CEMA
European Agricultural Machinery Association

Position Paper

EU Carbon Farming: Contribution of Smart Agricultural Machinery

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Introduction

CEMA, the European Agricultural Machinery Industry Association, welcomes the Fit for 55 Package proposed by the EU Commission for delivering the European Green Deal. **Carbon farming** is set to be the most important contributor of carbon removals, with a 2030 net removal target of 310 million tons CO_2 equivalent in the Land Use, Land Use Change and Forestry (LULUCF) sector. All the other EU economic sectors and activities combined are expected to sequester 5 million tons of CO_2 equivalent. Diverse carbon farming approaches should support the achievement of this key ambition for reaching an overarching EU-level goal of climate neutrality by 2050, while getting the compounded agricultural and LULUCF sectors climate-neutral already by 2035.

The European Commission defines carbon farming as "improved land management practices resulting in carbon sequestration in living biomass, dead organic matter, and soils by enhancing carbon capture and/or reducing the release of carbon to the atmosphere"[1]. **This definition of carbon farming focuses on the organic matter (i.e., humus) increase in soils, but other important opportunities for GHG emission reduction in agriculture should be considered as well.** This paper is meant to offer a perspective of carbon sequestration in agriculture from a broader context, which considers not only land management (arable farming) but also livestock management and other farming activities.

Monitoring, reporting and verification of carbon sequestration are seen by European authorities as necessary steps to set-up voluntary EU carbon offsetting markets which would handle harmonised carbon certificates. In November 2022, the European Commission proposed the first voluntary framework for certification of high-quality carbon removals[2]. It is expected to pave the way for subsequent legislative proposals on tailored certification methodologies for different types of carbon farming activities.

In April 2022, CEMA published a paper on the role of agricultural machinery in decarbonizing agriculture, laying the ground for our positioning on how smart technology can help turn agricultural land into carbon sinks[3]. The European agricultural machinery industry, shaped by its end customers, European farmers, is committed to the target of reducing GHG emissions and carbon sequestration. For many years, our industry has offered a wide range of innovative machines and technologies meeting the requirements of European and global environmental regulations and enabling climate-smart agricultural production processes.

In light of the forthcoming framework for voluntary carbon removal certifications, CEMA would like to contribute to the public discussion. Thereby we are focusing on the following questions:

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[1] EU Commission Staff Working Document on Sustainable Carbon Cycles – Carbon Farming, accompanying the Communication from the Commission to the European Parliament and the Council Sustainable Carbon Cycles, 15.12.2021.

[2] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7156

[3] https://www.cema-agri.org/publications/17-position-papers-publications/916-the-role-of-agricultural-machinery-in-decarbonising-agriculture

- How can smart practices and technologies support carbon farming and measurement of carbon sinks?
- What methodological framework would be feasible for the quantification of carbon removals?
- What policy support measures are necessary for fostering and scaling-up the uptake of carbon farming and carbon removal certification?

1. Smart practices and technologies in support of carbon sinks

Good agricultural practices exist in the LULUCF sector that are indisputably positive for the GHG balance. The EU Sustainable Carbon Cycles initiative especially highlights as exemplary the restoration and rewetting of peatlands and wetlands, agroforestry, and maintaining and enhancing soil organic carbon (SOC) on mineral soils. In our view, **the overall potential of carbon farming practices must be clearly assessed in relation with the crop production function**. Peatlands and wetlands are natural carbon sinks in organic soils which in case of restoration turn into a large carbon source. However, most EU farmers deal with carbon matter in mineral soils whose carbon sequestration potential is much more limited in comparison to organic soils, while they are delivering the highest crop production output.

Across farming practices and production systems suitable for enabling and maintaining carbon removals in mineral soils, the most promising ones focus on increasing the root mass for reducing soil erosion and creating soil carbon. Respective carbon capture and storage results correlate with several region- and spot-specific natural factors like the soil type, climate, and landscape conditions. **The use of connected precision farming technologies** to optimize the application of soil work, seeds, fertilisers, and pesticides in accordance with individual needs of specific agricultural areas and crop varieties **is a key solution for enabling and maintaining soil health and carbon sequestration.** This includes:

- less soil compaction, less traffic marks in the field,
- use of improved, adapted practices in soil tillage and crop residue management leading to increased soil fertility and soil resilience to erosion,
- use of more plant- and soil-specific and precise monitoring and treatment of sowing, planting, fertilising, spraying pesticides, and harvesting operations,
- adaptation of mechanisation for cover- and deep-rooting crops, intercropping, multi-cropping, rotation extension, agroforestry, conversion from arable to grassland; and for a combination of these practices,
- use of dedicated operations for organic farming like mechanical or electrical weeding.

The digital transformation of agriculture can support in reaching the carbon capture and storage targets. Connectivity (5G and broadband), advanced digital technologies and data analytics are key for carbon farming. **Sensing technologies (including remote sensing) and data driven monitoring tools** can enable farmers to make better decisions towards carbon farming, help them establish the most suitable agricultural production systems, prove the achievements of good practices, and lower their administrative burden. The establishment of a common European agricultural data space is an important part of this transformation. Also, **advanced agricultural machinery** embedding the application of remote and local sensing technologies and data driven monitoring tools is an essential part of carbon farming ecosystems.

Already today, farmers can apply different tools to document farming operations. The data generated through these tools can be used to analyse and certify the corresponding impact on the on-farm CO_2 and soil carbon balance, especially for **action-based carbon farming outcomes.** Those outcomes are often linked to the use of good practices, along with basic and additional requirements set up by the Common Agricultural Policy (CAP).

Going forward, more **result-based carbon farming indicators** can be potentially measured and certified with soil sensors (also installed on agricultural machinery) – in combination with quantitative inputs coming from other machine sensors and data-driven monitoring tools, embedded on advanced agricultural machinery, and consolidated in farm data management systems. A more detailed overview of carbon farming practices and outcomes supported by smart agricultural machinery technologies can be seen in Annex I.

At this stage, there are still challenges to overcome in the measurement of carbon soil matter at field and/or spot level and in real time, but soil sensing technologies are evolving and start to become available. Such sensors, **calibrated and tamper-proof**, could be potentially mounted on agricultural machinery and reduce manual sampling significantly. In the near future, data collected from available soil sampling technologies, remote sensing and embedded agricultural sensors and/or stored in different equipment modules could be linked to each other within a modern and interconnected farm management system. These factors combined make it a less burdensome exercise for farmers to report on their carbon sequestration activities and outcomes.

Diverse technological solutions are under development that would support a broader implementation of carbon farming practices, enable their verification, as well as measurement and certification of the soil carbon balance (and related to that, prove impacts on biodiversity, water retention, soil structure, and soil compaction essential for soil health and humus building). The exponential growth in IT and data science will make it possible to offer affordable, environmentally friendly, and widespread agricultural sensing systems and data-driven analytical models for field-scale operations. Together with other advanced technology industries, CEMA is committed to further develop its smart agricultural technologies – in close alignment with the needs of European farmers and in collaboration with the up- and downstream agri-food value chain.

2. Methodological framework for certification of carbon removals

Methodologically and technologically, it remains challenging to quantify carbon sequestration in soils, especially in the long run and in accordance with the additionality principle. A scientifically sound determination of carbon removals must include an assessment of stable (recalcitrant) soil organic carbon, since not all soil organic matter can be sequestrated over a long time. The science and modelling to differentiate the organic carbon pools in the soil are both still in the realm of research and have yet to get to a place where the sampling techniques or the modelling are ready for a wide use in practice. In support of this exercise, carbon removal measurements should be extended to all relevant sources of CO_2 emissions from inputs like fertilisers, as well as from crops and the soil itself. This could be done by adding relevant emission models, establishing baselines, and monitoring carbon removal activities. **A systemic approach can serve best** to gain insights into the right practices, their interaction, and the overall land use to foster regenerative agriculture.

Natural saturation boundaries for soil humus can be limiting the long-term additionality prospects of carbon removals. It needs to be considered that **carbon farming is likely to compete with higher crop yields, at least in the short- and mid-term**. The reason is obvious: under carbon farming practices, more nutrients are needed for the straw and root building, so that less nutrients remain available for the crop output, especially under a limited use of fertilisers. Thus, for creating healthier agricultural soils and carbon removals, **there might be certain agronomic and economic trade-offs. In the longer term, co-benefits, as mentioned earlier, would gain in importance, and help grow healthier, less vulnerable, and more nutritional crops in more drought resistant soils.**

To deliver on carbon removals, European farmers must be given a free choice of farming practices and smart agricultural technologies. In a holistic sense, it would be feasible to install and incentivise the broad **concept of a 'carbon-neutral farm'**. In addition to direct carbon sequestration in soils, this concept should also consider good nutrient and fertiliser management practices, growing sustainable biofuel crops, generating sustainable bioenergy sources, and performing other carbon-friendly activities at farm level. **The 'carbon-neutral farm' state should help farmers achieve a baseline for additional carbon removals.** It would be also suitable to address potential indirect land use change (ILUC) risks, as pure carbon sequestration in soils competing with higher yields can otherwise shift agricultural production outside of the EU.

The concept of 'carbon-neutral farms' would create an opportunity to introduce circular economy models within the agricultural sector and deliver on the principles of a fully sustainable agriculture, towards the EU 2050 goals. In this regard **'carbon-neutral farms' could also become 'energy-independent farms'**, producing their own fuel/energy from available waste and residues and/or renewable sources. For instance, agri-voltaics can turn farmers into prosumers (both consuming and producing energy), generating energy for injection into the grid or to be consumed on-farm – including to power electric agricultural machinery. Biomethane, as an upgrade from biogas, namely fugitive methane from slurry manure, can enable production of 100% renewable fuel directly on-farm, to refuel agricultural vehicles. More details on these and other examples can be found in Annex II.

On the ‘carbon-neutral farm’ path, **improvements in nutrient use efficiency** at farm level could be considered. These improvements would reflect changes in the nutrient factors use between the current state and the future desired state supporting carbon sequestration in soils (first and foremost, nitrogen use efficiency per unit of crop output, expressed as N applied in relation to N removed at harvest). An accurate measurement of nutrients applied and removed (both organic and mineral) helps to properly determine the nutrient use efficiency – which has a **major impact on carbon footprint due to high contribution of fertilisers to CO_2 emissions in crop production**. It requires a precise quantification of yield and protein (site specific) to determine nutrient removal and nutrient balance.

Going forward, **measurement of overall CO_2 efficiency improvements** could be introduced (e.g. CO_2 emissions in relation to CO_2 uptake and removal, per unit of crop output). To measure CO_2 emissions per unit of output, it is essential to have **clear definitions and accurate measurement of respective CO_2 emissions for all production system steps** (tillage, seeding, nutrient application, spraying, harvesting, transport).

Also, farmers will increasingly need to **analyse the soil structure and soil compaction as well as the biodiversity dynamics** which have a crucial impact on soil fertility and soil health, and thus on the soil carbon sequestration potential. We welcome the fact that the European Commission proposal recommends “to prioritise the development of tailored certification methodologies on carbon farming activities that provide significant co-benefits for biodiversity”[4].

The envisioned EU carbon certification framework would require that the carbon amount captured by a carbon farming activity (especially by afforestation or rewetting peatlands) should outweigh the emissions from the machinery used to carry out the respective carbon removal activity. **It needs to be clarified** by the EU regulators **what type of CO_2 machinery emissions reporting will be necessary for future carbon certification schemes**. **Additional huge bureaucratic burdens weighing on the emission certification procedures and associated cost must be avoided.**

In our opinion, **a harmonized future EU framework for calibration of carbon measuring tools and methodologies** would be more beneficial for the Green Deal goals than any isolated local standards and regulations. Most importantly, any future efforts in this field should **foster an uninterrupted technology development and allow for a timely, large-scale technology adoption** by European farmers. Carbon removal certification procedures which are already available or will be under development in the coming years must become usable and affordable for all farm types and sizes, especially for small and medium-sized farms.

[4] EU Commission 2022/0394 (COD) Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a Union certification framework for carbon removals.

3. Policy support measures for EU smart carbon farming

To foster a large-scale implementation of carbon farming, the EU should start with action-based carbon farming outcomes for which **an EU-wide catalogue of good practices has to be developed**. **Payments under the new flagship CAP Eco-Scheme 'Neutral Carbon Farming'** could play a significant role for the initial adoption of these practices. **CAP payments need to be economically feasible**, i.e., adequate to compensate for the high production cost of carbon farming practices and for the opportunity cost of growing alternative cash crops (both short- and long-term opportunity cost).

New business models beyond the CAP framework must also ensure a fair income to farmers that adopt carbon farming and achieve additional carbon removals above the baseline. Carbon farming projects (including pilot initiatives) can be supported through the EU Innovation Fund financed by the EU Emission Trading System (ETS) revenues, the EU's funding instrument for the environment and climate action LIFE, and the Horizon Europe programs. Also, private funding should play an increasing role in rewarding farmers for carbon removals and enhancing their carbon accounting. Most importantly, **new financing schemes should undergo a thorough impact assessment** before being implemented, so that these do not cannibalize existing farmers' income opportunities.

We welcome the European Commission proposal that "**in the context of carbon farming, the use of available digital technologies**, including electronic databases and geographic information systems, remote sensing, artificial intelligence and machine learning, and of electronic maps **should be promoted** to decrease the costs of establishing baselines and of monitoring carbon removal activities"[5]. To streamline the data flows and create trust for data sharing between different stakeholders, ranging from farmers and suppliers to consumers and governments, the proper architectures and interoperability standards will need to be established. This would include many tamper-proof data flows generated from machinery or the information and task messages to be delivered to machinery.

The Agricultural Industry Electronics Foundation AEF is developing the Agricultural Interoperability Networks (AgIN) to make these data flows possible. Concepts like AgIN embedded within organisations that allow identity checks, work with state-of-the-art high-level security and tracking possibilities and that can perform compliance checks through independent third parties, may act as self-regulatory bodies to comply with specific legislation. In the future, additional carbon removals can be traded by farmers through carbon offsetting markets even without any intermediaries, by integrating them in digital platforms with a mechanism of self-regulation, so that additional and burdensome **third party's certification schemes could be avoided, especially for small and medium size farmers**. The development of respective enabling technologies should be supported as well.

In this regard, CEMA calls for an **open and dynamic support scheme for carbon farming technologies based on the list of good practices and enabling an EU level playing field.** In addition to Eco-Schemes under the CAP Pillar I, the CAP Pillar II funds for multi-annual environment

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[5] EU Commission 2022/0394 (COD) Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a Union certification framework for carbon removals.

and climate programs, as well as other CAP Pillar II incentives supporting the adoption of carbon removal practices should be considered (investments into smart agricultural technology, advisory services, training, research, collective approaches, etc.). Smaller farmers that cannot afford large investments into advanced machinery should be granted contractors' services vouchers for leveraging modern precision agricultural technologies. These vouchers should become an integrative part of the CAP Pillar II investment support.

Raising awareness of farmers, contractors, and advisers on carbon farming practices and technologies is crucial, and their assessment and optimisation must be promoted. It could be a combination of providing proofs of concept for innovative tools and practices through demonstration farms and promoting the outcomes of pilot projects. This can be supported by the CAP funds, as well as by national State aid programs.

Finally, **promotion of training and education** is key to realise the transition towards carbon neutral farming by way of new agricultural and digital skills. In this respect it is appropriate to mention the European Commission initiative "Pact for skills" as a joint effort on upskilling and reskilling the EU workforce – including European farmers, contractors, and advisers.

Conclusions and Recommendations

The European agricultural machinery industry is highly engaged with farmers to help reduce their GHG footprint and achieve climate neutrality for the combined EU agricultural and LULUCF sectors by 2035. We are fully committed to continue delivering on advanced machinery and digital technologies for carbon-smart agricultural practices. The digital transformation which brings better connectivity, data streams and advanced data analytics will be a key enabler for carbon farming. The establishment of a clear EU roadmap on carbon farming will be an important part of this transformation.

While the EU regulators are looking for ways to significantly scale up carbon removals, European farmers and enabling technology sectors must be granted reliable long-term business conditions to implement carbon farming activities and achieve their certification. The potential to become climate neutral by 2035 can be realized only in a technology-wise and cost-effective manner.

In this context, we would like to make the following **recommendations to the EU decision makers**:

- **Scope definition:** Upcoming regulations on certification methods for carbon removals should grant European farmers freedom in the agricultural practices and technologies applied. The scope definition of carbon removals should not be narrowed down to carbon sequestration in soils only. What really matters is the total GHG balance, with the **'carbon-neutral' farming** paving the way to climate-neutral EU agricultural and land use sectors. 'Carbon-neutral' farming should come first, to prepare the ground for additional carbon removals that can be achieved above the baseline.

- **Good practices:** The CAP could support the uptake of carbon farming and carbon removal certification, by covering upfront investments and by promoting relevant practices at farm level. For this, a **catalogue** of good practices matching with enabling smart technologies should be developed. Good practices should include diverse approaches to achieve the 'carbon-neutral' farming in the first place, and additional carbon removals above the baseline in the next phase. Future rewards for good practices can be also linked to soil fertility and soil health, higher biodiversity, and other outcomes of regenerative agriculture.

- **Level playing field:** New business models around carbon farming must ensure a **fair income for farmers** that adopt good carbon farming practices and might face opportunity costs, both short- and long-term. Future financing schemes should undergo a **thorough impact assessment** before being implemented. For a level playing field in Europe, **dynamic and open EU-wide incentive schemes** need to be aligned with respective national programs and state aid mechanisms. It should not lead to any unnecessary discrimination between farmers in different locations with varying pre-conditions for carbon farming.

- **Technology uptake: Awareness** of European farmers, contractors, and advisers towards good practices of carbon farming and enabling smart technologies should be promoted. It is also essential to **stimulate farmers' investments** into advanced agricultural machinery and precision technologies that underpin on-farm carbon removals and/ or provide the proof for carbon sinks. Limitations of the current sensing technology should be fully considered.

- **Technology calibration:** Any upcoming regulations or standardization criteria for calibration of carbon sensors and/ or other carbon measuring tools and technologies embedded on agricultural machinery should **respect a principle of uninterrupted technology development** and allow for a fast, large-scale technology adoption by European farmers.

- **Reporting obligations:** We call on simple administrative procedures not consuming too much of farmers' valuable time and resources. Additional **huge certification costs** for farmers and technology producers **must be avoided**. Potential requirements on reporting obligations for CO_2 machinery emissions in the field of carbon farming should be clarified by the EU regulators in a timely manner. Data exchange platforms should be able to deliver on these obligations, enabling easy, fast, and reliable reporting.

Annex I - Carbon farming outcomes supported by smart agricultural machinery technologies

Good practices (action-based outcomes)	Enabling technologies
Rewetting peatlands and wetlands	Adaptation of mechanisation/ New technologies for paludiculture
Agroforestry	Adaptation of mechanisation/ New technologies for agroforestry
Cover crops, intercropping, multi-cropping	Adaptation of mechanisation/ New technologies for cover crops, intercropping, multi-cropping
Crop rotation extension (incl. deep-rooting and nitrogen-fixing crops)	Adaptation of mechanisation/ New technologies for crop diversification practices
Crop residue management	Adaptation of mechanisation/ New technologies for crop residue management
Reduced soil tillage	Adapted/ New machinery for reduced soil tillage, increased soil fertility, and soil resilience to erosion
Reduced soil compaction	Precision guidance technologies for controlled traffic farming (e. g., RTK implement guidance, path planning tools)/ Central tire inflation system (CTIS) with low pressure tires and high flexion technologies)/ Tracks/ New types of autonomous equipment
Precision farming (incl. precision nutrient management)	Field-, plant- and/or soil-specific monitoring and treatment of sowing, planting, fertilising, spraying pesticides, and harvesting operations – incl. technologies for reducing fertiliser and fuel consumption and improving fertiliser and fuel efficiency. Examples of technologies for precision nutrient management: • Manure-, crop- and grain sensing and mapping • Variable Rate Application technology • Digital decision support tools for nutrient management and expert advice

	• Liquid fertiliser application equipment • Soil incorporation application technologies for organic and mineral fertilisers • Spot application of nutrients
Organic farming	Use of operations like mechanical or electrical weeding, also with new types of autonomous equipment
Result-based outcomes	**Enabling technologies**
Nutrient factors use efficiency, per unit of crop output (e.g., N applied in relation to N removed at harvest)	Advanced machinery for precision nutrient management, embedded sensing technology, remote sensors, data management tools
CO_2 efficiency, per unit of crop output (CO_2 emissions in relation to CO_2 uptake and removal)	Advanced machinery for precision crop lifecycle management, embedded sensing technology, remote sensors, data management tools
Soil organic carbon matter (SOC) change compared to baseline, t/ha	Advanced machinery for precision SOC lifecycle management, embedded sensing technology, remote sensors, data management tools

Annex II - Carbon neutral farming practices linked to the use of smart and sustainable agricultural machinery technologies

Good practices	Description and benefits
Agri-voltaics	Becoming more and more popular across European farms, incl. panels on farm buildings, also in combination with permanent crops like orchards and/or solar greenhouses. Generated renewable energy can be injected into the grid or be used for direct consumption (with or without storage) on-farm. Renewable electricity is suitable for various farm needs (lighting, irrigation system, etc.), as well as to power electric agricultural machinery.
Biomethane production on livestock farms	Fugitive methane from slurry manure is a large contributor of GHG emissions in agriculture. Manure and other agricultural waste may be processed to biogas, which can be used to generate electricity or be upgraded to biomethane. Biomethane is a 100% renewable fuel produced directly on-farm, to refuel agricultural vehicles instead of fossil diesel. Biomethane from manure has the best CO_2 balance of Well-to-Wheel of any currently known energy source and is considered CO_2-negative. Furthermore, digested material can be used as natural fertiliser to restore soil organic matter instead of chemical fertilisers.
Production and processing of sustainable biofuel crops on-farm	Sustainable crop feedstocks (rapeseed, sunflower, camelina/ false flax etc.) can be grown and processed either on-farm or in small regional oil refineries. Sustainable biofuel crops are considered ILUC-neutral and get certified in accordance with stringent EU criteria. Farm machinery can be run on sustainably produced liquid biofuels (pure plant oil, biodiesel, HVO), enabling CO_2 savings of at least 60% as compared to fossil diesel.

ABOUT CEMA

CEMA aisbl (www.cema-agri.org) is the association representing the European agricultural machinery industry. With 11 national member associations, the CEMA network represents both large multinational companies and numerous European SMEs active in this sector.

The industry comprises about 7,000 manufacturers, producing more than 500 different types of machines with an annual turnover of about €60 billion and 150,000 direct employees. CEMA companies produce a large range of machines that cover any activity in the field from seeding to harvesting, as well as equipment for livestock management.

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