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Outline of a Roadmap for further introduction of carbon farming and additional ESS payments

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ABSTRACT

Based on previous research within the Road4Schems project a decision-making tool – a roadmap – has been developed to facilitate the choice of CF-scheme(s) for an area of interest considering local characteristics and local environment(s) – natural as well as economical, technical, and regulative.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 862695

List of acronyms and abbreviations

CAP	Common Agricultural Policy
CF	Carbon Farming
CRCF	Carbon Removal Certification Framework
ESS	Ecosystem services
EU	European Union
GHG	Greenhouse Gases
MRV	Monitoring, Reporting, Verification
R4S	Road4Schemes
R4S countries	countries, where consortium members of R4S come from
SOM	Soil Organic Matter
WP	Work Package

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1. Introduction

In the last decades, there has been a growing recognition of the vital role of Soil Organic Matter (SOM) in soil fertility and its importance to the Earth's ecosystems, and of soils in the context of climate change adaption and mitigation. Soil management plays a central role in the global carbon cycle, both as a source of greenhouse gas (GHG) emissions and as a sink of carbon (C) in the form of Soil Organic Carbon (SOC). Notably, about 44% of the soil C pool is stored in the top 30 cm of soil and is affected by changes in land use and soil management (Batjes, 1996). The signing of the Paris Agreement in 2015 has promoted SOC sequestration as an important strategy for carbon mitigation. However, the complex biological processes driving soil carbon sequestration, coupled with significant spatial and temporal variability, introduce high uncertainty into these targets (Batjes, 2019). Yet, increasing the capacity/potential of soils to sequester carbon, while maintaining existing SOC levels, particularly in carbon rich-soils such as peatlands, is a key lever for effective climate change mitigation (Bossio et al., 2020). Carbon Sequestration in agricultural soils ('carbon farming', CF) is associated with a range of co-benefits, including increased yields, reduced nutrient leaching, and improved resilience. CF is therefore emerging as a promising strategy to address the threat of continued agricultural practices leading to SOC depletion and negative impacts on soil health, productivity, and resilience to climate-change related extreme events such as droughts (Keenor et al., 2021; Lal et al., 2018; Smith et al., 2020; EIP-AGRI, 2019). Successful efforts to maintain and increase SOC content requires the integration of scientific evidence into policy design and implementation to ensure mutual benefits for stakeholders, soils, and society.

Previous studies have identified knowledge transfer on management practices, policies, and regulations for carbon farming measures to maintain and increase SOC as a major challenge (Frelih-Larsen et al., 2020; Thorsøe et al., 2021). Results from the CIRCASA H2020 project (Coordination of International Research Cooperation on Soil Carbon Sequestration in Agriculture) highlight the lack of knowledge perceived by stakeholders as a key barrier to scaling up beneficial practices. Improved knowledge generation and sharing is therefore crucial to promote the uptake of SOC management, suggesting that scheme design should go beyond economic incentives to address broader barriers to the adoption of sustainable soil management practices (Claessens et al., 2019; Olesen et al., 2019).
Furthermore, as shown by the CIRCASA project, it is very important to consider and include farmer characteristics (such as f.e. farm size and farmer age), along with other multiple objectives, in policy making for upscaling SOC management practices to optimise the acceptance of such systems (Graversgaard, 2023). Understanding the implementation of such practices in current farming systems, along with monitoring requirements, is essential to ensure acceptance and to overcome barriers.
At the European level, carbon farming has been emphasised in current policy strategies. In line with the European Green Deal's ambition to make Europe the first climate neutral continent by 2050 (COM, 2019), the new EU Climate Target Plan aims to reduce GHG emissions by 55% GHG by 2030 (COM, 2020b). Agriculture, which is responsible for around 10% of total EU GHG emissions (excluding soil C emissions and sequestration), must contribute to these targets. The Common Agriculture Policy (CAP) emphasises a shift towards rewarding farmers for environmental and climate-friendly performance through a more results-oriented model from January 2023 (COM, 2020a). The recently launched EU Carbon Farming Initiative further incentivised climate-friendly farming practices through CAP funds or other public and private funds (Andersen et al., 2021).

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Given these policy imperatives, this deliverable aims to outline a roadmap for local and regional implementation of attractive and effective result-based schemes for carbon farming and additional Ecosystem Services (ESS) payments to facilitate successful performance and upscaling. The roadmap will consider different components to find the most appropriate scheme, starting with common principles and ending with the governance structure (see chapter 5). However, during the Road4Schems (R4S) project workshops, there was also a strong support for action-based or combined schemes. These are therefore also considered in this Roadmap.

2. Research leading up to the Roadmap

As a first basis for the development of this roadmap, an inventory of CF schemes currently existing in Europe (156) (http://reports.crea.gov.it/powerbi/CarbonSchemesInventory.html) was carried out. Based on this, a scoring of the quality of a selection of 40 CF schemes was carried out and published by Thorsøe et al. (2024) and Smit et al. (2024) (where more details on the criteria used to assess the quality of CF schemes can be found).

As part of work package (WP) 3, national workshops were organised in R4S partner countries (Denmark, Germany, the Netherlands, France, Switzerland, Austria, the Czech Republic, Belgium and Turkey) on "Land-users' perspective on schemes for carbon farming and additional ESS payments". The outcomes will be reported in a scientific paper. This was followed by surveys of experts responsible for national GHG inventories (in R4S countries) and surveys of relevant national experts on the level of implementation of CF policies and measures as well as future plans and expectations on its role in the respective national agricultural climate policies. The results of WP3 will then be published in a paper on policy barriers and drivers of CF schemes in 2024.

Based on these results, a first draft of a roadmap was developed (within WP4), which was then discussed in an online workshop (Figure 1).

Finally, already existing roadmaps such as the one published for Flanders by Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) were also taken into account (Facq et al., 2023).

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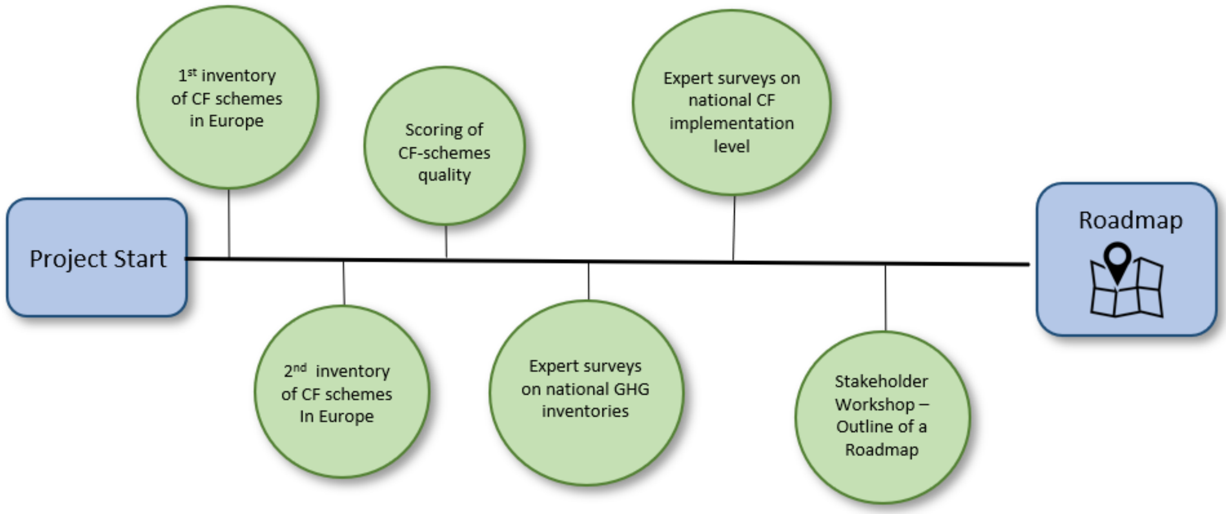

Figure 1: Schematic representation of the research leading up to the outline of the roadmap

3. Definition of carbon farming based on our experience

Carbon farming consists of "farm management practices that aim to deliver climate mitigation in agriculture" (McDonald et al., 2021). Because the scope of this definition involves the entire farm, it considers both arable as well as livestock farming and refers to "all pools of carbon in soils, materials and vegetation, plus fluxes of carbon dioxide (CO_2) and methane (CH_4), as well as nitrous oxide (N_2O)" (COWI, Ecologic Institute and IEE, 2021). "This can be done by voluntary agreement in which a farmer or a group of farmers commit themselves to apply carbon farming measures in return for a payment in any form" (Smit et al, 2024). Still a major aim of CF is the optimization of the carbon balance of soils.

These agreements (CF schemes) encompass explicit definitions regarding targets of C sequestration, avoided GHG emissions and eventually other ESS, potential measures, and the framework for monitoring, reporting, and verification (MRV), as well as the associated remuneration. The specifications of these agreements may vary, being territory-specific (such as a province or state), land use-specific (e.g., arable land), or ecosystem-specific (e.g., peatland). These schemes can be initiated either by governmental or private entities, and their implementation may involve bilateral agreements between farmers and scheme providers, or alternatively, they could undergo third-party auditing and external certification. Notably, there are three distinct approaches to these agreements: action-based, result-based, and hybrid schemes.

An **action-based** carbon farming scheme is a scheme where the farmer or landowner receives a payment for implementing predefined carbon farming measures, independently of the resulting impact of those measures (Smit et al., 2024; in preparation).

In detail, action-based payments are made for the adoption or avoidance of farming practices or technologies. Such payments shall be made to compensate for the increased costs incurred by the farmer as a result of the change in farming practice and/or the initial loss of crop yield.
A **result-based** carbon farming scheme is a scheme where the farmer or landowner receives a payment for reducing net GHG fluxes from their land, whether that is by reducing their GHG emissions or by sequestering and storing carbon in soil. A result-based approach requires a direct and explicit link between results delivered and payments. The measurable result is the balance between reduction of GHG emissions and carbon sequestered (Smit & van der Kolk, in preparation). Result-based schemes require a system of communication, monitoring, and verification of results, which could lead to increased administrative, bureaucratic and financial burdens, especially for small and medium-sized farms. In addition, results-based schemes require high accuracy and robustness of the data and high reliability of the measurements.
However, many of the expected results depend on complex phenomena (e.g. effects of climate change, natural disturbances, etc.), which are sometimes difficult to monitor or influence and in which agriculture and forestry are important, but not exclusive, players.
A **hybrid** carbon farming scheme is a scheme in which part of the payment is a reward for the carbon farming measures applied and the remainder is only paid when the results of these measures is as positive as agreed beforehand (Smit & van der Kolk, in preparation). In hybrid schemes, farmers receive a basic payment based on actions and an additional payment based on the desired and achieved result.

According to Smit et al. (2024) the most frequently implemented CF measures are the following:

- **cultivation of catch and cover crops**
  A cover crop is a close-growing crop, that provides soil protection, seeding protection, and soil improvement between periods of normal crop production, or between trees in orchards and vines in vineyards (Soil Science Society of America, Inc, 2008).
  A catch crop is defined as a fast-growing crop that is grown between successive plantings of a main crop.
- **crop residue management/incorporation**
  Disposition of stubble, stalks, cuttings, straw and other crop residues by tillage operations (Soil Science Society of America, Inc, 2008). The activities concern the on-site maintenance of plant residues, stubble and stalks or their burial.
- **application of manure, compost and digestate**
    - Manure: The excreta of animals, with or without an admixture of bedding or litter, fresh or at various stages of further decomposition or composting (Soil Science Society of America, Inc, 2008).
    - Compost: Organic residues, or a mixture of organic residues and soil, that have been mixed, piled, and moistened, with or without addition of fertilizer and lime, and generally allowed to undergo thermophilic decomposition until the original organic materials have been substantially altered or decomposed (Soil Science Society of America, Inc, 2008).
    - Digestate: organic matter resulting from the anaerobic digestion process of the matrices and substances used alone or mixed together such as straw, cuttings and pruning and other non-hazardous agricultural material (Gazzetta Ufficiale della

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Republica Italiana, 2006); agricultural material coming from dedicated agricultural crops; from livestock effluents; from waste water; from the vegetation waters of mills and wet marc (Gazzetta Ufficiale della Republica Italiana, 1996); residues from agri-food activity; animal by-products used and agricultural and forestry material not intended for human consumption.

- Many of the above-mentioned measures are part of organic or regenerative farming. Thus, farms using these cultivation systems can also contribute to a positive carbon balance. The definitions of both terms are given below:
  - **Organic farming:**
    Crop production system that reduces, avoids, or largely excludes the use of synthetically compound fertilizers, pesticides, growth regulators, and livestock feed additives (Soil Science Society of America, Inc, 2008).
  - **Regenerative farming:**
    an approach to farming that uses soil conservation as the entry point to regenerate and contribute to multiple provisioning, regulating and supporting services, with the objective that this will enhance not only the environmental, but also the social and economic dimensions of sustainable food production' (Schreefel et al., 2020).
- **Agroforestry**
  Any type of multiple cropping land-use that entails complementary relations between tree and agricultural crops and produces some combination of food, fruit, fodder, fuel, wood, mulches, or other products (Soil Science Society of America, Inc, 2008).
- **Land use change**: Changing managed (arable) land to other land uses may be a possibility to increase or preserve carbon in the soil. Possibilities are:
  - **Permanent grassland**
    Land used permanently (for several consecutive years, normally 5 years or more) to grow herbaceous fodder, forage or energy purpose crops, through cultivation (sown) or naturally (self-seeded), and which is not included in the crop rotation on the holding (Eurostat, 2023).
  - **Rewetting of drained peatland**
    All deliberate actions that aim to bring the water table of a drained peatland (i.e., the position relative to the surface) back to that of the original, peatforming peatland (Joosten, 2021).
  - **Afforestation**
    is the conversion of abandoned and degraded agricultural lands into forests (Santos et al., 2019).

4. Steps of implementation – Outline of the Roadmap

The following steps should be taken into consideration when planning the implementation of a CF scheme/measure/project in a targeted region, based on the previously mentioned existing report for the Flanders region – based on the report from Flanders (ILVO) (Facq et al., 2023). Although action-

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based or hybrid schemes are still favoured by practitioners, we focus on the result based scheme as this is the one aimed at in the initial project layout.

a) Definition of a main responsible institution

As a first step, a main responsible party should be defined to designate a registration entity as an official, central communication point to take care of the administration and set up of the CF design. This could be either at country or regional level and carried out by a public institution (e.g. governmental institutions, chambers, or unions), private institutions (private companies in economy, agricultural service, technical service, etc..), or a collaboration of different institutions. This party would then be responsible for setting the framework and monitoring the project.

b) International framework – orientation for planned system:

A comprehensive overview/analysis of already existing CF measures/guidelines should help to guide the individual system in terms of defining the objectives of CF (measures), establishing reporting schemes/procedures and addressing harmonisation topics. By identifying pioneer projects/countries, similarities and differences in different steps and designs of effective CF systems/projects can be highlighted and learned from. This can not only be of help ongoing projects, but also provide inspiration for other projects and countries, as well as sharing experiences and recommendations with an international audience. Furthermore, a central contact point per e.g. country could facilitate this international exchange of experiences/recommendations. The establishment of a strong institutional framework is not only important for aligning and comparing soil carbon optimisation systems and ensuring their meaningful utilization in offsetting emissions, but also for assuring their attractiveness to all stakeholders, in particularly to farmers. A first orientation can be derived from the inventories carried out during the R4S project.

c) Local awareness of CF

A collaboration with local advisory services, institutions, policy makers, CF scheme developers (MRV network) is essential to raise and/or secure the local awareness for CF and CF practices for the target area of the CF project as well as to develop the knowledge system for MRV methodologies. An 'inventory' of available practices and suitable/adaptable resources (e.g. machinery) should be compiled. Close collaboration with institutions involved in an MRV network will facilitate the development of a positive list of CF practices, which should include a comprehensive cost-benefit analysis. It will also help to identify those measures and policies that yield the most significant impact and optimal results, taking into account co-benefits, trade-offs, and current adoption rates. Emphasizing the positive aspects of CF schemes (such as increases yields and stability, improved soil structure and increased resilience) can build capacities and motivated stakeholders, particularly farmers. However, it may be difficult to monetarise the total cost-benefit ratio to show farmers that it is worthwhile investing in CF. In addition, the suggested measures need to fit in with the workload that farmers are already experiencing with increasing farm sizes and administrative tasks. Finally, it is important to investigate available financing schemes and existing business models to identify viable options. Schemes can be financed from three different financing sources, which were defined within

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the R4S project: by public payments, within the corporate value chain, or through the voluntary carbon market (Figure 2). These measures will reduce the cost of developing an MRV methodology. However, MRV differs for action or result based schemes.

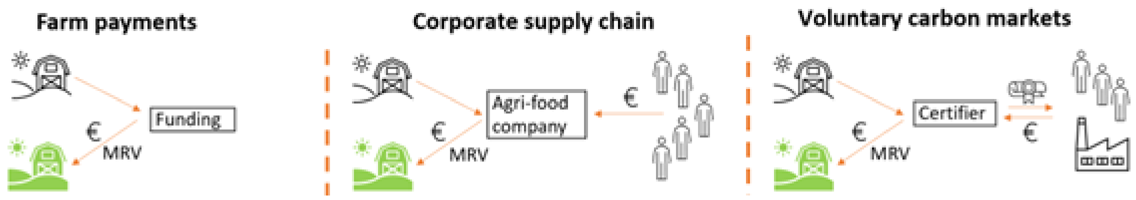

Figure 2: Typology of schemes applied in the assessment of CF schemes (Source: Thorsøe et al., 2024, adapted from McDonald et al., 2021)

d) Local framework for CF

Based on the R4S project, we suggest establishing a local framework based on six components, a shared narrative, clear communication, data infrastructure, reporting systems and funding clarity. These elements jointly serve as important enabling conditions for developing and establishing CF at the local level (Facq et al. 2023).

i. Creation of a shared narrative among stakeholders (governments, farmers, society, private actors, researchers)

The establishment and adherence to a shared narrative serves as the linchpin for effective knowledge exchange and collective learning. It is needed to cultivate a common understanding of best practices, promoting a collaborative ethos, and facilitating the emergence of a cohesive framework that sustains growth, innovation and reliability. Establishing networking initiatives is a key interest to facilitate knowledge exchange and the creation of a comprehensive knowledge hub for practical insights. This involves clearly defining CF schemes and management practices. Emphasising the necessity for a clear, robust, and inspiring long-term vision of the purpose and objectives of CF, ensures lasting legal certainty. It is also important to establish clear and robust protocols, MRV procedures, and payment regulations. Integrating CF practices into agricultural education is essential to raise awareness and introduce CF knowledge and provide tools for farmers and practical stakeholders. Further, providing clear guidance on strategy and CF options and implementation at national level helps to prevent confusion about their effects (recognising the potential for individual strategies to create ambiguity in the hierarchy of importance amongst stakeholders). Additionally, it is also important to communicate the outcomes/results of CF projects clearly and frequently to all stakeholders.

ii. Clear communication of CF-principles: additionality, long term storage, co-benefits (ESS)

Information on the principles and effects of CF in relation to agri-environmental challenges such as nutrient management, biodiversity, yield, and erosion should be consistently

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disseminated. Clear communication is needed to ensure that investors, famers and policy makers have a realistic idea of what CF can deliver, which is an important basis for confidence in CF schemes. The primary message should centre around soil health and climate adaptation to effectively motivate farmers. Utilize suitable modes and forms of communication tailored to reach specific stakeholder groups. It would therefore be appropriate to provide carbon farming practices that are closely linked to agroecological principles in order to promote holistic and sustainable agricultural techniques that deliver real environmental benefits. An agroecological approach (as defined by the FAO) should include a combination of techniques designed to promote overall soil and environmental health.

Based on the proposed criteria by the European Green Deal (QU.A.L.ITY), the following CF principles were defined within R4S: Additionality, Long Term Storage ('Permanency') and multiple focuses.

'Additionality' refers to the extent to which the carbon farming project increases carbon removals and/or carbon reductions beyond what would have occurred in the baseline, i.e. in the absence of the project. Additionality implies that the removals/reductions are caused by carbon farming measures additional to national and EU-wide regulatory requirements or the incentive effect of certification.

Long-term storage or *'Permanence'* refers to the longevity of the storage of C-removals as a result of carbon farming measures. These issues should be translated into standards or regulations that CF schemes should comply with.

It is noted that the permanence of C storage in the soil is subject to structural risks, such as the risk of carbon release (*reversal effect*) from the soil due to uncontrollable/unintentional natural events (e.g. effects of extreme weather events such as erosion and drought, forest fires, etc.) or intentional events (e.g.: due to management changes) (McDonald et al., 2021). Also, the *leakage effect* should be considered when planning a CF schemes. Leakage is defined as the net change in anthropogenic emissions/removals that occur outside the project boundary. If leakage occurs, the overall mitigation impact of the project is reduced; if this is not considered in net quantification of removals, these removals will not all be additional (Smit et al., 2024).

Therefore, standard relocation and release risks should be applied or calculated based on risk assessment tools.

Finally, there are also *multi focus schemes and co-benefits for ESS* such as biodiversity, water regulation or nutrient cycling.

Ideally, *possible trade-offs, co-benefits, and leakage effects* of implemented CF schemes should also be transparently discussed, communicated, and considered in subsequent implementation steps and remuneration of carbon differences in the planned system. The same applies to possible reversal effects, that need to be taken into account in CF mechanisms.

It is also essential to clearly communicate specific targets related to climate mitigation/change, such as the expected reduction of CO_2-eq emissions per hectare per year, or the total CO_2-eq emissions reduced over the entire project duration. It is important

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to recognise that these figures are strongly related to regional conditions such as weather and soil types.

iii. Data infrastructure integration: databases (geodata, measurements – verification (baseline, aim)), public registries

The integration and connection of existing data(bases) with new measurements and innovative technologies such as sensor or satellite measurements can reduce the administrative burden on farmers and the cost of implementing MRV for a CF project. Consideration could be given to utilizing a geodata platform as a stepping stone towards the establishment of a central registry, which is advised to be open source. The creation of a data hub and platform specifically designed to host CF calculation modules might facilitate effective and accurate MRV.

The main objectives of CF measures/projects are to increase/stabilise carbon stocks, reduce GHG-emissions, avoid GHG-emissions and, if possible, combined with other ESS (biodiversity, water regulation, nutrient cycling etc.). Before verifying the results/outcomes against the CF project objectives, a baseline has to be defined. This baseline should reflect (and be highly representative of) the standard performance of comparable activities in similar social, economic, environmental and technological circumstances and geographical locations, or/and be obtained by using models and remote sensing. The baseline is a reference point that can be used to quantify the project outcomes by comparing realised carbon sequestration to the defined baseline (Facq et al., 2023). However, the baseline may be dynamic and adapted to local/regional historical facts/numbers (i.e. soil has continuously lost C for the past measurements/monitorings, etc.), land use (agricultural vs. forest vs. grassland), and other significant possible effects, that might lead to results that are disproportionate to the given circumstances.
The CF project results can be validated in different ways – through science-based standards, soil analysis (e.g. TOC, oxidizable C, TOC/C_{ox} ratio) modelling, remote sensing, or internationally approved standards. If the project objectives are met, this can result in either certificates, labels, or Carbon Credits.
Furthermore, it is also important to establish a national registry for carbon credits or a national certification scheme in line with the EU Carbon Certification Framework (EU CRCF).

iv. Reporting systems – harmonized protocols, collecting data in support of CF

Project results can be reported at different levels and in different systems. Results could be reported either directly from the farmer(s) to the financing parties (personal reports), from the analytical institutions (laboratories) to the financing parties or collected by a responsible person in a governmental institution reporting e.g. for a region (regional reports) or for a whole country (national reports). Hence, the results may be reported in systems such as being included in a national inventory/monitoring reports, EU reports (in case of cooperation with EU projects, etc.) or the results may be presented in research

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papers/studies/reports (Figure 3). However, in order to guarantee quality, it is crucial to harmonize protocols and formulate a collective approach, especially for joint improvement of modelling efforts. This involves establishing standardized experiments and monitoring plots to support MRV, as well as the development of uniform/standardized/harmonized protocols for soil and crop sampling protocols, data templates, and databases to systematically collect data from these sites. The aim is to establish accurate MRV systems that are adapted to regional conditions.

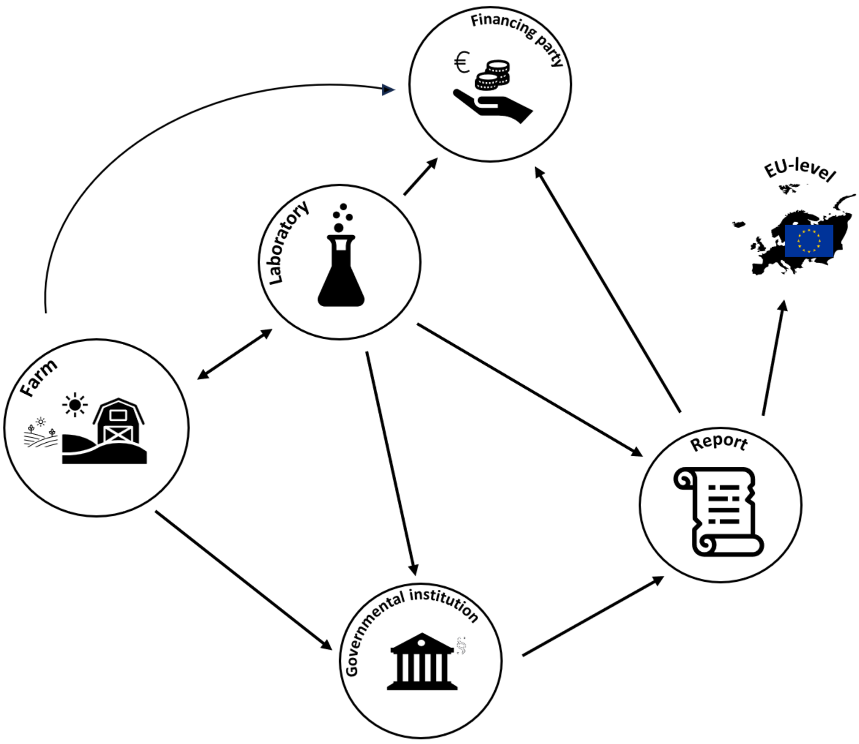

Figure 3: Overview of reporting possibilities and levels

While action-based schemes are predominantly used currently, a shift towards result-based schemes necessitates the implementation of an accurate MRV system. This system is essential for quantifying the additional carbon sequestration achieved by specific management practices in both space and time. However, a key objective should be to try to limit costs for this provement of a permanent additional carbon sequestration. This becomes particularly important as payment levels in result-based schemes are designed to reflect the actual impact of management practices on carbon stocks.

To facilitate harmonization, there is a need to establish data infrastructure platforms, as mentioned in the previous point. These platforms should enable data exchange between public and private entities, fostering collaboration and ensuring a standardized approach across different stakeholders.

v. Clarity on combining public and private financing

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Clarity about the governance structure (including reporting and verification), the definition of clear guiding principles and the division of responsibilities is essential for effective implementation. This could be done by official institutions (government bodies, chambers, agencies, etc.) associations, private companies, or cooperatives of different institutions. In the case of cooperation, especially in the case of combined financing schemes, transparency and exchange between public and private funders is crucial to facilitate collaboration. As mentioned above, this could be supported and assisted by the creation of a networked platform or tool to ensure smooth communication between the responsible parties.

vi. Ensuring attractiveness for farmers and/or financing organisations/institutions

An appropriate incentive structure is an important basis for a functioning CF system. However, it has to be taken into account that certain CF activities are already included within existing regulations and subsidy schemes. In addition, effective communication is essential to highlight the differences between scheme options, such as result-based versus action-based, and the creation of secure payment models for result-based schemes, particularly in anticipation of potential climate change-related changes.
For farmers in particular, the provision of clear frameworks, guidelines, transparent financial remuneration, additional benefits for the promotion of multiple ESS, and concrete recommendations for the implementation of CF measures are of main importance. For financing parties, these factors are important to incentivise trade and establish a clear business image.
For private carbon markets, whether voluntary carbon markets or value chain schemes, it is recommended to clarify the scope and aims (see point iii) of CF while ensuring compliance with both national and international standards (see point iv). This requires the establishment of reliable quantification methods for CF measures and the implementation of an effective MRV system, all without escalating costs.
Furthermore, a better understanding of the policies and measures that can deliver the best results and have the most significant effects/impacts is essential to promote successful CF initiatives.

e) Experience from initial projects (if available) – lessons learned from inventory, scoring for evaluation, development of continuously improving knowledge base

To guarantee an optimal CF scheme, it is beneficial to actively exchange experience and knowledge, highlighting inspiring ideas from pioneering countries, taking into consideration factors such as awareness and business models. The aim is to provide comprehensive information and a clear overview for the relevant contact persons within the different stakeholder groups, and to design national monitoring systems that is better suited to serve as a lever for the implementation of CF schemes.

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With regard to research organizations, the exchange plays an important role in continuously documenting new knowledge on CF practices, business models, and potential improvements. This involves facilitating the exchange of information between research entities and projects, contributing to a collaborative and evolving knowledge base in the field of CF.

f) Local implementation (according to a decision matrix), including local and regional knowledge hubs and contact to existing advisory services

As explained in earlier sections and also emphasized by workshop participants, it is recommended to include a country/local practical exchange through knowledge hubs or similar initiatives during the implementation of CF practices. This should be managed/led by the main responsible party/person (see point a). Local advisory services could facilitate this by establishing connections to best-practice farms and demonstrations, thereby facilitating the dissemination of practical recommendations to stakeholders. These recommendations draw upon the insights gained from best-practice farms or relevant documentation. Moreover, where possible, advisory services should disseminate information/conclusions/(historical)data on local practices, considering specific local/country (soil) characteristics (i.e. soil data and classification such as soil texture, soil classes, soil depths, C-stocks, management practices, climate data, etc.). This could be done by developing specific calculation modules for farmers and advisors, taking into account the different complexities mentioned above.
Furthermore, before locally implementing CF measures or schemes it is crucial to define the specific target area for intervention, which can range from individual agricultural fields to entire farms or another designated space. Additionally, it is also important to consider the planned economic framework of the CF-scheme, in particular to clarify the responsibilities and roles of farmers. These roles may vary depending on factors such as occupation or involvement status (e.g. membership in a cooperative, participation on a board, or being a shareholder). Other factors to be considered include the duration of the contract (1, 1-5, 5-10 and >10 years) and the mode of contribution to the scheme, whether individual or collaborative within a team.

g) Identify knowledge gaps, development of solutions including further research

In maintaining ongoing communication with knowledge hubs, research institutes, advisory services and other relevant entities, it is essential to institutionalize a continuous exchange. This ensures an early identification of barriers to be addressed and knowledge gaps, facilitating the timely allocation of resources to address these gaps in the future.

h) National upscaling – possibilities, prerequisites

Taking into account and harmonising the previously mentioned points, all perspectives and circumstances need to be considered when upscaling the CF system(s). Examples of prerequisites include: awareness raising, inclusion into educational and training programmes, information/knowledge exchange, clear guidelines and regulations, incentives (financial, agro-economic and -ecological), cost-benefit analysis and appropriate funding, transparent

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compensation structures/schemes, data transparency, uniform standards and baselines, close and clear cooperation with MRV system managers and support for system adaptation.

5. Decision Matrix

Based on the above-mentioned parameters the following decision matrix was created. Following this matrix should then facilitate the appropriate selection of a CF-system/measures adapted to local requirements and aims.

5.1. Decision matrix approach based on the outline

a) Common principles

- baseline
- long term storage/permanency
- leakage
- possible reversal
- multiple focuses/ESS
- co-benefits
- result-based
- action-based
- combination/hybrid system
- dynamic baseline (adapted modelling!) or standardised baseline

b) Definition of the aim

- increasing or stabilizing C-content (C-Seq)
- reducing GHG-emissions
- avoiding GHG-emissions
- additional ESS (biodiversity, etc.)/additionality

c) Local characteristics to be considered

- soil characteristics (incl. management influence)
- climate (incl. expected climate mitigation/change)
    - …ton CO_2-eq per ha/in total per year
    - …ton CO_2-eq per ha/in total over the full project duration
- agricultural structure
    - field based
    - farm based
    - total area/share of area (%)
- "legslative " framework
    - farmers responsibility (member of cooperation, member of board, shareholder)
    - contract duration
    - number of farmers included per scheme

d) Preferred financing scheme

Schemes funded

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- by public payments
- within the corporate value chain
- via the voluntary carbon market
- cost-benefit ratio

e) Preferred CF measures

- cultivation of catch and cover crops
- crop residue management/incorporation
- application of manure, digestate and compost
- tillage management
- organic or regenerative farming
- agroforestry
- If none of the above mentioned measures seem to be sufficient:
  - grassland management
  - rewetting
  - afforestation
  - other (e.g. species diversity, hedge management)

f) Preferred monitoring method

- science based standards
- analysis of soil samples (TOC, oxidizable C, ...) - for result based schemes
- modelling
- remote sensing
- international approved standards

Resulting in

- *certificates*
- *labels*
- *Carbon Credits*
- *Increased product prices*
- *Official subsidies*
- *important: Documentation of long-term storage*

g) Preferred reporting

- direct reporting by the farmer
- collective reporting (e.g. by a group of farmers, performing labs)
- regional reports
- national inventory reports (Monitoring reports)
- EU reports
- research papers/studies/reports

h) Governance structure and verification

Who is in charge? What is the individual role?

- official institutions – governmental body, chambers, agencies,…
- associations
- private companies
- cooperating institutions

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5.2. Development of a matrix

Based on the different topics according to the points mentioned before, the development of a matrix with preferences is possible. You might use the tables presented below, filling in the preferred options, ranked by applicability (see Table 1 & Table 2). However, the involved institutions/stakeholders should be determined at the beginning.

Table 1: Template for a decision matrix (number of columns dependent on individual topic)

	1st option	2nd option	3rd option	4th option	5th option
Common principles ((dynamic) baseline, leakage, possible reversal, long term storage, etc.)					
Aim					
Financing scheme					
Economic framework					
Governance					
Measures					
Validation method					
Reporting					

Table 2: Local characteristics as determining framework conditions

		1st option	2nd option	3rd option	4th option	5th option
Local characteristics	**Soil**					
	Soil Management					
	Climate					
	Agricultural structure					
	Type of practice implemented to reduce greenhouse gas emissions					

5.3 Example – vegetable farmer at Marchfeld (AT)

By following this decision matrix/form, stakeholders can systematically make decisions tailored to the unique characteristics and goals of their carbon farming project. This can be done e.g. by evaluating the different options according to a scoring system from 1 (not important) to 10 (crucially important). The alignment across these different components is crucial for creating a cohesive approach to CF

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schemes. Such cohesion not only enhances the efficiency of resource allocations, but also promotes a holistic and integrated strategy, contributing to more effective and sustainable solutions.

Common principles:

- If additionality is a primary concern:
  Implement additionality-focused measures.
- If permanency is a priority:
  Choose measures with long-lasting effects (e.g. long-lasting contracts, land use change)
- If multiple focuses/ESS is essential:
  Select measures that address various environmental and social issues (e.g., biodiversity enhancement, organic farming).
- If possible trade-offs, leakage and/or reversal effects are of concern:
  Consider possible effects of selected measures

	Additionality	Permanency	Multiple ESS	Trade-offs
Common principles	5	10	5	6

Definition of the Aim:

- If increasing or stabilizing C-content is the aim:
  Choose measures that enhance or stabilize soil C
- If reducing GHG-emissions is the goal:
  Implement measures that directly reduce emissions
- If avoiding GHG-emissions is the goal:
  Implement measures that directly avoid emissions
- If additional ESS are focused:
  Implement measures that aim to affect multiple ESS

	Increasing/stabilizing C	Reducing GHGs	Avoiding GHGs
Aim	10	6	7

Local Characteristics:

- Consider local conditions:
  Soil characteristics: chernozem on calcareous loess
  climate: Pannonian
  agricultural structure: field based
  soil management: crop rotation according to XY + conv. NPK-fertilization
- Based on that assess the potential:
  Ton CO_2-eq per ha/in total per year or over the full project duration (choose gross or net): 5-10 t/ha/y net C-Sequestration
- Evaluate farm-specific factors:

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Field-based: 5 ha

- Evaluate the economic framework
  farmers' responsibility (member of cooperative, member of board, shareholder): land user
  contract duration (1, 1-5, 5-10, >10 years): 5-10
  number of farmers included per scheme: 10

Preferred Financing Scheme:

- If public payments are available:
  Explore schemes funded by public payments: ÖPUL
- If corporate value chain involvement is possible: -
  Consider schemes within the corporate value chain.
- If the voluntary carbon market is viable: Zukunft Erde
  Explore schemes via the voluntary carbon market.
- Evaluate Cost-benefit ratio for each financing option.

	Public Payment	Corporate Value Chain	Voluntary Carbon Market
Financing Scheme	7	3	10

Preferred CF Measures:

- Based on aims and local conditions:
  Choose appropriate carbon farming measures:
    - Cultivation of catch and cover crops x
    - Crop residue management/incorporation x
    - Application of manure and compost x
    - Organic or regenerative farming x
    - Agroforestry
    - If othrs not sufficient:
        - Permanent grassland
        - Rewetting of peatlands
        - Afforestation
        - Other (species diversity, tillage management,…): reduced tillage

	catch and cover crops	crop residue manageme nt/incorpor ation	Manure and compost	Organic or regenerativ e farming	Agroforestry	Grassland managem ent	rewetting	afforestation	other
Measures	9	8	8	7	2	1	1	1	8

Preferred Monitoring Method:

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- Regarding scientific rigor l:
  Use science-based standards or international approved standards.
- Regardingpracticality:
  Consider analysis of soil samples, x
  modelling
  remote sensing

Specify the resulting documentation:

Certificates x
Labels
Carbon Credits x
Increased product prices
Official subsidies

	Science based standards	International standards
Scientific	1	1

	Soil analysis	Remote sensing	Modelling
Practical	10	5	5

	Certificates	Labels	Carbon Credits	Increased product prices	Official subsidies
Documentation	8	1	6	2	3

Preferred Reporting:

- Based on governance and project scale:
  direct reporting by the farmer: direct report to land manager/user
  collective reporting (e.g. by a group of farmers, performing labs)
  regional reports
  National Inventory reports
  EU reports
  or research papers/studies/reports:

	Direct reporting by farmer	Collective reporting	Regional reports	National inventory	EU report	Research papers/studies/reports
Reporting	9	5	5	3	1	7

Governance Structure:

- Depending on the decision-makers:
  Official institutions (governmental bodies, chambers, agencies),
  associations,
  private companies: RWA in cooperation with AGES
  cooperations

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- Define individual roles and responsibilities within the chosen governance structure: RWA for sampling and funding, AGES for soil analysis

	Official institutions	Private companies	cooperations
Governance	7	10	9

Conclusion

Based on careful analysis of regional characteristics and requirements, a roadmap for the implementation of widely accepted carbon farming measures can be developed. As a first prerequisite, a functioning governance system comprising a responsible institution has to be determined. Using the proposed matrix, it should be possible to develop tailor made systems. Nevertheless, principles of compatibility with systems of other European regions should be obtained.

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