estimated net GHG soil-based emissions in Project year t for the common practice baseline for sample unit i, at field level [t CO_2e/ha]

$N_20_{cpbaseline,soil,t}$ = Total nitrous oxide emission from nitrification/denitrification in Project year t for the common practice baseline for sampling unit i, at field level [t CO_2e/ha]

$UNC_{t,N2O\_cpbaseline,soil,i}$ = Uncertainty deduction in Project year t from nitrous oxide emission from nitrification/denitrification for common practice baseline for sampling unit i, at field level (fraction between 0 and 1)

Equation 15 :

$$\mathbf{E_{cpbaseline,rem,i,t} = ((SOC_{cpbaseline,i,t} - SOC_{cpbaseline,i,t-1}) \times 44/12) \times (1 - UNC_{t,SOC,cpbaseline,i})}$$

where:

$E_{cpbaseline,rem,t}$ = Estimated net GHG removals in Project year t for the common practice baseline for sample unit I, at field level [t CO_2e/ha]

$SOC_{cpbaseline,i,t}$ = Mean carbon stocks in the SOC pool for the common practice baseline scenario for sample unit i at the end of Project year t, at field level [t CO_2e/ha]

$SOC_{cpbaseline,i,t-1}$ = Mean carbon stocks in the SOC pool for the common practice baseline scenario for sample unit i at the end of year t – 1, at field level [t CO_2e/ha]

$UNC_{t,SOC,cpbaseline,i}$ = Uncertainty deduction in Project year t associated with modelling SOC stock changes for the common practice baseline scenario for sample unit i, at field level (fraction between 0 and 1)

Equation 16 :

$$\mathbf{ERR_{cpbaseline,soil,i,t} = E_{cpbaseline,soil,i,t} + E_{cpbaseline,rem,i,t}}$$

where:

$ERR_{cpbaseline,soil,i,t}$ = Estimated net soil related GHG emissions and removals in Project year t for the common practice baseline for sampling unit i, at field level [t CO_2e/ha]

To calculate the Project soil-based emission reductions and removals each year at individual farm level for baseline scenario 2, the following equation is applied:

Equation 17 :

$$\mathbf{ERR\_BS2_{soil,t} = (ERR_{cpbaseline,soil,i,t} \times A_{farm,i}) - ERR_{farm,soil,t}}$$

where:

$ERR\_BS2_{soil,t}$ = Estimated net soil-based GHG emissions reductions and removals in Project year t at individual farm level for baseline scenario 2 [t CO_2e]

To calculate the overall Project soil-based emissions reductions and removals each year for farms using BS2, the following equation is applied :

Equation 18 :

$$\mathbf{ERR_{soil,t} = \sum ERR\_BS2_{soil,t}}$$

To calculate the overall Project non soil-based emission reductions each year for farms using BS2, the following equations are applied:

Equation 19 :

$$\mathbf{ER_{nonsoil,t} = ER\_BS2_{nonsoil,t} \times (1 - UNC_t)}$$

Where:

$ER_{nonsoil,t}$ = Estimated net non soil-based GHG emission reductions for the Project year t for all farms using BS2 [t CO_2e]

$ER\_BS2_{nonsoil,t}$ = Estimated net non soil-based GHG emission reductions for the Project t for all farms using BS2 [t CO_2e]

Equation 20 :

$$\mathbf{ER\_BS2_{nonsoil,t} = \sum ER_{nonsoil,BS2}}$$

Where:

$ER\_BS2_{nonsoil,t}$ = Estimated net non soil-based GHG emission reductions for the Project year t for all farms using BS2 [t CO_2e]

$ER_{nonsoil,BS2}$ = Estimated net non soil-based GHG emission reductions for an individual farm using BS2 in Project year t [t CO_2e]

Equation 21 :

$$\mathbf{ER_{nonsoil,BS2} = (BE_{nonsoil,t} - PE_{nonsoil,t})/1000}$$

Where:

$ER_{nonsoil,BS2}$ = Estimated net non soil-based GHG emission reductions for an individual farm using BS2 in Project year t [t CO_2e]

$BE_{nonsoil,t}$ = Common practice baseline non soil-based GHG emissions in Project year t calculated with CFT equation number 2.3.1 + 2.4.1 + 2.6.1a + 2.6.1b presented in Annex VI [kg CO_2e]

$PE_{nonsoil,t}$ = Project non soil-based GHG emissions for an individual farm in Project year t calculated with CFT equation number 2.3.1 + 2.4.1 + 2.6.1a + 2.6.1b presented in Annex VI [kg CO_2e]

Unless $PE_{nonsoil,t}$ is greater than $BE_{nonsoil}$, in which case the farmer has not generated any improvement over the baseline, this calculation is always performed to identify the absolute difference between $BE_{nonsoil}$ and $PE_{nonsoil,t}$, including when the latter is a negative integer.

To calculate the overall Project net emission reductions and removals each year, the following equation is applied :

Equation 22 :

$$\mathbf{ERR\_BS2_{sc(t)} = (ERR_{soil,t} + ER_{nonsoil,t})}$$

Where:

ERR_BS2sc(t) = Estimated net GHG emissions reductions and removals in Project year t for all farms using BS2 (t CO2e)

5.2 Calculation of the GHG emission reductions and removals

5.2.1 Justification of quantification procedure

In the mySoilCapital tool, farmers collect data and enter the raw data per farm using the tool. This is done with the help of information boxes in the tool, the support of trained agronomists, and a built-in system that alerts agronomists if the data farmers entered deviates from the normally reported ranges or if those data deviate widely from previous years encodings (i.e. pace of transition seems too fast). This data is then processed in a Soil Capital database and automatically inputted into the CFT and DNDC. Based on the data inserted in the models, they generate results which are stored back in the Soil Capital database and made available in an Excel spreadsheet. The results generated from both models are verified and converted into VERRs. More detailed information regarding this process can be found in Section 6.1.

5.2.2 Forecast of the emissions reductions and removals

Clearly, assumptions had to be made to generate the forecast detailed in Table 2 in section 2.9.

First, as described in section 3, the typical farmer profile today is that of a conventional farmer at the beginning of the project, and their practices result in net emissions of GHGs. This means that most of the farmers will have to improve their practices to generate VERRs, i.e. transitioning from conventional practices towards regenerative agriculture practices.

Second, based on Soil Capital's prior market experience accumulated during the first three years of our Climate change mitigation Project for arable farming: Cohort 1 to 3, the annual rate of decrease of a farm GHG balance is around 0.5 tCO2e/ha on average.

With these elements, it is possible to produce a high-level forecast for the emission reductions and removals of a group of farmers who are dedicated to transitioning their practices, using 0.5 VERR per hectare per year as a starting point.

Table 2: Total GHG emission reductions and removals likely from the Project

	2024 vintage	2025 vintage	2026 vintage	2027 vintage	2028 vintage	Total
Total emission reductions and removals (tCO_2e)	60,000	120,000	180,000	240,000	300,000	900,000
Buffer contribution @ 20% (tCO_2e)	6,000	12,000	18,000	24,000	30,000	90,000

(Source: Soil Capital 2024)

6 Monitoring the data information management system and data controls

6.1 The monitoring, reporting and verification (MRV) process

In this Project, monitoring emission reduction results ex-post is conducted on an annual basis before each verification and issuance of VERRs. To calculate the net emission reductions achieved, the relevant baseline for each individual farmer is compared to their ex-post monitoring results.

Individual farmer reporting has been used successfully in other Projects as the basis for monitoring results. Usually, a regular census is undertaken to collect the necessary data during the Project before each verification can take place. Each farmer is responsible for keeping records about the operations undertaken on their own fields and, ahead of each annual verification, a full census is taken of all farms participating in the Project. This type of monitoring is suitable for a Project such as this one, as each farmer is rewarded for their individual practice changes. Additionally, since this Project is located in EU countries as well as the UK, it benefits from being able to draw on-farm data (e.g. precise areas and locations of fields within a farm boundary) that farmers must submit to public authorities to receive subsidies under the CAP or equivalent UK regulations, which is already subject to a stringent, regulatory audit process.

Each participating farmer accepts terms and conditions when they join the Project, which commit them to provide operational data for the preceding season into mySoilCapital once every year with the support of a trained agronomist. All farmers enrolled in the Project must use mySoilCapital, as it is a dedicated farm assessment tool that is crucial for the analysis of the farmers' net GHG balances. The data from the mySoilCapital tool is then transferred into DNDC version 12.1.0 and the CFT version 1.0 via bespoke application programming interfaces (APIs), where the emission reductions and removals are calculated. The more detailed steps of this process will be addressed in the section below.

Each farmer must collect raw data necessary in the first year to establish the baseline (3 last growing seasons), and each following year for the monitoring of the Project. The specific data and parameters monitored at each verification can be found in Tables 13 to 18 of the PDD. More broadly, farmers must collect and retain data relating to:

- The farm area under cropland and crops in the rotation as and when reported under the CAP;
- Any farm management software or manual records used to keep track of the crop management (e.g. tillage, cover cropping, fertiliser use, etc.) of each field ;
- Purchased inputs (fertilisers, pesticides, etc.) and purchased operations (i.e., those conducted by third-party contractors);
- Fuel and energy use for the farm;
- Inventory reporting of pesticide purchased but not used and stored;
- Official accounting details for the farm;
- The number of livestock animals at the farm.

Once the data is collected for the last three growing seasons preceding the start of the Project (baseline year) or the last growing season (Project year), the farmers must enter this data into the mySoilCapital tool.

A monitoring period covers a period of time that encompasses the full growing to harvesting cycle of an individual cash crop, including any cover crops that precede it. Following typical farming operations these cycles occur between the beginning of September until the end of August of the following year. Operational cycle periods exceeding these 12 months monitoring periods, if any, will be considered ex-post as being fully part of these monitoring periods.

Encoding data in mySoilCapital

In mySoilCapital, farmers collect data and enter the raw data per field using the mySoilCapital tool version 3. In this tool, farmers are entering data at the field level and benefit from a publicly available map-based information source created by third parties to support them. Soil Capital sources data from third parties on a number of soil characteristics (i.e. SoilGrids for clay content and bulk density) and on weather conditions (NASA). Farmers select the relevant field using the maps and enter the data pertinent to that field only.
For instance, this creates a data entry per farmer per season and per field, and appears as follows Farmer ID, Farmer season ID, Farmer season field ID, and would appear as the following:

$$3585\ (farmer\ ID)\ -\ 4573\ (farmer\ season\ ID)\ -\ 156965\ (farmer\ season\ field\ ID)$$

Farmers insert the raw data into the tool with the help of information boxes in the tool, through the support of trained agronomists for more sensitive data, and a built-in system that alerts agronomists if the data farmers entered deviates from the normally reported ranges or if those data deviate widely from previous years encodings (i.e. pace of transition seems too fast). Soil Capital agronomists oversee the farmers' reporting by validating the encoded data in mySoilCapital for each farmer based on each report generated using their knowledge and expertise. This can be considered a plausibility check. In addition, if farmers are uncertain about how to encode data or which category to use, they can ask for the support of the agronomist at any time. DNDC requires information regarding the crop planted (e.g. crop type, date of seeding and harvest), the crop residue management, the tillage operations (dates, depth and type), fertiliser inputs (type, amount and dates of application), soil characteristics (e.g. SOC, pH, bulk density, etc.) and weather conditions (e.g. daily precipitations, temperatures, etc.). The CFT requires information on crop protection inputs, direct energy use, the field operation energy use, wastewater emissions, processing, storage, irrigation and transport.[81] Based on the data inserted in DNDC and the CFT, the models generate results which are stored back in the Soil Capital database and made available in an Excel spreadsheet, as for version 1, called 'FarmerResultsExport'. The results provide information on the GHG emissions balance per crop per field and therefore per farm. Once verified, the data is converted into VERRs. Soil Capital uses this information to determine how many certificates farmers generate from the farming management practices implemented.

6.1.1 Data and parameters available at validation

Data related to crops

Table 13 : Data and parameters available at validation for non soil-based emissions

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
A	ha	Project area	Farmer reporting	Start of Project

[81] For the Soil Capital Project, the information regarding co-products, wastewater emissions, processing and storage was excluded from the CFT.

Fertiliser production	kg CO_2e	Emissions from mineral fertiliser production		
R_i	kg ha^{-1}	Application rate of fertiliser type I	Farmer reporting	Start of Project
$EF_{fert}(i)$	kg CO_2e kg^{-1}	Emissions factor of fertiliser type I	Appendix A1 in the Cool Farm Tool Technical Documentation (2020); for default values see Annex VIII	Start of Project

Pesticide emissions	kg CO_2e	Emissions related to the different kinds of pesticides used		
$N_{app.\ pest.}$	#	Number of pesticide applications for post-emergence and seed treatment	Farmer reporting	Start of Project
$EF_{app.\ pest.}$	kg CO_2e app^{-1}	Emissions factor for individual application (for post-emergence and seed treatment)	Cool Farm Tool Technical Documentation (2020); default = 20.5	Start of Project
$R_{app.}$	kg ha^{-1}	Application rate	Farmer reporting	Start of Project
AI_{frac}	Dimensionless	Fraction of active ingredient	Farmer reporting	Start of Project
EF_{pest}	kg CO_2e kg^{-1}	Emissions factor for individual application	Cool Farm Tool Technical Documentation (2020), default = 41	Start of Project
Direct energy use	**kg CO_2e**	**Provide figures for direct energy use**		
C_{fuel}	Litre (l)	Consumption of fuel	Farmer reporting of equipment used, fuel usage derived from industry look-up table	Start of Project

EF_{fuel}	kg CO_2e l^{-1}	Emission factor of fuel	Table 2.12 in the Cool Farm Tool Technical Documentation (2020); for default values see Annex VII	Start of Project
Irrigation energy use	kg CO_2e	Estimate petrol and diesel use irrigation		
D_{irri}	mm	Irrigation depth	Farmer reporting	Start of Project
A_{irri}	ha	Area under irrigation	Farmer reporting	Start of Project
$ER_{irri.\ meth.}$	kWh mm^{-1} ha^{-1}	Energy used based on irrigation method and fuel type	Table 2.14 of the Cool Farm Tool Technical Documentation (2020); for default values see Annex VIII	Start of Project
$dist_h$	Metre (m)	Horizontal distance to water source	Farmer reporting	Start of Project
ER_{htrans}	kWh mm^{-1} ha^{-1} km^{-1}	Energy used for horizontal transport	Cool Farm Tool Technical Documentation (2020); default = 0.95	Start of Project
$dist_v$	m	Vertical transport defined by borehole depth	Farmer reporting	Start of Project
ER_{vtrans}	kWh mm^{-1} ha^{-1} m^{-1}	Energy used for vertical transport	Cool Farm Tool Technical Documentation (2020); default = 0.095	Start of Project

(Source: Soil Capital, 2021)

Table 14 : Data and parameters available at validation for soil-based emissions

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
A	ha	Project area	Farmer reporting	Start of Project
Soil fertiliser, N-fixing crops and residue induced emissions	tCO_2e	Emissions from soils including from the application of N-fertilisers, use of N-fixing crops and limestone and residue management		
R_i	kg or L ha^{-1}	Application rate of fertiliser	Farmer reporting	Start of Project
Date of application		Date of application for	Farmer reporting	Start of Project
Presence of urease/nitrification inhibitor		For each synthetic fertiliser application, use of inhibitors needs to be specified	Farmer reporting	Start of Project
Application method		For each organic fertiliser, method of application needs to be specified (spread vs buried)	Farmer reporting	Start of Project
Crop yield	t ha^{-1}	Harvested yield of the main crop grown on each field	Farmer reporting	Start of Project
Residues exported	t ha^{-1}	Amount of crop residues that have been exported from the field	Farmer reporting	Start of Project
Date of crop/cover crop seeding		Date of crop/cover crop seeding	Farmer reporting	Start of Project

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
Date of crop harvest/cover crop destruction		Date of crop harvest/cover crop destruction	Farmer reporting	Start of Project
Carbon dioxide emissions from liming	tCO_2e	Carbon dioxide emissions from the application of calcitic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$)		
MLimestone,bsl	t ha^{-1}	Amount of calcitic limestone ($CaCO_3$) applied to sample unit i in year t	Farmer reporting	Start of Project
EFLimestone =	t C per t of limestone	Emission factor for calcitic limestone	Default value = 0.12	Start of Project
MDolomite,bsl,i,t	t ha^{-1}	Amount of calcitic dolomite ($CaMg(CO_3)_2$) applied to sample unit i in year t	Farmer reporting	Start of Project
EFDolomite	t C per t of dolomite	Emission factor for calcitic dolomite	Default value = 0.13	Start of Project
C:CO_2 molar mass ratio	/	Molar mass ratio of CO_2 to C applied to convert CO_2-C emissions to CO_2 emissions	Default value = 44/12	Start of Project
Carbon stock changes (SOC)	tCO_2e	Changes in carbon stocks		
Crop yield	t ha^{-1}	Harvested yield of the main crop grown on each field	Farmer reporting	Start of Project

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
Residues exported	t ha^{-1}	Amount of crop residues that have been exported from the field	Farmer reporting	Start of Project
Date of crop/cover crop seeding		Date of crop/cover crop seeding	Farmer reporting	Start of Project
Date of crop harvest/cover crop destruction		Date of crop harvest/cover crop destruction	Farmer reporting	Start of Project
Method of destruction		Method of destruction	Farmer reporting	Start of Project
Number of species		Number of species	Farmer reporting	Start of Project
Presence of leguminous in the mix		Presence of leguminous in the mix	Farmer reporting	Start of Project
Date of tillage operation		Date of tillage operation	Farmer reporting	Start of Project
Machinery used		Machinery used	Farmer reporting	Start of Project
Depth of tillage	cm	Depth of tillage	Farmer reporting	Start of Project
$R_{org,i}$	kg or L ha^{-1}	Application rate of organic fertiliser	Farmer reporting	Start of Project
Date of application		Date of application for	Farmer reporting	Start of Project
Application method		For each organic fertiliser, method of application needs to be specified (spread vs buried)	Farmer reporting	Start of Project

Data related to livestock

Table 15 : Data related to livestock

Parameter	Data unit	Description	Source/origin	Monitoring frequency
CH_4 emissions from enteric fermentation	kg CO_2e	Methane is produced in herbivores as a by-product of enteric fermentation		
$EF_{(T)}$	kg CH_4 head^{-1} year^{-1}	Emission factor for the defined livestock population	Table 10.11, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 117 for dairy, 57 for other cattle	Start of Project
$N_{(T)}$	#	The number of head of livestock species/category	Farmer reporting	Start of Project
T	Cattle beef, cattle dairy, pigs, sheep, poultry, etc.	Species/category of livestock	Farmer reporting	Start of Project
GWP_{CH4}	kg CO_2e (kg CH_4)$^{-1}$	Global warming potential of CH_4	IPCC Fourth Assessment Report, 2007; default = 25	Start of Project
CH_4 emissions from manure management	kg CO_2e	Methane produced during the storage and treatment of manure, and from manure deposited on pasture		
$EF_{(T)}$	kg CH_4 head^{-1} year^{-1}	Emission factor for the defined livestock population	Table 10.14, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 51 for dairy, 15 for other cattle, 12 for pigs, 0.28 for sheep, 1.4 for poultry, 2.34 for horses, 0.08 for rabbits	Start of Project
Direct N_2O emissions from manure management		N_2O produced, directly, during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel or construction purposes		

Parameter	Data unit	Description	Source/origin	Monitoring frequency
S	Dimensionless	Manure management system	Regional common practice from Tables 10.14 and 10.15, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = liquid/slurry and pit storage systems	Start of Project
$MS_{(T,S)}$	Dimensionless	Fraction of total annual N excretion for each livestock species/category T that is managed in manure management system S	Regional common practice from Tables 10.14 and 10.15, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories	Start of Project
$EF_{3(s)}$	kg N_2O-N/kg N	Emission factor for direct N_2O emission from manure management system S	Table 10.21 Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 0.005 for dairy, 0.005 for other cattle, 0.07 for pigs, 0 for sheep, 0.001 for poultry, 0 for horses, 0.005 for rabbits	Start of Project

Parameter	Data unit	Description	Source/origin	Monitoring frequency
$N_{rate(T)}$	kg N (1000 kg animal mass)$^{-1}$ day^{-1}	Default N excretion rate for livestock species/category T	Table 10.19 Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 0.48 for dairy, 0.33 for other cattle, 0.51 for pigs, 0.85 for sheep, 1.1 for poultry, 0.26 for horses, 8.1 for rabbits	Start of Project
$TAM_{(T)}$	kg animal^{-1}	Typical animal mass for livestock category T	Tables 10 A-5, A-1, A-7 and A-9 Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 600 for dairy, 420 for other cattle, 50 for pigs, 48.5 for sheep, 1.8 for poultry, 377 for horses, 1.6 for rabbits	Start of Project
Indirect N_2O emissions from manure management		N_2O produced, indirectly, during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes		
EF_4	kg N_2O-N	Emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces	Table 11.3, Chapter 11, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 0.01 kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$	Start of Project

Parameter	Data unit	Description	Source/origin	Monitoring frequency
$Frac_{GasMS}$	%	Percent of managed manure nitrogen for livestock category T that volatilises as NH_3 and NO_x in the manure management system S	Table 10.22, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 0.3 for dairy, 0.45 for other cattle, 0.4 for pigs, 0.12 for sheep, 0.4 for poultry, 0.12 for horses, 0.12 for rabbits	Start of Project
$N_{rate(T)}$	kg N (1000 kg animal mass)$^{-1}$ day^{-1}	Annual average N excretion per head of species/category T	Table 10.19 Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 0.48 for dairy, 0.33 for other cattle, 0.51 for pigs, 0.85 for sheep, 1.1 for poultry, 0.26 for horses, 8.1 for rabbits	Start of Project
$TAM_{(T)}$	kg animal^{-1}	Typical animal mass for livestock category T	Tables 10 A-5, A-1, A-7 and A-9 Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories; default = 600 for dairy, 420 for other cattle, 50 for pigs, 48.5 for sheep, 1.8 for poultry, 377 for horses, 1.6 for rabbits	Start of Project

(Source: Soil Capital, 20

6.1.2 Data and parameters monitored

Data related to crops

Table 16 : Data and parameters monitored related to crops for non soil-based emissions

Parameter	Data unit	Description	Source/origin	Monitoring frequency	Verification mechanism & uncertainty rating (UR)[82]
A	ha	Project area	Farmer reporting	Annually	Cross-reference with farm data records, including official CAP reporting UR: low
Fertiliser production	kg CO_2e	Emissions from mineral fertiliser production			
R_i	kg or L ha^{-1}	Application rate of fertiliser type I	Farmer reporting	Annually	Cross-reference with farm data records UR: low
Pesticide emissions	kg CO_2e	Emissions related to the different kinds of pesticides used			
$N_{app. pest.}$	#	Number of pesticide applications for post-emergence and seed treatment	Farmer reporting	Annually	Cross-reference with farm data records UR: low
$R_{app.}$	kg ha^{-1}	Application rate	Farmer reporting	Annually	Cross-reference with farm data records, including pesticide inventory reporting UR: low
Direct energy use	kg CO_2e	Provide figures for direct energy use			

[82] Low = most likely will not allow for input data uncertainty post-verification; medium = possible to allow for input data uncertainty post-verification; high = likely to allow for input data uncertainty post-verification.

$C_{fuel\ \&\ energy}$	l or megajoule (MJ)	Consumption of fuel or energy i	Farmer reporting of equipment used, fuel usage derived from industry look-up table	Annually	Cross-reference with farm data records UR: low
Field operations and irrigation energy use	kg CO_2e	Estimate petrol and diesel use for common agricultural machinery from tillage, spraying, spreading, harvesting and irrigation			
N	#	Number of operations of machinery	Farmer reporting	Annually	Cross-reference with farm data records UR: low
D_{irri}	mm	Irrigation depth	Farmer reporting	Annually	Cross-reference with farm data records UR: low
A_{irri}	ha	Area under irrigation	Farmer reporting	Annually	Cross-reference with farm data records UR: low
$dist_h$	m	Horizontal distance to water source	Farmer reporting	Annually	Cross-reference with farm data records UR: low
$dist_v$	m	Vertical transport defined by borehole depth	Farmer reporting	Annually	Cross-reference with farm data records UR: low
Carbon stock changes	kg CO_2e	Changes in carbon stocks			

$T_{y=0}$	# ha^{-1}	Number of trees at year of assessment	Farmer reporting; remote sensing for verification	Annually	Cross-reference with farm data records and remote sensing UR: low
T_{y-1}	# ha^{-1}	Number of trees in year prior to year of assessment	Farmer reporting; remote sensing for verification	Annually	Cross-reference with farm data records and remote sensing UR: low
$DBH_{y=0}$	cm	Trunk diameter at breast height at year of assessment	Farmer reporting	Annually	Verifiable via a site visit UR: low
DBH_{y-1}	cm	Trunk diameter at breast height in year prior to year of assessment	Farmer reporting	Annually	Verifiable via a site visit UR: low

(Source: Soil Capital, 2021)

Table 17 : Data and parameters monitored related to crops for soil-based emissions

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
A	ha	Project area	Farmer reporting	Start of Project
Soil fertiliser, N-fixing crops and residue induced emissions	tCO_2e/ha	Emissions from soils including from the application of N-fertilisers, use of N-fixing crops and limestoneand residue management		
R_i	kg or L ha^{-1}	Application rate of fertiliser	Farmer reporting	Start of Project
Date of application		Date of application	Farmer reporting	Start of Project
Presence of urease/nitrification inhibitor		For each synthetic fertiliser application, use of inhibitors needs to be specified	Farmer reporting	Start of Project

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
Application method		For each organic fertiliser, method of application needs to be specified (spread vs buried)	Farmer reporting	Start of Project
Residues exported	t ha^{-1}	Amount of crop residues that have been exported from the field	Farmer reporting	Start of Project
Date of crop/cover crop seeding		Date of crop/cover crop seeding	Farmer reporting	Start of Project
Date of crop harvest/cover crop destruction		Date of crop harvest/cover crop destruction	Farmer reporting	Start of Project
Carbon dioxide emissions from liming	tCO2e/ha	Carbon dioxide emissions from the application of calcitic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$)		
MLimestone,proj	t ha^{-1}	Amount of calcitic limestone ($CaCO_3$) applied to sample unit i in year t		Start of Project
EFLimestone =	t C per t of limestone	Emission factor for calcitic limestone	Default value = 0.12	Start of Project
MDolomite,projl, i,t	t ha^{-1}	Amount of calcitic dolomite ($CaMg(CO_3)_2$) applied to sample unit i in year t		Start of Project
EFDolomite	t C per t of dolomite	Emission factor for calcitic dolomite	Default value = 0.13	Start of Project

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
C:CO_2 molar mass ratio	/	Molar mass ratio of CO_2 to C applied to convert CO_2-C emissions to CO_2 emissions	Default value = 44/12	Start of Project
Carbon stock changes (SOC)	tCO_2e	Changes in carbon stocks		
Crop yield	t ha^{-1}	Harvested yield of the main crop grown on each field	Farmer reporting	Start of Project
Residues exported	t ha^{-1}	Amount of crop residues that have been exported from the field	Farmer reporting	Start of Project
Date of crop/cover crop seeding		Date of crop/cover crop seeding	Farmer reporting	Start of Project
Date of crop harvest/cover crop destruction		Date of crop harvest/cover crop destruction	Farmer reporting	Start of Project
Method of destruction		Method of destruction	Farmer reporting	Start of Project
Number of species		Number of species	Farmer reporting	Start of Project
Presence of leguminous in the mix		Presence of leguminous in the mix	Farmer reporting	Start of Project
Date of tillage operation		Date of tillage operation	Farmer reporting	Start of Project
Machinery used		Machinery used	Farmer reporting	Start of Project
Depth of tillage	cm	Depth of tillage	Farmer reporting	Start of Project
$R_{org,i}$	kg or L ha^{-1}	Application rate of organic fertiliser	Farmer reporting	Start of Project
Date of application		Date of application for	Farmer reporting	Start of Project

Parameter	Data unit	Description	Source/origin and default value where relevant	Monitoring frequency
Application method		For each organic fertiliser, method of application needs to be specified (spread vs buried)	Farmer reporting	Start of Project

Data related to livestock

Table 18 : Data and parameters monitored related to livestock

Parameter	Data unit	Description	Source/origin	Monitoring frequency	Verification mechanism & uncertainty rating (UR)
CH_4 emissions from enteric fermentation	kg CO_2e	Methane is produced in herbivores as a by-product of enteric fermentation			
$N_{(T)}$	#	The number of head of livestock species/category	Farmer reporting	Annually	Cross-reference with farm data records, including official CAP reporting UR: low
T	Cattle beef, cattle dairy, pigs, sheep, poultry, etc.	Species/category of livestock	Farmer reporting	Annually	Cross-reference with farm data records, including official CAP reporting UR: low

Parameter	Data unit	Description	Source/origin	Monitoring frequency	Verification mechanism & uncertainty rating (UR)
Direct N_2O emissions from manure management		N_2O produced, directly, during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel or construction purposes			
S	Dimensionless	Manure management system	Regional common practice from Tables 10.14 and 10.15, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories	Annually	Conservative common practice factor used for all anyway UR: low
$MS_{(T,S)}$	Dimensionless	Fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S	Regional common practice from Tables 10.14 and 10.15, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories	Annually	Conservative common practice factor used for all anyway UR: low

6.2 Data quality management procedures and controls

6.2.1 Assessment and management of uncertainty

According to ISO 14064-2, the Project must have quality management procedures in place to manage data and information, including the assessment of uncertainty, relevant to both the baseline and Project scenarios.

Two fundamental types of uncertainty exist that the Project can assess and manage:

- **parametric uncertainty**: driven by the applicability of constants within the CFT (e.g., geography-specific EFs) and Regrow uncertainty model to the modelled scenario;
- **input data uncertainty:** driven by the accuracy of the user's input for representing the true situation on the ground.

6.2.1.1 Parametric uncertainty

With respect to parametric uncertainty, the CFT "incorporates the IPCC Tier 1 and Tier 2 methods for crops" (Cool Farm Alliance, 2020). The CFT also uses a farm's location to derive country-specific EFs for electricity usage on farm. Regarding DNDC, Regrow has developed an empirical uncertainty model that estimates the lack of fit between DNDC model estimates and measured values of differences in a given emissions source (ES) between two paired scenarios from literature data, as described in section 5.1.4.

To manage parametric uncertainty within the Project, four steps are taken:

1) analysis of the farm's soil organic carbon (SOC) is required at two stages in the Project, with guidance provided by the Project to improve the consistency and representativeness of sampling and analysis methodologies. Soil analyses, either at or within five years prior to the Project start, are used to verify the SOC contents applied in the baseline assessment for each farm. SOC analyses using the same guidance at the end of the crediting period are then required so that field-based data can be made available to Regrow to further calibrate and improve the model over time;

2) the CFT and DNDC are the GHG quantification methodologies applied to calculate assessments of farm GHG emissions in both the baseline and the Project scenarios. This ensures that emission reduction calculations are solely based on differences in input data for a given farm, rather than differences in constants applied by the model; bias associated with the application of the methodology is reduced to a practical minimum; and

3) as the CFT is constantly being reviewed and updated by an international team of leading scientists, new versions are released periodically. In line with the VCS, the Project adopts a careful approach to ensure that, if the verification body determines that a new update to the CFT methodology released during the crediting period has resulted in "material changes that affect the integrity of the methodology revision"[83], only the CFT methodology version that was applied to all baseline and Project calculations at that point in the Project life cycle is used for the rest of the crediting period. On Regrow's side, the observational database (CALVIN) and computational code (model source code, processing scripts, uncertainty model code) necessary to fully reproduce the entirety of this work is permanently archived and versioned for posterity. They have demonstrated that such an archiving procedure is the best method to ensure reproducibility of prior simulations. Documenting a list of model parameters that are influenced by (or in some way derivative to) a set of user inputs does not, in itself, ensure reproducibility because there may be various updates to the model base. Regular updates of the model source code are intended to improve skill or performance, to update process-representation (e.g., a new N_2O emission pathway), add simulated events (e.g., fire, erosion), or provide bug fixes. For these reasons, they regularly version and archive to ensure reproducible results and transparency of the model code base. Archived versions associated with Validation Reports or Projects are available upon request.

4) For this Project, Regrow will estimate uncertainty separately for both soil organic carbon (SOC) sequestration and soil direct N_2O emissions. Uncertainty deductions are then calculated individually for each DNDC pool included within the Project boundary and the selected approach to estimate uncertainty is representative of the quantification approach used.

6.2.1.2 Input data uncertainty

For the Project, input data uncertainty relates to the data that is collected from farmers each year and how that data is encoded into the mySoilCapital tool. Rigorous quality management procedures and controls have been established to manage this source of uncertainty.

[83] "Where the programme applies a revision to an approved GHG program methodology and the version of the (underlying) methodology referenced by the methodology revision is no longer current, the validation/verification body shall determine whether material changes have occurred to the underlying methodology that affect the integrity of the methodology revision. Where such material changes have occurred, the programme shall not be approved", VCS Standard v4.0, 2019

To assess random error associated with collecting data from farmers, the Project applies a qualitative assessment system to categorise input data uncertainty for each parameter required for the monitoring report as low, medium or high. Tables 13 to 18 detail, for each parameter, the quality management procedure that is applied for each monitoring report to manage the uncertainty associated with each. The type of quality management procedures implemented are:

1) data records: each participating farmer must retain data records for all inputs (e.g., fertilisers, pesticides, seeds and fuel) and operations that are relevant to a given monitoring report. Reasonable precautions to ensure the safe storage of these records in line with national, legal, and contractual requirements (e.g., insurance contracts) must be taken. These records must be readily available for inspection by the verification body when it is preparing its verification report. Records include:

i) all invoices for purchased inputs and purchased operations (i.e., those conducted by third-party contractors);

ii) data relating to the farm area under cropland and crops in the rotation, as reported under the CAP or equivalent UK regulation;

iii) inventory reporting of pesticides purchased but not used and stored, as required by laws relating to pesticide use, for the season in question;

iv) data from any farm management software used to log operational and input use data for the farm;

v) if relevant, operational and input use data reported to organic certification bodies; and

vi) official accounting details for the farm.

2) uncertainty deduction: if, during any verification event, the verification body deems that a farmer cannot provide any reasonable evidence to satisfactorily account for at least 75% of their inputs by volume (while noting, for instance, that manure is sometimes traded informally), then the farm is not permitted to generate VERRs for that season. This is equivalent to an uncertainty deduction;

3) remote sensing: as quality assurance cannot be conducted for all of the data set against the parameters in Tables 13, 14, 16 and 17 using the above data records, remote sensing techniques are also employed by the Project. The technical approach used is detailed in Section 6.2.2; however, to summarise, farming practices such as land preparation are monitored in a spatially explicit manner through area stratification using remote sensing.

When encoding farmer data into the mySoilCapital tool, the possibility of data entry error arises. For example, incorrect quantities of farming inputs may be encoded unintentionally by putting a decimal point in the wrong place, adding a zero, etc. Several further quality management procedures and controls are implemented to address this risk, including:

4) training of encoders: data that is more sensitive and/or complicated is encoded by farmers into the mySoilCapital tool with the help of agronomists, who are trained by Soil Capital in the correct usage of mySoilCapital and are supported on an ongoing basis;

5) data verification: to manage the risk of data entry errors, Soil Capital has implemented a verification procedure for data entry. This procedure automatically requires additional verification from a trained agronomist in case potential errors are highlighted. To serve that purpose, after the data entry by the farmer, flags are raised in the mySoilCapital app to alert Soil Capital trained agronomists. These flags are built to :

- identify data that are outside a normal expected range, defined using both the expert judgement of trained agronomists as well as mySoilCapital constantly growing dataset. For the latter, it means that for example in the case of organic fertilisers application, the dataset is used to flag abnormally high amount used per product and per field using 'average use' + 3*standard deviation. This means that the system becomes smarter and more accurate to the market reality over time. If the data is outside of the normal expected range, an alert pops up.

- identify data or practice that deviate widely from previous year encodings. The goal of these flags is to alert the agronomists of potential unrealistic transition rates towards regenerative agriculture. For example, a farmer going from 20 % area with cover crops to 80 % in only one year needs to be double checked to make sure it is indeed realistic.

Data validation occurs once all flagged data entries have been verified by the agronomist, i.e. in the case of data being out of range, either changed to fall within the normal expected range or confirmed, to fall outside of this range.

6) API connection to the CFT and DNDC: once data has been encoded into mySoilCapital, there is no further opportunity for human error, as the connection to the CFT and DNDC is made via bespoke APIs that has been thoroughly tested to confirm its reliability.

Finally, when GHG emission calculations are pulled from the CFT and DNDC by the APIs, a further quality management procedure and control is implemented:

7) quality assurance review: a two step review is performed at each verification process.

- Step 1 : Each farm-level assessment is reviewed at this point by at least one member of the Soil Capital team, composed of experienced agronomists and farm managers. An individual farmer's data is only input into the Emission Reduction Calculator and, subsequently, the monitoring report once this quality assurance review has been completed.
- Step 2 : In addition to this internal review, a second QA/QC process is operated by Regrow, DNDC model's provider, at the moment of submission of the whole portfolio of data through the bespoke API. This process aims to ensure that the model's outputs, their associated uncertainty and consequently the VERRs that are generated are based on complete and quality inputs.

Finally, a range of control procedures are in place to safeguard the security of farmer data throughout this process. For example, access to mySoilCapital is restricted by password access and the database is hosted on a secure server (https) protected by Microsoft Azure.

6.2.2 Remote sensing

Remote sensing plays an increasing role in near real-time soil, crop and pest management in precision agriculture (Mulla et al., 2013). The primary purpose of using remote sensing data for precision agriculture is to identify the in-field variability of soil and plant properties and subsequently optimise crop management to maximise crop performance and minimise environmental effect (Ge et al., 2011). In this Project, this service is provided by a third-party, Regrow, and is used throughout the Project as from late 2023 as a quality management procedure and control to improve the certainty of input data provided by farmers regarding land management practices. This capability enables the Project and its verification body to check for any intensification of tillage practice year on year. The table 23 below summarises the use of remote sensing throughout the Project:

Table 19 : Uses of remote sensing in this Project

<table>
<tr><th>Land management practice</th><th>Baseline</th><th>Monitoring during the crediting period</th><th>Monitoring during the retention period</th></tr>
<tr><td>Tillage practices</td><td rowspan="2">Applied to: all farms, sampling one ha per field

Period: upon first verification</td><td rowspan="2">Applied to: all farms, sampling one ha per field;

Period: annual verification of growing seasons in crediting period</td><td rowspan="2">Applied to: all farms, sampling one ha per field;

Period: ongoing monitoring for the 10 growing seasons after the end of the crediting period</td></tr>
<tr><td>Cover crop practices</td></tr>
</table>

Cover crops are mapped by observing a field over the autumn, winter and spring following a given growing season. Within each season, Regrow observes the vegetation dynamics of each field, taking into account both field management activities (summer crop harvest, planting in the spring, etc) and regional variations in weed and snow cover. At each step, the persistence of vegetation on the field (a collection of pixels) and likelihood it is a cover crop is assessed. Accuracy for the cover crop model varies regionally and has a baseline performance level of 80% at the field level.

Residue cover at the field level is evaluated using remote sensing estimates of non-photosynthetically active vegetation cover on a field during two periods: post-harvest and pre-planting. During each of these periods, Regrow evaluates both the change in residue over time and the minimum residue coverage, normalising the data to minimise the effects of precipitation and soil colour. Tillage intensity on a field is classified as one of the following: no-till, reduced till, or conventional tillage using residue coverage on a field as a proxy for tillage. Since different crops generate differing amounts of crop residue (e.g. corn is a high residue crop, soybeans are a low residue crop), the tillage classification also considers the prior crop on the field. Accuracy of the tillage model varies regionally, generally classifying tillage practices at a level of 60% - 80%.

6.3 Roles and responsibilities for quality management procedures

As part of the monitoring process, Soil Capital will archive all of the data digitally for the entire crediting and retention periods. Other roles and responsibilities are summarised in Table 20 below.

Table 20 : Responsibilities of the data and quality management

Data collection	Description
Data collection	Soil Capital
Monitoring report	Soil Capital
Quality assurance	Depending on which level: Input data: Soil Capital and Regrow Emission reduction calculator: Soil Capital
Data archiving	Soil Capital
Data verification	TÜV Rheinland

(Source: Soil Capital, 2023)

7 Reporting and validation details

TÜV Rheinland Energy & Environment GmbH has been assigned to undertake the validation services under the scopes of ISO 14064-2:2019 and ISO 14064-3:2019.

TÜV Rheinland holds an ISO/IEC 17029: 2019 accreditation from German accreditation body, ANSI National Accreditation Board, including the aforementioned scopes. The certificate number is TUVREU 0986. The certificate expires on 17 November 2027.

TÜV Rheinland also holds an ISO 14065:2020 accreditation under both accreditation bodies ANAB and DAkkS.

TÜV Rheinland's validation report for this Programme Document is going to be filed under Report ID 21270043.

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Annex I

■ **Soil Capital soil analysis requirements**

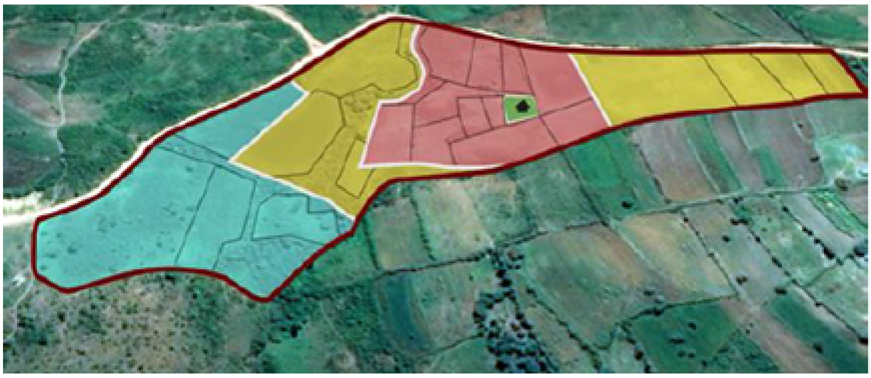
Objective: to provide the average **Soil Organic Carbon (SOC)** for each of your soil types

External standards informing the development of these requirements, which draw on international best practice and standards such as those from the FAO, ISO and the IPCC:

- Label bas Carbone *La méthode Grandes Cultures, July 2021*
- Verra's VM0042 *Methodology for Improved Agricultural Land Management v2.0, May 2023*
- UK Farm Soil Carbon Code (UKFSCC) initiative's *Report and recommendations on minimum requirements for high-integrity soil carbon markets in the UK v1.0*
- Climate Action Research *US Soil Enrichment Protocol v1.1, May 2022*

These requirements apply at two moments in the Projectme: (1) to verify soil conditions associated with the Baseline Assessment and (2) at the end of the Crediting Period. If soil analysis in line with these requirements has already been conducted within the five years prior to a farm's Baseline Assessment, the results from that analysis are sufficient.

1. **Separate your farm into zones ("stratification")**
   - **Each zone** ("stratum") should be homogenous in terms of **soil type**
   - Use a **soil map** to identify the **major soil types** across your farm
   - Zones can be further sub-divided, for instance to account for major differences in **topography** or **historical land use**
   - These strata should remain the **same over time**
   - An example is given below, in which three zones (the three different colours) have been identified:



2. **Choose where to sample within each stratum**
   - Within each stratum, a **minimum of three samples** must be taken; more samples will increase overall accuracy
   - A **random sampling technique** must be used to choose the location for each sample
   - **GPS locations** (including units, and in full - not rounded) of all sample sites must be recorded for use in future re-sampling campaigns. Each sample must be clearly labelled with a unique identifier.
3. **Collect soil samples**
   - It can improve data quality and be more practical for **sample collection to be done by entities appointed by laboratories**; in France, Belgium and the UK, laboratories provide sample collection services for a small additional fee - this is recommended but not mandatory
   - Sampling and re-sampling must be conducted during the **same season of the year over time**
     - Where **organic amendments** have been applied, sampling should be **delayed** until the latest time possible after the previous application and the shortest time

possible before the next application

- All **organic material** (e.g. living plants, crop residue) **must be cleared** from the soil surface before soil sampling
- Each sample must be taken to a **depth of at least 30cm**
    - Soils less than 30cm deep (e.g. due to shallow bedrock) must be sampled to the depth of the impeding layer
- To account for local variability, each sample should be a **composite sample**, following the EU's LUCAS sampling protocol:
    - Sample first at the specific point within the stratum identified through random sampling and record the GPS location (including units, and in full - not rounded)
    - Then add 4 sub-samples from North, South, East and West of that point at a 2 metre distance from the original sample location
    - Mix those 5 sub-samples and send a portion of this composite sample for laboratory analysis
- **Re-sampling** should be from the same locations, avoiding disturbed areas

4. **Conduct lab analysis**
    - Laboratories must be **accredited against ISO or equivalent** standards
    - SOC content should be measured using **dry combustion (Dumas method)**
        - Analysis should account for inorganic carbon
        - Walkley Black (wet) oxidation and loss on ignition (LOI) are not recommended due to lower accuracies but may be applied where no other method is available
5. **Maintain records**
    - Records of **results direct from the laboratory** must be kept, together with their GPS location information, **for the duration of the Project** - they may be requested by an auditor during the annual verification process

Annex II

Soil Capital Beyond Carbon metrics technical description

1. Soil Health

a. *Physical Soil Health*

Indicator	Description	Unit	Computation method
STIR *(Stir Measurement)*	Weighted average of STIR per field	Unitless	Soil Tillage Intensity Rating (STIR) is calculated from the speed, depth and type of tillage, as well as the soil surface disturbed. For each machine, guideline values have been set for working speed and depth, as well as the proportion of soil disturbed. However, these values can be modified according to the use made of the machine.
No Ploughing Land *(No Tillage Measurement)*	Percentage of arable land without ploughing (reduced or no till)	%	We calculate the ratio between the land managed with ploughing/tillage and the total area of non-permanent crops. Note that we homologue soil preparation works relative to their STIR, where all operations with a STIR>43 are counted as tillage. A potato ridger has the same destructive capacity as a plough, so they'll each need to be assessed.
Cover Crops *(CC Measurement)*	Percentage of arable land planted with cover crops	%	We calculate the ratio between the areas that had cover crops, companion crops or regrowth of a previous crop such as rapeseed and the total area of non-permanent crops.
Soil Coverage *(Soil Coverage Measurement)*	Days of soil cover living plants (cover crops + cash crops)	Days	We sum the number of days of cash crop duration and cover crop duration.

b. *Chemical Soil Health*

Indicator	Description	Unit	Computation method
Field residue application *(Residue Measurement)*	Net residues quantity	t/ha	We calculate the difference between the crop residues produced based on the yield of the cash crop and the crop residues removed from the field by being exported as straws. We estimate the crop residue quantity from the yield, as per SIMEOS AMG model.

2. Biodiversity

a. *In Field Biodiversity*

Indicator	Description	Unit	Computation method
Spatial Crop Diversity *(Rotation Diversity Measurement)*	Spatial crop diversity index during one growing season	Unitless	We count the total cultivated area, excluding permanent grassland and the Surface area of each species. For all non-permanent crops during one growing season Weight of each crop = (relative_crop_area) / (UAA of the farm excluding permanent pastures) Diversity index = 1 / sum (weight of each crop^ 2)

b. *Habitat Creation*

Indicator	Description	Unit	Computation method
Field Border Density *(Field Border Density Measurement)*	Length of field border/surface of border	m/ha	The index is calculated as the ratio between the sum of the perimeters of the arable land parcels divided by the arable land surface area of the farm.

c. *Minimising Pollution*

Indicator	Description	Unit	Computation method
Non Treated Area *(No Insecticide Proportion Measurement)*	Percentage of crop land without insecticides	%	We calculate the ratio between the area managed without synthetic pesticides and the total area of the farm.

3. Water Management

a. *Water Quality*

Indicator	Description	Unit	Computation method
Pesticide Consumption *(Pesticide Consumption Measurement)*	Load of pesticides	IFT/ha	The calculation of the IFT is based on the amount of pesticides really applied by the farmers on their agricultural plots. For each product, a standard dose is defined, according to the product's marketing authorisation.
Mineral phosphorus consumption *(Min P Measurement)*	Mineral phosphorus consumption	Kg P/ha	The calculation of mineral phosphorus is based on the sum of mineral phosphorus supplied per field. This is then weighed with the field area to obtain an average figure per ha on the farm.

4. Climate

a. *GHG Emissions*

Indicator	Description	Unit	Computation method
Synthetic GHG emission *(Synthetic Field Emissions Measurement)*	Crop emissions related to synthetic products	tCO2e/ ha	To calculate the field emissions, we sum of CFT components (fertiliser_production, pesticides, irrigation, fuel, fertiliser_application) To get the farm aggregation we divide this sum by weighted average on UAA

b. Carbon Sequestration

Indicator	Description	Unit	Computation method
Soil Carbon Storage *(Soil Storage Measurement)*	Soil carbon storage related to cover crops, reduced tillage intensity and organic fertilisation	tCO2e/ha	Soil carbon storage related to cover crops, reduced tillage intensity and organic fertilisation, as returned by CFT. We score this normalised to a SOM of 3%.

5. Farm Socio-Economics

a. *Input Management*

Indicator	Description	Unit	Computation method
Farm Fertiliser Cost *(Cost Min fertiliser Measurement)*	Costs related to mineral fertiliser	EUR/t	We compute the cost of mineral fertilisation per field by using an estimated price of fertiliser input (N, P, K input multiplied by a unitary cost, either specific for 4 main N fertilisers, or an average price per kg N,P,K). We sum across all fertilisers on the field. We compute cost per T of crop production by dividing by the crop yield. We calculate a weighted average (area based) across all fields on the farm
Farm Pesticides Cost *(Cost PPP Measurement)*	Costs related to pesticides	EUR/t	We compute the cost of pesticides per field by using an estimated price of pesticide input (price per IFT herbicide, fungicide, insecticide). We sum across all phytochemicals on the field. We compute cost per T of crop production by dividing by the crop yield. We calculate a weighted average (area based) across all fields on the farm
Farm Fuel Cost *(Cost Fuel Measurement)*	Costs related to fuel	EUR/ha	Per field, we sum the fuel consumption modelled in mSC and multiply by a unitary fuel price. We calculate a weighted average across all fields on the farm

b. Productivity

Indicator	Description	Unit	Computation method
Farm Yield *(Relative Yield Measurement)*	An indicator measuring the crop yield performance compared to regional benchmark, describing how well the farmer performed compared to the farms in the region	Unitless	Per crop, we compute the relative yield index = (crop yield) / regional crop yield We calculate the weighted average per field area.
Farm Profitability *(Profit Measurement)*	Standardised profitability balance between income and costs	EUR/ha	Standardised profit = • income = Standardised sales price per crop * yield • costs = Input costs related to fertiliser, PPP, seeds, cover crop seeds, fuel, irrigation using standardised unitary costs multiplied by the quantity used + Mechanisation costs: amortisation of tool and tractor using *barème d'entraide* (mutual assistance rate) for average grade tools + Workforce cost using *barème d'entraide* (mutual assistance rate) for average grade tools Computed per field, then aggregated to the farm level.

c. *Social Role*

Indicator	Description	Unit	Computation method
Farm Working Hours *(Working Hours Measurement)*	Working hours on farm related to (cover crop) seed, soil works, fertiliser, PPP, harvest	h/ha	Per field, lookup workforce duration (h/ha) for all mechanical operations. Weighted average across the farm.

Annex III

Screenshots of the centralised GHG database from mySoilCapital tool.

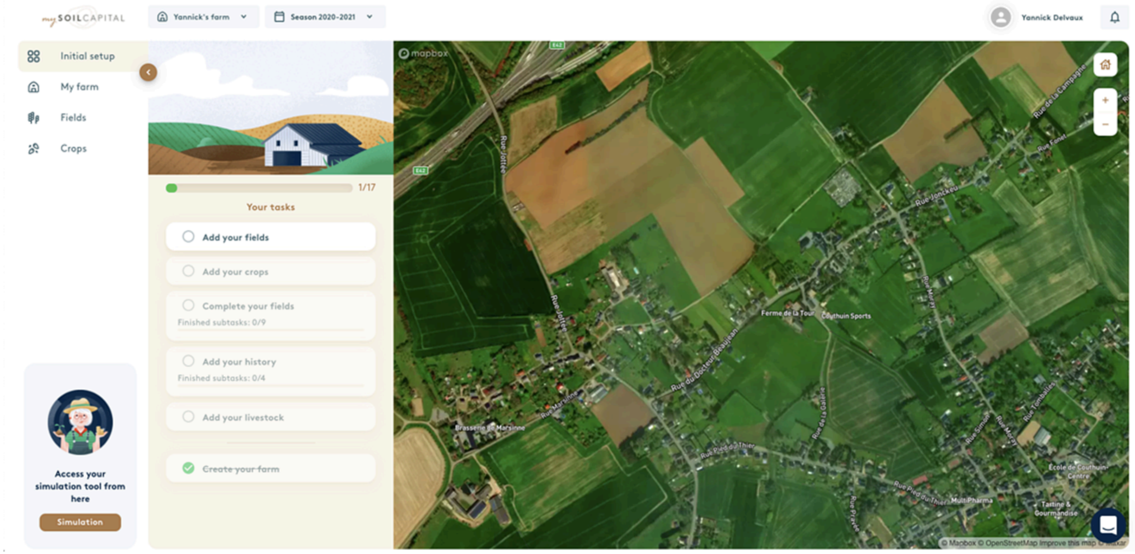


Figure 12 : Screenshot of the mySoilCapital platform for farmers to enter data

(Source: Soil Capital, 2024)

id int8	farm_season_id	results	created_at	created_by	updated_at	updated_by
2091	1692	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-21 12:00:59+00	NULL	2022-03-21...	NULL
1833	1162	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-28 23:10:42+00	NULL	2022-02-28...	NULL
1953	1219	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-09 13:39:06+00	NULL	2022-03-09...	NULL
1961	1284	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-09 13:50:53+00	NULL	2022-03-09...	NULL
1839	1213	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-01 09:24:54+00	NULL	2022-03-01...	NULL
1720	1279	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-21 12:51:51+00	NULL	2022-02-21...	NULL
1624	1225	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:13:02+00	NULL	2022-02-18...	NULL
1634	1224	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:14:57+00	NULL	2022-02-18...	NULL
1968	1283	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-09 15:23:56+00	NULL	2022-03-09...	NULL
2099	1229	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-21 16:36:44+00	NULL	2022-03-21...	NULL
1865	1386	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-03 08:53:09+00	NULL	2022-03-03...	NULL
1982	1463	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-10 13:30:28+00	NULL	2022-03-10...	NULL
1988	1606	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-11 10:00:51+00	NULL	2022-03-11...	NULL
1563	1227	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 10:55:42+00	NULL	2022-02-18...	NULL
2105	1860	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-22 09:02:47+00	NULL	2022-03-22...	NULL
1572	1309	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 10:59:07+00	NULL	2022-02-18...	NULL
1902	1433	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-03 14:54:26+00	NULL	2022-03-03...	NULL
1583	1250	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:04:40+00	NULL	2022-02-18...	NULL
2117	1753	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-25 12:26:20+00	NULL	2022-03-25...	NULL
2124	1510	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-28 12:50:14+00	NULL	2022-03-28...	NULL
1592	1555	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:06:59+00	NULL	2022-02-18...	NULL
1645	1218	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:19:13+00	NULL	2022-02-18...	NULL
1649	1253	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 14:45:44+00	NULL	2022-02-18...	NULL
1472	1332	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-16 16:49:33+00	NULL	2022-02-16...	NULL
1475	1062	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-16 16:51:10+00	NULL	2022-02-16...	NULL
1601	1335	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:09:17+00	NULL	2022-02-18...	NULL
1924	1527	{"texts": {"map_data": {"slug": "map_data", "values...	2022-03-04 17:09:52+00	NULL	2022-03-04...	NULL
1607	1263	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:10:37+00	NULL	2022-02-18...	NULL
1613	1098	{"texts": {"map_data": {"slug": "map_data", "values...	2022-02-18 11:11:28+00	NULL	2022-02-18...	NULL

Figure 13 : Screenshot of an extract of the centralised GHG database

(Source: Soil Capital, 2022)

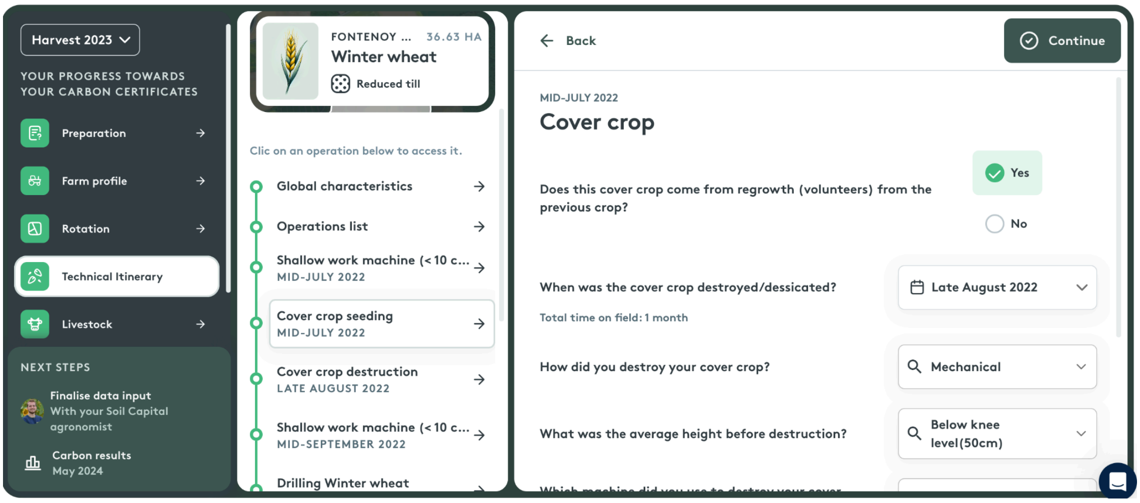
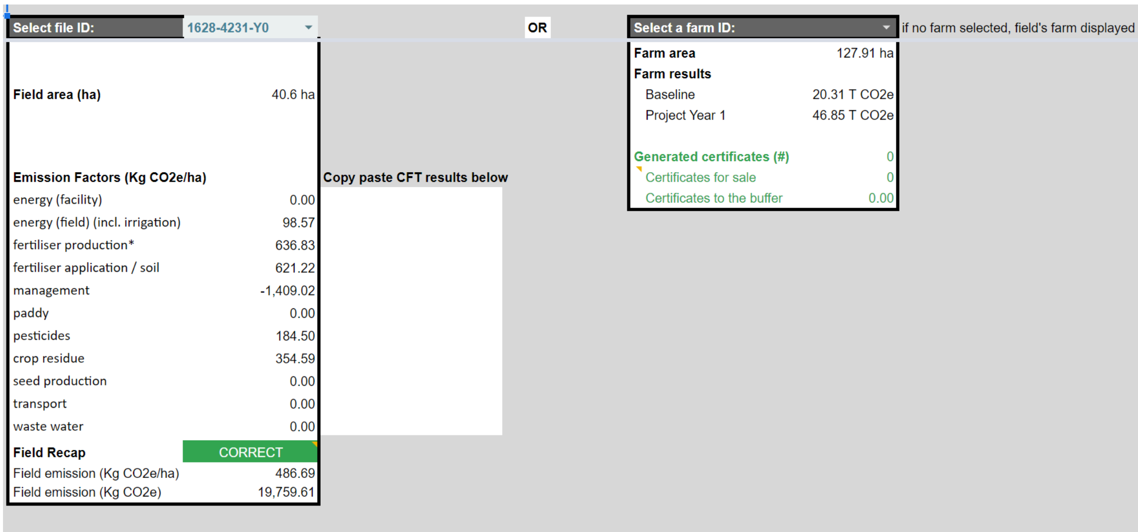


Figure 14 : Screenshot of mySoilCapital database, showing the data entered by a farmer for a field of winter wheat

(Source: Soil Capital, 2024)



Select file ID:	1628-4231-Y0	
Field area (ha)	40.6 ha	
Emission Factors (Kg CO2e/ha)		Copy paste CFT results below
energy (facility)	0.00	
energy (field) (incl. irrigation)	98.57	
fertiliser production*	636.83	
fertiliser application / soil	621.22	
management	-1,409.02	
paddy	0.00	
pesticides	184.50	
crop residue	354.59	
seed production	0.00	
transport	0.00	
waste water	0.00	
Field Recap	CORRECT	
Field emission (Kg CO2e/ha)	486.69	
Field emission (Kg CO2e)	19,759.61	

OR

Select a farm ID:		if no farm selected, field's farm displayed
Farm area	127.91 ha	
Farm results		
Baseline	20.31 T CO2e	
Project Year 1	46.85 T CO2e	
Generated certificates (#)	0	
Certificates for sale	0	
Certificates to the buffer	0.00	

Figure 15 : Screenshot of the summary table for the Soil Capital database, with GHG

(Source: Soil Capital, 2022)

Annex IV

Key characteristics of the two baseline scenarios of the Project

Table 21 : Key characteristics of the two baseline scenarios of the Project

Design	Baseline scenario 1	Baseline scenario 2
Crediting period	A farmer stays in this category for a minimum of five years (crediting period). After this period a re-evaluation is made to determine whether to stay under this baseline or move to the regional common practice baseline during a second commitment period.	A farmer stays in this category for a minimum of five years (crediting period).
Project scenario	The Project scenario is that farmers convert from conventional to regenerative agriculture practices.	The Project scenario is that farmers either continue their conversion to regenerative practices or at least maintain and protect the carbon in their farmland soils so that historical removals are maintained and farmers can also be rewarded for carbon removals that continue to take place.
Analysis of alternative scenario	The alternative scenario is that farmers in this group will continue emitting as they did before the start of the Project.	The alternative scenario is that the regenerative farmers return to the common practice baseline.
Data used	Individual historical practice data from the complete three growing seasons directly preceding enrolment;	Regional common practices based on expert judgement of practice data for each region (defined as no larger than a NUTS 2 region in France or a NUTS 1 region in Belgium).
Forecast 'ex-ante' estimation	Historical baseline practices (i.e. the practices implemented in the last 3 growing seasons preceding the Project) are kept constant for the whole duration of the Project. The GHG emissions and removals linked to these historical practices are re-assessed every year through the building of a counterfactual baseline to take the Project Year's weather into account	A constant set of common practices, as determined by the BEG of each region, is kept constant throughout the whole duration of the Project. The GHG emissions and removals linked to those practices is re-assessed each year for specific SOC contents to take the Project Year weather into account.

Design	Baseline scenario 1	Baseline scenario 2
Additionality	Without carbon finance from this Project and advice from the agronomists supported by Soil Capital (i.e., knowledge sharing), the farmers do not adopt regenerative practices.	Without carbon finance from this Project and advice from the agronomists supported by Soil Capital (i.e. knowledge sharing), the farmers do not have an incentive to further increase their regenerative practices or, in the face of common barriers, maintain their practices. Thus, it can be assumed that a significant proportion would return to common practices.
Barriers	The list below summarises the most common barriers preventing the farmers from transitioning to regenerative agriculture: • investments needed are judged as too large; • uncertainty about the economic benefits; • technical difficulties; and • lack of information and knowledge.	Farmers experience regular and common barriers to maintain and conserve carbon in the soil in the absence of clear financial incentives or benefits for soil conservation. List of barriers: • extreme bad weather; • control of pest pressure; • lack of premium pricing offers no new revenue to offset additional costs; • lack of access to organic fertilisation as demand grows; • loss of yield in a poorly managed transition; and • social and peer pressure.
Permanence	Analysis of non-permanence risk and the establishment of a pooled buffer in line with other AFOLU Projects including VCS (Verra); 20% of each farmer's verified removals are set aside and reserved in the Project's pooled buffer and used to account for any reversals (at each verification).	Same as individual historical practice baseline.
Target farmer group	Conventional farmers (farmers with a net emissions profile).	More regenerative farmers (farmers with a net removals profile).

(Source: Soil Capital, 2024)

Annex V

Overview of the barriers that farmers can face over their pathway to achieving and maintaining regenerative agriculture practices.

Farmers seeking to transition from conventional to regenerative agriculture practices face a number of barriers throughout their transition. Yet, even when they have adopted regenerative practices, a number of powerful barriers persist that prevent them from maintaining these practices. These barriers are summarised below.

Table 22 : Overview of the barriers that farmers can face over their pathway to achieving and maintaining regenerative agriculture practices

Stage of transition	Barrier	Summary
Moving from conventional to regenerative agriculture practices	Upfront investments	While it is true that regenerative agriculture practices can result in lower costs, farmers commonly report a fear of loss associated with the transition. This is fuelled by the upfront investments that they see as necessary, for example, new land preparation equipment like direct drills for no till planting, cover crop seed mixes, trees for agroforestry or organic fertiliser, which is more expensive than its synthetic equivalent.
	Uncertainty about economic benefits	Today, there is no market premium commonly paid for crops that are grown regeneratively. Therefore, regenerative farmers mostly continue to sell into conventional commodity markets. In addition, if a farmer is diversifying their crop rotation as part of their transition, they may not be confident that they can sell new crops as readily, or what they will earn for them. Together, this makes the economic benefits of the transition uncertain. The importance of this barrier is put into context by the reality that 50% of French farmers on medium or large farms earned less than EUR 14,000 per year in net income in 2016, and the majority of UK arable farmers were only able to return a positive net margin per hectare on three crops between 2017 and 2020.

Stage of transition	Barrier	Summary
	Technical difficulties	Conventional agriculture has developed a system of tried and tested synthetic solutions to combat pests and support yields and relies on intensive land preparation to maintain optimal seeding conditions. All of these solutions are 'quick fixes' that undermine soil health. Regenerative agriculture is more complex and knowledge-intensive for the farmer to implement. Since its underlying philosophy is to 'farm with nature' rather than against it, it requires proactively managing the agricultural ecosystem to prevent problems arising, instead of relying on prescriptions of agrochemicals and other synthetic inputs in reaction to problems that have already emerged. Regenerative agriculture simply isn't as easy as conventional farming and can lead to multiple technical difficulties.
	Lack of information and knowledge	Connected to the above barrier, farmers commonly report a lack of confidence in implementing regenerative solutions to everyday farming solutions. Since regenerative agriculture is still a niche activity, examples of local peer farmers already demonstrating such practices are rare. Similarly, since the agriculture advice industry is still orientated around conventional agriculture – with most advisors being employed by input dealers – professional advice on regenerative practices is hard to come by.

Stage of transition	Barrier	Summary
Maintaining regenerative agriculture practices	Bad weather	i) If waterlogging of soils is a result of intense periods of rainfall, this presents a direct threat to continued operations in affected fields, and therefore to yields and revenue opportunities. Farmers will be easily tempted to resume ploughing in order to turn the soil profile and deliver drier soil to the surface in order to facilitate seeding of Winter crops. This has been seen far and wide in France, Belgium and the UK in recent years. ii) If the season post-harvest is very dry, or even in drought conditions, farmers will have little incentive to spend money trying to establish cover crops. Equally, if the weather conditions have led to a very late harvest, the available window for seeding and growing cover crops may appear too short to make it worthwhile. In both of these circumstances, the weather conditions incentivise farmers to abandon their plans to do cover-cropping. iii) Organic fertilisation requires greater volumes of fertiliser to be applied and, because more time is needed for manure to break down into the soil as compared to synthetic fertiliser, it needs to be applied after summer harvest. Synthetic fertiliser, on the other hand, is applied in lower volumes and is applied just before seeding. Wet conditions delay the delivery of manure since the conditions prevent the logistics needed to clear livestock barns and complete transport operations. This alone means farmers relying on organic fertilisation can be several weeks behind conventional farmers in seeding their crops. Also, if conditions are wet and fields impassable, this can make application of organic fertiliser very difficult, if not impractical. In both of these circumstances, it is the lower risk and more practical option to resume synthetic fertilisation.
	Pest pressures	In no-till farming systems, pressure from pests such as rodent populations, can get out of control. In addition, severe outbreaks of weeds such as blackgrass, can be experienced in minimum or no-till farming systems. In both cases, the resumption of ploughing is often seen as the quickest and most effective way to regain control of pest pressures, which directly threatens yields and therefore revenue from the farm.

Stage of transition	Barrier	Summary
	Lack of premium pricing	Today, there is no market premium commonly paid for crops that are grown regeneratively. Therefore, regenerative farmers mostly continue to sell into conventional commodity markets. However, because regenerative agriculture is more complex and knowledge-intensive for the farmer to implement, the lack of premium pricing to reward farmers for maintaining a more complex approach to farming is a powerful factor in a farmer's decision-making.
	Lack of access to organic fertiliser	The more farmers seeking to undertake a transition to regenerative agriculture means that access to organic fertilisation becomes more challenging. The absolute volume of supply of organic fertilisation is limited, so, whether through increased prices or lack of availability, farmers can find procurement of organic fertiliser increasingly challenging.
	Loss of yield	When a farmer transitions from conventional to organic practices (typically over a three-year period), the relatively sudden shift from synthetic fertilisation to relying on the natural fertility of the soil can result in short-term declines in yield. If the transition from conventional to regenerative agriculture follows a similar speed and abruptness as the transition to organic – especially with regard to shifting from synthetic to organic fertilisation and reduction in agrochemicals to control pests – a similar decline in yield of up to 21% can be experienced. For the farmer, this represents a decline in revenue in the short-term.

Stage of transition	Barrier	Summary
Throughout the process	Social and peer pressure	Farming communities remain important sources of influence over a farmer's decision-making, a reality that is only enhanced by social media. Furthermore, the practices that a farmer implements on their fields are visible for all to see, leaving them more exposed to social and peer pressure than in many other industries. Since conventional agriculture remains the common practice, those practising regenerative agriculture remain outliers, breaking with the tradition of social norms. Concretely, leaving crop residues ('trash') to be incorporated into the soil and feed the soil biology stands in stark contrast to the common practice of ploughing the soil, leaving a 'clean' field. Therefore, regenerative farmers continue to be subject to peer pressure from those practising conventional agriculture, and this is known from survey data across Europe to be a material factor in their decision-making.

(Source: Soil Capital, 2022)

Annex VI

Description of formulae and data used to calculate non soil-based baselines emissions related to crops

Table 23 : Description of formulae and data used to calculate non soil-based baseline emissions related to crops

CFT equation number(s)	Name of parameter	Parameter's name under the CFT	Description under the CFT	Equation from the CFT	Unit
GHGs related to crops					
2.3.1	CO_2 emissions from synthetic fertiliser production	Fertiliser production	Emissions from mineral fertiliser production.	$L_{fert.\ prod.} = \sum_i R_i \times EF_{fert}(i)$ Where: $L_{fert.\ prod.}$ = Emissions for the production of fertilisers [kg CO_2e] R_i = Application rate of fertiliser type I [kg] $EF_{fert}(i)$ = Emissions factor of fertiliser type I, taken from Appendix A1 in the Cool Farm Tool Technical Documentation (2020) [kg CO_2e kg^{-1}]	kg CO_2e

CFT equation number(s)	Name of parameter	Parameter's name under the CFT	Description under the CFT	Equation from the CFT	Unit
2.4.1	CO_2 emissions from use of pesticides	Pesticide emissions	CFT considers different kinds of pesticides, with these being categorised based on the timing and location of application: post-emergence, seed treatment, and soil treatment.	For post-emergence and seed treatment applications: $L_{pest.} = A \times N_{app.\ pest.} \times EF_{app.\ pest.}$ Where: $L_{pest.}$ = Pesticide emissions [kg CO_2e] A = Area [ha] $N_{app.\ pest.}$ = Number of pesticide applications for post-emergence and seed treatment $EF_{app.\ pest.}$ = Emissions factor for individual application 20.5 kg CO_2eapp^{-1}	kg CO_2e
2.4.2				For soil treatment applications: $L_{pest.} = A \times R_{app.} \times AI_{frac} \times EF_{pest.}$ Where: $L_{pest.}$ = Pesticide emissions [kg CO_2e] A = Area [ha] $R_{app.}$ = Application rate [kg ha^{-1}] AI_{frac} = Fraction of active ingredient $EF_{pest.}$ = Emissions factor for individual application 41 kg CO_2e kg^{-1}	

CFT equation number(s)	Name of parameter	Parameter's name under the CFT	Description under the CFT	Equation from the CFT	Unit
2.6.1a	CO_2 emissions from fossil fuels	Direct energy use	Emissions from direct energy use for operation of machinery (e.g. consumption of diesel, petrol, gas or coal).	$L_{fuel} = \sum i(C_{fuel} \times EF_{fuel})$ Where: L_{fuel} = Emissions from machinery use [kg CO_2e] C_{fuel} = Consumption of fuel i [l] EF_{fuel} = Emission factor of fuel i [kg CO_2e l^{-1}] taken from Table 2.12 in the Cool Farm Tool Technical Documentation (2020)	kg CO_2e
2.6.1b	CO_2 emissions from fossil fuels	Field operations and irrigation energy use	This option is for the CFT to estimate petrol and diesel use for irrigation. The total energy requirements for irrigation consider the area under irrigation as well as the amount of irrigation applied.	$L_{energy} = \sum i(C_{energy} \times EF_{energy})$ Where: L_{energy} = Emissions from energy use for irrigation [kg CO_2e] C_{energy} = E_{irri} [kWh] EF_{energy} = Emission factor of energy i [kg CO_2e MJ^{-1}] taken from Table 2.12 in the Cool Farm Tool Technical Documentation (2020)	kg CO_2e

CFT equation number(s)	Name of parameter	Parameter's name under the CFT	Description under the CFT	Equation from the CFT	Unit
2.6.6				$E_{irri} = ER_{irri.\ area} \times D_{irri} \times A_{irri}$ Where: E_{irri} = Energy used for irrigation [kWh] $ER_{irri \cdot\ area}$ = Energy used for irrigation per area and mm [kWh mm^{-1} ha^{-1}] D_{irri} = Irrigation depth [mm] A_{irri} = Area under irrigation [ha]	
2.6.5				$ER_{irri.\ area} = ER_{irri.\ meth.} + dist_h \times ER_{htrans} + dist_v \times ER_{vtrans}$ Where: $ER_{irri:area}$ = Energy used for irrigation per area and mm [kWh mm^{-1} ha^{-1}] $ER_{irri.\ meth.}$ = Energy used based on irrigation method and fuel type (taken from Table 2.14 of the Cool Farm Tool Technical Documentation, 2020) [kWh mm^{-1} ha^{-1}] $dist_h$ = Horizontal distance to water source [m] ER_{htrans} = Energy used for horizontal transport 0.95 kWh mm^{-1} ha^{-1} km^{-1} $dist_v$ = Vertical transport defined by borehole depth [m] ER_{vtrans} = Energy used for vertical transport 0.095 kWh mm^{-1} ha^{-1} m^{-1}	

2.9.8a	CO_2 emissions from SOC stocks from tree planting	Biomass changes from loss or gain of forest	Changes in carbon stocks can also result from alterations in tree biomass. Again, the word 'emissions' can be misleading in this context, as the value may be positive or negative depending on management interventions. An increase in tree biomass and removals result in negative emissions.	$C_{forest} = G_w \times (1 + RS) \times CF$ Where: C_{forest} = Annual change in tree carbon stocks [kg C $ha^{-1} yr^{-1}$] G_w = Annual change in tree above-ground dry matter [kg $ha^{-1} yr^{-1}$] RS = Root-shoot ratio (the ratio of below-ground dry matter to above-ground dry matter for a specific vegetation type), taken as 0.31 for temperate US eastern hardwoods CF = Carbon fraction, taken as 0.48 for temperate US eastern hardwoods [kg C $(kg\ DM)^{-1}$] $G_w = (T_{y=0} \times G_{tree,\ y=0}) - (T_{y-1} \times G_{tree,\ y-1})$ Where: G_w = Annual change in above-ground tree dry matter [kg $ha^{-1} yr^{-1}$] $T_{y=0}$ = Number of trees at year of assessment [# ha^{-1}] $G_{tree,\ y=0}$ = Above-ground dry matter for temperate US eastern hardwoods at year of assessment [kg] T_{y-1} = Number of trees in year prior to year of assessment [# ha^{-1}] $G_{tree,\ y-1}$ = Above-ground dry matter for temperate US eastern hardwoods in year prior to year of assessment [kg]	kg C

CFT equation number(s)	Name of parameter	Parameter's name under the CFT	Description under the CFT	Equation from the CFT	Unit
				$G_{tree,\ y=0}$ = 0.5 + ((25,000 x $DBH_{y=0}^{2.5}$) / ($DBH^{2.5}$ + 246,872)) Where: $G_{tree,y=0}$ = Above-ground dry matter for temperate US eastern hardwoods at year of assessment [kg] $DBH_{y=0}$ = Trunk diameter at breast height at year of assessment [cm] $G_{tree,\ y-1}$ = 0.5 + ((25,000 x $DBH_{y-1}^{2.5}$) / ($DBH^{2.5}$ + 246,872)) Where: $G_{tree,y-1}$ = Above-ground dry matter for temperate US eastern hardwoods in year prior to year of assessment [kg] DBH_{y-1} = Trunk diameter at breast height in year prior to year of assessment [cm]	

CFT equation number(s)	Name of parameter	Parameter's name under the CFT	Description under the CFT	Equation from the CFT	Unit
GHGs related to crops					

2.3.1	CO_2 emissions from synthetic fertiliser production	Fertiliser production	Emissions from mineral fertiliser production.	$L_{fert.\ prod.} = \sum_i R_i \times EF_{fert}(i)$ Where: $L_{fert.\ prod.}$ = Emissions for the production of fertilisers [kg CO_2e] R_i = Application rate of fertiliser type I [kg] $EF_{fert}(i)$ = Emissions factor of fertiliser type I, taken from Appendix A1 in the Cool Farm Tool Technical Documentation (2020) [kg CO_2e kg^{-1}]	kg CO_2e
2.4.1	CO_2 emissions from use of pesticides	Pesticide emissions	CFT considers different kinds of pesticides, with these being categorised based on the timing and location of application: post-emergence, seed treatment, and soil treatment.	For post-emergence and seed treatment applications: $L_{pest.} = A \times N_{app.\ pest.} \times EF_{app.\ pest.}$ Where: $L_{pest.}$ = Pesticide emissions [kg CO_2e] A = Area [ha] $N_{app.\ pest.}$ = Number of pesticide applications for post-emergence and seed treatment $EF_{app.\ pest.}$ = Emissions factor for individual application 20.5 kg CO_2eapp^{-1}	kg CO_2e

2.4.2				For soil treatment applications: $L_{pest.} = A \times R_{app.} \times AI_{frac} \times EF_{pest.}$ Where: $L_{pest.}$ = Pesticide emissions [kg CO_2e] A = Area [ha] $R_{app.}$ = Application rate [kg ha^{-1}] AI_{frac} = Fraction of active ingredient $EF_{pest.}$ = Emissions factor for individual application 41 kg CO_2e kg^{-1}	
2.6.1a	CO_2 emissions from fossil fuels	Direct energy use	Emissions from direct energy use for operation of machinery (e.g. consumption of diesel, petrol, gas or coal).	$L_{fuel} = \sum i(C_{fuel} \times EF_{fuel})$ Where: L_{fuel} = Emissions from machinery use [kg CO_2e] C_{fuel} = Consumption of fuel i [l] EF_{fuel} = Emission factor of fuel i [kg CO_2e l^{-1}] taken from Table 2.12 in the Cool Farm Tool Technical Documentation (2020)	kg CO_2e

2.6.1b	CO_2 emissions from fossil fuels	Field operations and irrigation energy use	This option is for the CFT to estimate petrol and diesel use for irrigation. The total energy requirements for irrigation consider the area under irrigation as well as the amount of irrigation applied.	$L_{energy} = \sum i(C_{energy} \times EF_{energy})$ Where: L_{energy} = Emissions from energy use for irrigation [kg CO_2e] $C_{energy} = E_{irri}$ [kWh] EF_{energy} = Emission factor of energy i [kg CO_2e MJ^{-1}] taken from Table 2.12 in the Cool Farm Tool Technical Documentation (2020)	kg CO_2e
2.6.6				$E_{irri} = ER_{irri. area} \times D_{irri} \times A_{irri}$ Where: E_{irri} = Energy used for irrigation [kWh] $ER_{irri. area}$ = Energy used for irrigation per area and mm [kWh mm^{-1} ha^{-1}] D_{irri} = Irrigation depth [mm] A_{irri} = Area under irrigation [ha]	

2.6.5				$ER_{irri.\ area} = ER_{irri.\ meth.} + dist_h \times ER_{htrans} + dist_v \times ER_{vtrans}$ Where: $ER_{irri:area}$ = Energy used for irrigation per area and mm [kWh mm^{-1} ha^{-1}] $ER_{irri.\ meth.}$ = Energy used based on irrigation method and fuel type (taken from Table 2.14 of the Cool Farm Tool Technical Documentation, 2020) [kWh mm^{-1} ha^{-1}] $dist_h$ = Horizontal distance to water source [m] ER_{htrans} = Energy used for horizontal transport 0.95 kWh mm^{-1} ha^{-1} km^{-1} $dist_v$ = Vertical transport defined by borehole depth [m] ER_{vtrans} = Energy used for vertical transport 0.095 kWh mm^{-1} ha^{-1} m^{-1}	

2.9.8a 2.9.9d	CO_2 emissions from SOC stocks from tree planting	Biomass changes from loss or gain of forest	Changes in carbon stocks can also result from alterations in tree biomass. Again, the word 'emissions' can be misleading in this context, as the value may be positive or negative depending on management interventions. An increase in tree biomass and removals result in negative emissions.	$C_{forest} = G_w \times (1 + RS) \times CF$ Where: C_{forest} = Annual change in tree carbon stocks [kg C $ha^{-1} yr^{-1}$] G_w = Annual change in tree above-ground dry matter [kg $ha^{-1} yr^{-1}$] RS = Root-shoot ratio (the ratio of below-ground dry matter to above-ground dry matter for a specific vegetation type), taken as 0.31 for temperate US eastern hardwoods CF = Carbon fraction, taken as 0.48 for temperate US eastern hardwoods [kg C $(kg\ DM)^{-1}$] $G_w = (T_{y=0} \times G_{tree,\ y=0}) - (T_{y-1} \times G_{tree,\ y-1})$ Where: G_w = Annual change in above-ground tree dry matter [kg $ha^{-1} yr^{-1}$] $T_{y=0}$ = Number of trees at year of assessment [# ha^{-1}] $G_{tree,\ y=0}$ = Above-ground dry matter for temperate US eastern hardwoods at year of assessment [kg] T_{y-1} = Number of trees in year prior to year of assessment [# ha^{-1}] $G_{tree,\ y-1}$ = Above-ground dry matter for temperate US eastern hardwoods in year prior to year of assessment [kg]	kg C

				$G_{tree,\ y=0} = 0.5 + ((25{,}000\ x\ DBH_{y=0}^{2.5})\ /\ (DBH^{2.5} + 246{,}872))$ Where: $G_{tree,y=0}$ = Above-ground dry matter for temperate US eastern hardwoods at year of assessment [kg] $DBH_{y=0}$ = Trunk diameter at breast height at year of assessment [cm] $G_{tree,\ y-1} = 0.5 + ((25{,}000\ x\ DBH_{y-1}^{2.5})\ /\ (DBH^{2.5} + 246{,}872))$ Where: $G_{tree,y-1}$ = Above-ground dry matter for temperate US eastern hardwoods in year prior to year of assessment [kg] DBH_{y-1} = Trunk diameter at breast height in year prior to year of assessment [cm]	

(Source: Soil Capital, 2022)

Annex VII

Description of formulae and data used to calculate soil-based baselines emissions related to crops

Table 24 : Description of formulae and data used to calculate soil-based baseline emissions and removals related to crops

DNDC equation number (s)	Name of parameter	Description under the DNDC	Equation from the CFT	Unit
GHGs related to crops				
1	Soil organic carbon stocks	Baseline SOC stocks will be estimated via the combination of; I. management activities in the baseline scenario constructed through the creation of a three year historical period, i.e. three last growing seasons;; II. measured SOC stocks to true up baseline and Project SOC stocks modelled for each sample unit, through the collection of directly measured SOC; and III. sourcing of required secondary data such as climate information for each model run	SOCbsl,i,t = ʃ(SOCbsl,i,t) where: SOCbsl,i,t = Estimated carbon stocks in the SOC pool in the baseline scenario for sample unit i at the end of year t (t CO_2e/ha) ʃ(SOCbsl,i,t) = Modelled soil organic carbon stocks in the baseline scenario for sample unit i at the end of period t (t CO_2e/ha) i = Sample unit	t CO_2e ha^{-1}
2	Carbon dioxide emissions from liming	Carbon dioxide emissions from the application of calcitic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$)	CO2_ limebsl,i,t = ELbsl,i,t / Ai	t CO_2e ha^{-1}

DNDC equation number (s)	Name of parameter	Description under the DNDC	Equation from the CFT	Unit
2a			ELbsl,i,t = ((MLimestone,bsl,i,t X EFLimestone) + (MDolomite,bsl,i,t X EFDolomite)) x 44/12 where: CO_2limebsl,i,t = Mean carbon dioxide emissions from liming in the baseline scenario for sample unit i in year t (tCO_2e/ha) ELbsl,i,t = Carbon dioxide emissions from liming in the baseline scenario for sample unit i in year t (t CO_2e) MLimestone,bsl = Amount of calcitic limestone ($CaCO_3$) applied to sample unit i in year t (tonnes) EFLimestone = Emission factor for calcitic limestone (0.12) (t C per t of limestone) MDolomite,bsl,i,t = Amount of calcitic dolomite ($CaMg(CO_3)_2$) applied to sample unit i in year t (tonnes) EFDolomite = Emission factor for calcitic dolomite (0.13) (t C per t of dolomite) 44/12 = Molar mass ratio of CO_2 to C applied to convert CO_2-C emissions to CO_2 emissions i = Sample unit	

DNDC equation number (s)	Name of parameter	Description under the DNDC	Equation from the CFT	Unit
3	Nitrous oxide emissions from fertiliser application, nitrogen fixing species and residues decomposition	Nitrous oxide emissions due to (i) the application of nitrogen-containing fertilisers, (ii) presence of nitrogen fixing species within a crop rotation and (iii) decomposition of plant residues (above and below ground)	$N_2O\_soilbsl_{i,t}$ = $GWPN_2O$ x ∫$N_2O\_soilbsl_{i,t}$ where: $N_2O\_soilbsl_{i,t}$ = Mean direct and indirect nitrous oxide emissions due to nitrogen inputs to soils in the baseline scenario for sample unit i in year t (t CO_2e/ha) ∫N_2Obsl_{i} = Modelled nitrous oxide emissions from soil in the baseline scenario for sample unit i in year t, calculated by modelling soil fluxes of nitrogen forms over the course of the preceding year (t N_2O/ha) $GWPN_2O$ = Global warming potential for N_2O (t CO_2e / t N_2O) i = Sample unit	t CO_2e ha^{-1}

Annex VIII

Default emission factors to calculate baseline and Project emissions.-

Parameter: EFfert(i)

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
Europe 2014	Urea - 46% N	0.878009263
Europe 2014	Urea ammonium nitrate solution - 32% N	0.781585094
Europe 2014	Ammonium nitrate - 33.5% N (granulated)	1.144603371
Europe 2014	Ammonium nitrate - 33.5% N (prilled)	1.111945741
Europe 2014	Calcium ammonium nitrate - 27% N	0.951245127
Europe 2014	Ammonium sulphate - 21% N	0.563541287
Europe 2014	Ammonium sulphate nitrate - 26%N	0.797155511
Europe 2014	Calcium nitrate - 15.5% N	0.63580065
Europe 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.438909678
Europe 2014	Diammonium phosphate - 18% N / 46% P2O5	0.6266511
Europe 2014	Triple super phosphate - 48% P2O5	0.179965501
Europe 2014	Super phosphate - 21% P2O5	0.077741084

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
Europe 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	0.620195718
Europe 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	0.707577156
Europe 2014	Anhydrous ammonia - 82% N	2.296676454
Europe 2014	Compose your own NPK	0.067346665
N America 2014	Urea - 46% N	1.006047297
N America 2014	Urea ammonium nitrate solution - 32% N	1.332291618
N America 2014	Ammonium nitrate - 33.5% N (granulated)	2.283445258
N America 2014	Ammonium nitrate - 33.5% N (prilled)	2.248686989
N America 2014	Calcium ammonium nitrate - 27% N	1.869955658
N America 2014	Ammonium sulphate - 21% N	0.612546611
N America 2014	Ammonium sulphate nitrate - 26%N	1.286693277
N America 2014	Calcium nitrate - 15.5% N	1.578612695
N America 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.464943448
N America 2014	Diammonium phosphate - 18% N / 46% P2O5	0.669616692
N America 2014	Triple super phosphate - 48% P2O5	0.183575546
N America 2014	Super phosphate - 21% P2O5	0.07961156
N America 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.055677408
N America 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.148381262

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
Africa 2014	Ammonium nitrate - 33.5% N (granulated)	2.100006998
Africa 2014	Ammonium nitrate - 33.5% N (prilled)	2.061243598
Africa 2014	Calcium ammonium nitrate - 27% N	1.723625873
Africa 2014	Ammonium sulphate - 21% N	0.618695849
Africa 2014	Ammonium sulphate nitrate - 26%N	1.216191358
Africa 2014	Calcium nitrate - 15.5% N	1.435771878
Africa 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.506021082
Africa 2014	Diammonium phosphate - 18% N / 46% P2O5	0.69572705
Africa 2014	Triple super phosphate - 48% P2O5	0.21985846
Africa 2014	Super phosphate - 21% P2O5	0.097407823
Africa 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.00219314
Africa 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.092176867
Africa 2014	Anhydrous ammonia - 82% N	2.379418882
Africa 2014	Compose your own NPK	0.079478519
Middle East 2014	Urea - 46% N	0.813984649
Middle East 2014	Urea ammonium nitrate solution - 32% N	1.341912927
Middle East 2014	Ammonium nitrate - 33.5% N (granulated)	2.43664071
Middle East 2014	Ammonium nitrate - 33.5% N (prilled)	2.396109064
Middle East 2014	Calcium ammonium nitrate - 27% N	1.995608755

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
N America 2014	Anhydrous ammonia - 82% N	2.490252759
N America 2014	Compose your own NPK	0.071665409
S America 2014	Urea - 46% N	1.012783474
S America 2014	Urea ammonium nitrate solution - 32% N	1.286648984
S America 2014	Ammonium nitrate - 33.5% N (granulated)	2.169733374
S America 2014	Ammonium nitrate - 33.5% N (prilled)	2.133519758
S America 2014	Calcium ammonium nitrate - 27% N	1.778816196
S America 2014	Ammonium sulphate - 21% N	0.660296146
S America 2014	Ammonium sulphate nitrate - 26%N	1.269038819
S America 2014	Calcium nitrate - 15.5% N	1.466084447
S America 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.522785597
S America 2014	Diammonium phosphate - 18% N / 46% P2O5	0.727873407
S America 2014	Triple super phosphate - 48% P2O5	0.211850081
S America 2014	Super phosphate - 21% P2O5	0.093382157
S America 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.029838756
S America 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.114949322
S America 2014	Anhydrous ammonia - 82% N	2.557834438
S America 2014	Compose your own NPK	0.074288315
Africa 2014	Urea - 46% N	0.927584842
Africa 2014	Urea ammonium nitrate solution - 32% N	1.2269914

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
Middle East 2014	Ammonium sulphate - 21% N	0.588118668
Middle East 2014	Ammonium sulphate nitrate - 26%N	1.334178818
Middle East 2014	Calcium nitrate - 15.5% N	1.750606256
Middle East 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.50814474
Middle East 2014	Diammonium phosphate - 18% N / 46% P2O5	0.679448364
Middle East 2014	Triple super phosphate - 48% P2O5	0.23700595
Middle East 2014	Super phosphate - 21% P2O5	0.105811122
Middle East 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.132306326
Middle East 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.220595087
Middle East 2014	Anhydrous ammonia - 82% N	2.194645754
Middle East 2014	Compose your own NPK	0.082911802
Russia (CIS countries) 2014	Urea - 46% N	1.104688482
Russia (CIS countries) 2014	Urea ammonium nitrate solution - 32% N	1.427467671
Russia (CIS countries) 2014	Ammonium nitrate - 33.5% N (granulated)	2.42084696
Russia (CIS countries) 2014	Ammonium nitrate - 33.5% N (prilled)	2.38251518
Russia (CIS countries) 2014	Calcium ammonium nitrate - 27% N	1.982062794
Russia (CIS countries) 2014	Ammonium sulphate - 21% N	0.68478338
Russia (CIS countries) 2014	Ammonium sulphate nitrate - 26%N	1.385103887

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
Russia (CIS countries) 2014	Calcium nitrate - 15.5% N	1.664124595
Russia (CIS countries) 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.530709127
Russia (CIS countries) 2014	Diammonium phosphate - 18% N / 46% P2O5	0.747135819
Russia (CIS countries) 2014	Triple super phosphate - 48% P2O5	0.211320623
Russia (CIS countries) 2014	Super phosphate - 21% P2O5	0.093250085
Russia (CIS countries) 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.126955882
Russia (CIS countries) 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.219258255
Russia (CIS countries) 2014	Anhydrous ammonia - 82% N	2.674790182
Russia (CIS countries) 2014	Compose your own NPK	0.078702812
SE Asia 2014	Urea - 46% N	0.93355072
SE Asia 2014	Urea ammonium nitrate solution - 32% N	1.359007972
SE Asia 2014	Ammonium nitrate - 33.5% N (granulated)	2.388317259
SE Asia 2014	Ammonium nitrate - 33.5% N (prilled)	2.344043366
SE Asia 2014	Calcium ammonium nitrate - 27% N	1.958126076
SE Asia 2014	Ammonium sulphate - 21% N	0.646584029
SE Asia 2014	Ammonium sulphate nitrate - 26%N	1.349330402
SE Asia 2014	Calcium nitrate - 15.5% N	1.680217217

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
SE Asia 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.552262254
SE Asia 2014	Diammonium phosphate - 18% N / 46% P2O5	0.737842798
SE Asia 2014	Triple super phosphate - 48% P2O5	0.253598256
SE Asia 2014	Super phosphate - 21% P2O5	0.114061444
SE Asia 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.127659756
SE Asia 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.220982917
SE Asia 2014	Anhydrous ammonia - 82% N	2.378851217
SE Asia 2014	Compose your own NPK	0.090460016
S Asia 2014	Urea - 46% N	1.273530323
S Asia 2014	Urea ammonium nitrate solution - 32% N	1.437875938
S Asia 2014	Ammonium nitrate - 33.5% N (granulated)	2.318444314
S Asia 2014	Ammonium nitrate - 33.5% N (prilled)	2.267019657
S Asia 2014	Calcium ammonium nitrate - 27% N	1.904613284
S Asia 2014	Ammonium sulphate - 21% N	0.805501827
S Asia 2014	Ammonium sulphate nitrate - 26%N	1.415355634
S Asia 2014	Calcium nitrate - 15.5% N	1.534661045
S Asia 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.659390816
S Asia 2014	Diammonium phosphate - 18% N / 46% P2O5	0.888912109
S Asia 2014	Triple super phosphate - 48% P2O5	0.283802866

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
S Asia 2014	Super phosphate - 21% P2O5	0.129100157
S Asia 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.132018966
S Asia 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.235618623
S Asia 2014	Anhydrous ammonia - 82% N	2.922959334
S Asia 2014	Compose your own NPK	0.104904786
Oceania 2014	Urea - 46% N	0.751115178
Oceania 2014	Urea ammonium nitrate solution - 32% N	1.167837885
Oceania 2014	Ammonium nitrate - 33.5% N (granulated)	2.094607514
Oceania 2014	Ammonium nitrate - 33.5% N (prilled)	2.050525105
Oceania 2014	Calcium ammonium nitrate - 27% N	1.721333315
Oceania 2014	Ammonium sulphate - 21% N	0.561844621
Oceania 2014	Ammonium sulphate nitrate - 26%N	1.18032377
Oceania 2014	Calcium nitrate - 15.5% N	1.48129745
Oceania 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.505608087
Oceania 2014	Diammonium phosphate - 18% N / 46% P2O5	0.663978972
Oceania 2014	Triple super phosphate - 48% P2O5	0.251502079
Oceania 2014	Super phosphate - 21% P2O5	0.113035637
Oceania 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.00665141

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
Oceania 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.100262845
Oceania 2014	Anhydrous ammonia - 82% N	2.054683783
Oceania 2014	Compose your own NPK	0.090091652
China 2014	Urea - 46% N	1.994498539
China 2014	Urea ammonium nitrate solution - 32% N	2.19616163
China 2014	Ammonium nitrate - 33.5% N (granulated)	3.499605512
China 2014	Ammonium nitrate - 33.5% N (prilled)	3.441278228
China 2014	Calcium ammonium nitrate - 27% N	2.857174116
China 2014	Ammonium sulphate - 21% N	1.120779507
China 2014	Ammonium sulphate nitrate - 26%N	2.079900255
China 2014	Calcium nitrate - 15.5% N	2.343010389
China 2014	Monoammonium phosphate - 11% N / 52% P2O5	0.805891657
China 2014	Diammonium phosphate - 18% N / 46% P2O5	1.147062705
China 2014	Triple super phosphate - 48% P2O5	0.274995113
China 2014	Super phosphate - 21% P2O5	0.133007739
China 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (mixed-acid process)	1.607553377
China 2014	Compound NPK - 15% N / 15% K2O / 15% P2O5 (nitrophosphate process)	1.709144517
China 2014	Anhydrous ammonia - 82% N	4.199784582
China 2014	Compose your own NPK	0.111513595

Manufacturing region	Fertiliser type	Emission Factor [$kg\ CO_2e\ kg^{-1}$]
World 2014	Limestone - 55% CaCO3 / 29%CaO	0.069
World 2014	Muriate of potash / Potassium chloride - 60% K2O	0.248
World 2014	Phosphate/Rock Phosphate - 32% P2O5	0.079
World 2014	Potassium sulphate - 50% K2O / 45% SO3	0.124

Parameter: $EF_{\text{fuel \& energy}}$

Table 2.12: Default fuel use emissions factors $EF_{\text{fuel \& energy}}$. Most values are derived from GHGprotocol [21].

Energy source	Emission factor $EF_{\text{fuel \& energy}}$	Unit
diesel	2.680000	$kg\ CO_2e\ l^{-1}$
petrol	2.320000	$kg\ CO_2e\ l^{-1}$
bioethanol	2.320000	$kg\ CO_2e\ l^{-1}$
biodiesel	2.680000	$kg\ CO_2e\ l^{-1}$
electricity (grid)	0.280750	$kg\ CO_2e\ kWh^{-1}$
electricity (hydroelectric)	0.006000	$kg\ CO_2e\ kWh^{-1}$
electricity (wind)	0.012000	$kg\ CO_2e\ kWh^{-1}$

[4] Bioethanol is assumed to be the same as petrol. Biodiesel is assumed to be the same as diesel.

Energy source	Emission factor $EF_{\text{fuel \& energy}}$	Unit
electricity (photo-voltaic)	0.070990	$kg\ CO_2e\ kWh^{-1}$
high-density biomass	0.000000	$kg\ CO_2e\ kg^{-1}$
fuel wood	0.000000	$kg\ CO_2e\ kg^{-1}$
coal (by weight)	2.920050	$kg\ CO_2e\ kg^{-1}$
gas (by weight)	2.983000	$kg\ CO_2e\ kg^{-1}$
oil (by volume)	3.162133	$kg\ CO_2e\ l^{-1}$
gas (by volume)	0.002130	$kg\ CO_2e\ l^{-1}$
coal (by energy)	0.333690	$kg\ CO_2e\ kWh^{-1}$
gas (by energy)	0.226060	$kg\ CO_2e\ kWh^{-1}$
oil (by energy)	0.278260	$kg\ CO_2e\ kWh^{-1}$
biodiesel (low)	1.340000	$kg\ CO_2e\ l^{-1}$
bioethanol (low)	1.160000	$kg\ CO_2e\ l^{-1}$
propane	1.492900	$kg\ CO_2e\ l^{-1}$
CHP onsite (natural gas)	0.204210	$kg\ CO_2e\ kWh^{-1}$
CHP onsite (biogas)	0.000000	$kg\ CO_2e\ kWh^{-1}$
CHP export - electricity (natural gas)	-0.136140	$kg\ CO_2e\ kWh^{-1}$
CHP export - heat (natural gas)	0.068070	$kg\ CO_2e\ kWh^{-1}$
CHP export - (biogas)	0.000000	$kg\ CO_2e\ kWh^{-1}$
CHP import - electricity (natural gas)	0.136140	$kg\ CO_2e\ kWh^{-1}$
CHP import - heat (natural gas)	0.068070	$kg\ CO_2e\ kWh^{-1}$
CHP import (biogas)	0.000000	$kg\ CO_2e\ kWh^{-1}$

Parameter: $ER_{irri.\ meth.}$

Table 2.14: Energy requirements in kWh for irrigating 1 $mm\ ha^{-1}$ depending on irrigation method and fuel.

Irrigation method	Electricity	Diesel
Centre pivot	3.0	3.2
Rain gun, sprinkler	3.5	3.7
Flooding	1.6	1.7
Drip irrigation	2.0	2.1