ClieNFarms Policy Brief #2: Challenges of using models for monitoring and assessing GHG emissions of European farms

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Introduction

The EU has set targets to achieve zero emissions in several sectors by 2050 as defined in the EU climate law. Agriculture is one of the sectors that is expected to reduce and compensate from other sectors at the same time. Therefore, monitoring, reporting and verifying (MRV) the greenhouse gas (GHG) emissions and potential carbon sequestration on farms is critical to assess progress towards net-zero emissions farming across the EU. This is particularly relevant now that the European Commission is proposing carbon farming methodologies for certifying carbon removals in accordance with the Carbon Removal and Carbon Farming Regulation (CRCF). To estimate GHG emissions and removals accurately, the Intergovernmental Panel on Climate Change (IPCC) introduced three methodologies called Tiers, each providing different degrees of accuracy and complexity. The higher the Tier, the more complex the approach is, with Tier 1 describing a generic factor, Tier 2 referring to a national factor or simple equation and Tier 3 characterising process-based models. While there is a wide diversity of tools available on the market for assessing GHG emissions of a farm, agricultural products and area-based emissions[i], knowing which tools to use in each context poses challenges.

Aim of the Policy Brief

This policy brief aims to inform policy makers about the challenges and opportunities of modelling approaches in MRV systems and their application on farms. Especially, as the release of the new CRCF will include modelling as a suitable option, advantages and challenges of applying models are in the focus of interest.

ClieNFarms

The content of this policy brief is based on the research carried out within the EU Horizon 2020 project ClieNFarms and the experiences of farmers involved in it. ClieNFarms involved more than 200 farms organised in Innovative Systemic Solution Spaces (I3S) across the EU's different pedoclimatic areas and production systems. In them, different models and climate performance tools were assessed and compared with the following purposes:

1. To analyse how farmer and advisor assessments differ from scientific expert assessments
2. To compare different climate-performance results and methodologies of tools commonly used in the EU context
3. To evaluate co-benefits from agricultural practices implemented at the farm that go beyond the climate-performance scope (e.g. biodiversity).

MRV systems for farm assessments of climate performance

Key finding: The choice of tool in MRV systems and how these tools are parameterised affects the result of the farm assessments of climate performance.

The modelling experiences within ClieNFarms elucidated the factors that affect result accuracy. The available tools are summarised in Figure 1.

- Field measurements have standardized sample procedures that allow for comparisons between field sites, but they are time and labour-intensive.

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- Modelling approaches can simulate different processes over time and provide information about a wide range of relevant environmental variables. However, we have seen that the large variety of tools challenges the comparison between different field sites. In this document, we classify models in two categories:
    - Farm assessment tools, which include the quantification of nitrous oxides (N_2O), methane (CH_4) and carbon dioxide (CO_2) emissions from all farm practices, including upstream emissions and non-agricultural practices (e.g. energy or fuel).
    - Process-based models, which require a different set of data, including detailed soil information (at minimum texture, bulk density and pH) and time series for weather data, which are usually not available for each farm.

Tier 1 and Tier 2 methods are developed and designed to be used by non-modellers, while process-based models (Tier 3) are usually developed for research and can appear to be challenging tools for users without prior modelling experience. User-friendly interfaces can help address the challenge of tool usability, while an underlying structured database—such as that used in the COMET-Farm Tool[ii]—can help overcome issues of data availability. However, this approach requires appropriate database maintenance and ongoing tool support, which in turn pose additional challenges.

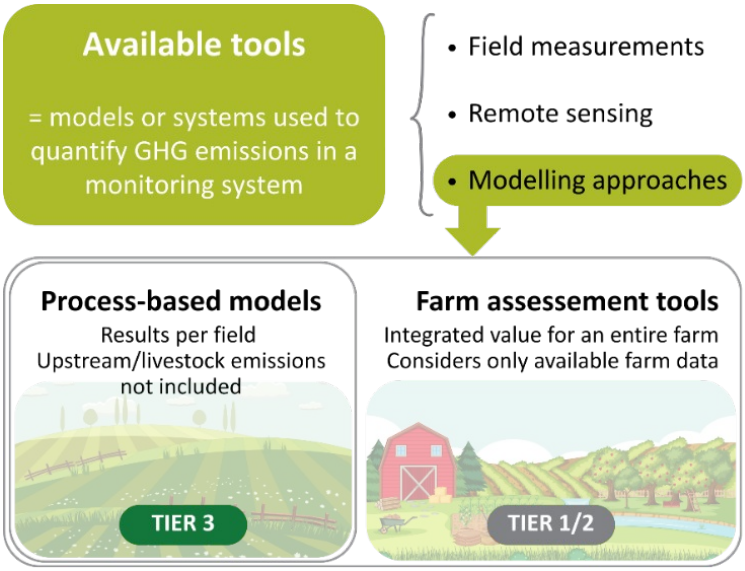

Figure 1 - Available tools to assess GHG emissions can be divided into field measurements, remote sensing and modelling approaches, the latter being associated with different Tier methodologies depending on the type of model. Source: Alba Saez, ClieNFarms.

Organic farming and non-conventional farming focus

Models and assessment tools should reflect the variety of management systems encountered on agricultural land, but studies show that they tend to be better developed and parametrised for conventional farming[ii,iii]. This poses challenges when attempting to apply them to other systems such as organic farming and mixed livestock farming. The experience within the ClieNFarms project has shown that organic farming is misrepresented in the modelling and tool applications. For example, crop rotations, which play a crucial role in the sustainable use of natural resources, cannot be simulated. These tools take each crop for each year separately and do not take temporal variations into account. At the same time, intercropping and many other organic practices such as compost application, etc. are not yet sufficiently represented. The result of the emissions by an organic product or farm are therefore not accurate and misleading.

Experiencing practical application in the EU: challenges of the tools

Key finding: Data availability and sampling also affect result accuracy.

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Tier 1- and Tier 2- based tools are mainly designed for applications on the farm scale and have relatively low data demand that are easily available on a farm. However, local, field-specific measurements are required to follow the temporal development and history of the soil. For example, data collected on-farm and for specific fields is necessary to distinguish crop and grassland areas. Therefore, only process-based models in Tier 3 methodologies complemented with measurements can be used to assess or monitor soil organic carbon (SOC) with an acceptable accuracy (see Figure 2).

On the other hand, to properly validate field measurements and evolution of SOC, several samples are required to get representative SOC measurements. The number of samples depends on the heterogeneity of the target parameters and variables in space and time (e.g. texture, actual SOC, bulk density, pH). For example:

Space: The higher the SOC heterogeneity, the higher the number of samples required to get accurate results.

Time: For a correct representation of the SOC changes, the target period should be adapted to the management on the field.

The CRCF reflects our findings and suggests complementing Tier 3 modelling with field measurements. However, work and energy spent on the assessment should be minimised.

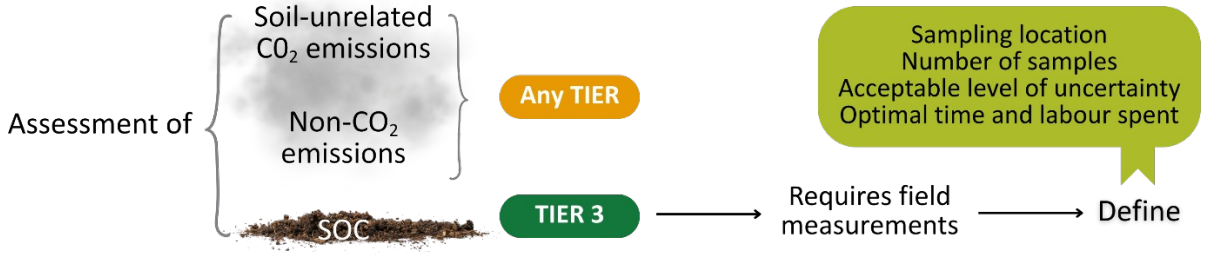

Figure 2 - Tier methodologies recommended for the assessment of different GHG emissions and soil organic carbon (SOC). The light green box shows things to consider when taking field measurements, which are necessary in Tier 3 approaches. Source: Alba Saez, ClieNFarms.

Recommendations

- For SOC assessments and monitoring, process-based models should be used. For the assessment or monitoring of non-CO2 emissions, farm tools are a good option.
- Any Tier 3 methodology used to assess and monitor SOC changes must be complemented with field measurements.
- Clear protocols are required to limit differences between results due to user-led parameterisation, sample heterogeneity and data availability. Assessments should define the target area and time period considering entire crop rotations, to achieve more accurate results and put organic farmers on a level-playing field.

Experiencing practical application in the EU: insights into the user experience

Key finding: The project has shown that, without providing regular and clear training on how to use the climate performance tools for a given purpose and how to interpret the final assessments, the calculations are unlikely to lead to changes for climate action on farms.

The practice of MRV within ClieNFarms was performed by appointed and trained experts that supported farmers of a given pedoclimatic area and production system. Working closer together with researchers, farm advisors and farmers across the EU has highlighted the challenges summarised in Figure 3:

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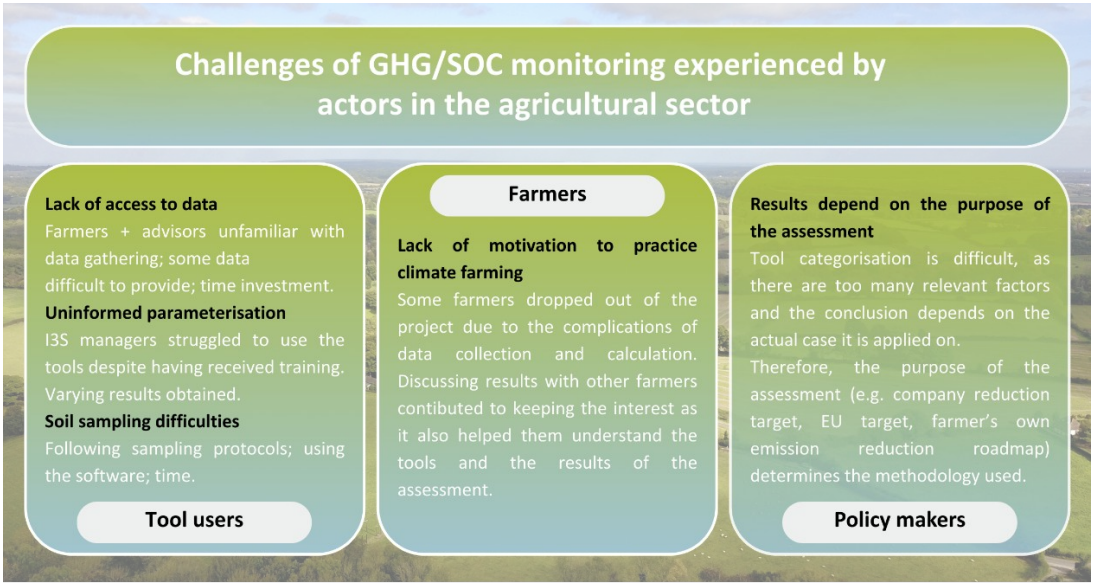

Figure 3 - Challenges of GHG/SOC monitoring experience that affect tool users, farmers and policy makers within the EU agricultural sector. Source: Alba Saez, ClieNFarms.

Farmers and farm advisors unfamiliar with providing data struggled to use the tools, which contributed to uninformed parameterisation and lack of motivation throughout the project, especially when farmers did not understand how results could be interpreted and what actions could follow from the results.

As mentioned in the previous section, farm tools and process-based models can play a role in the quantification of GHG emissions and are enough to quantify non-CO2 emissions, but the error and uncertainty are usually too high for the required standards of SOC changes and soil-related emissions. Therefore, measurements are required, which takes additional time and resources. Some of the data was easily available for farmers (e.g. fertilizer input), while other data remained challenging to answer (e.g. soil data, grassland yield, dry matter (DM) yields for certain crops).

Recommendations

- Policy makers must define the appropriate methodologies for the purpose of achieving emission reductions within the EU agricultural sector. Besides, the people performing the assessments should be adequately trained and rewarded for the time and resources that data collection takes. Policy should ensure that farmers are not bearing this burden alone.

Key references

[i]Niels H. Batjes, Eric Ceschia, Gerard B.M. Heuvelink, Julien Demenois, Guerric le Maire, Rémi Cardinael, Cristina Arias-Navarro & Fenny van Egmond (2024) Towards a modular, multi-ecosystem monitoring, reporting and verification (MRV) framework for soil organic carbon stock change assessment, Carbon Management, 15:1, 2410812, DOI: 10.1080/17583004.2024.2410812

[ii]Ellis, E., et al. 2024. Importance of on-farm research for validating process-based models. Notes models are parameterized on limited experiments and need farm-scale validation. Carbon Balance and Management, 19, 16. doi.org/10.1186/s13021-024-00260-6

[iii]Montemayor, E., et al. 2022. Critical analysis of life cycle inventory datasets for organic crop production systems. International Journal of Life Cycle Assessment, 27, 543–563. doi.org/10.1007/s11367-022-02044-x

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