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Carbon Credits System in the Dairy Sector: Possibilities and Challenges. An Italian Case Study †

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Abstract: In response to the European Community objectives of achieving zero net emissions by 2050 and pending the publication of a EU legislation on carbon accounting and trading, some voluntary carbon credit markets have already developed also in the agricultural and livestock sector. managed by regional/national bodies. In Italy, for example, a similar system has been developed from a methodological point of view even if it is not yet implemented by the farms. In this study, taking as a reference an intensive dairy farm located in the Po Valley, the possibilities of reducing the milk production carbon footprint by implementing various mitigation strategies are discussed. This was done through a cradle-to-farm gate life cycle assessment analysis applied to the current production scenario and then adapted to different alternative scenarios. This was managed through an online tool developed precisely for carbon accounting for livestock farms operating in a hypothetical carbon credit market. While cattle farms have the opportunity to reduce their carbon footprint and indeed even generate carbon credits through different strategies, the difficulty of reaching net zero emissions appeared clear in the different scenarios.

Keywords: dairy; carbon credits; life cycle assessment; carbon compensation

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1. Introduction

The European Union set the ambitious goal of achieving net zero CO_2-equivalent emissions by 2050. Activities aimed at emission compensation will therefore have to be implemented in the coming years by all sectors, including agriculture and livestock. Cattle breeding appears particularly affected by this policy, as on the one hand it is currently responsible of the largest carbon footprint in the food sector in absolute terms as well as per kg of product, and because some emission sources such as enteric fermentations could at most be mitigated but never eliminated.

An official regulation by the European Union has not yet been published regarding (i) how to calculate the GHG emissions of an agricultural activity and above all (ii) how to calculate the carbon credits that can be generated by mitigation actions and (iii) how exchange these credits on the market. However, in the Cicular Economy Action Plan (COM/2020/98 final), the Commission announced that it will develop a regulatory framework for certifying carbon removals based on robust and transparent carbon accounting. In the annex of the document, the indicative date for publication is set for 2023.

However, for some years there have already been cases of projects connected to local approaches for the creation of voluntary mechanisms for the reduction and compensation of emissions concerning the agricultural sector. In Italy, such a mechanism was developed by the Institute of Services for the Agricultural Food Market (ISMEA) and the Euro-Mediterranean Center on Climate Change (CMCC) under the guidance of the Ministry of Agricultural, Food and Forestry Policies (Mipaaf), focused on the livestock sector, due to the weight of the sector on national emissions and its potential in terms of reducing its environmental impact.

According to the proposed mechanism, the guidelines of which were first published in 2018 and revised in 2020 [1], the impacts generated by livestock production in a given territory, can be reduced and compensated through activities of reduction and absorption of GHG in the vicinity of the emissive source. A similar approach, defined as "proximity", would generate also a benefit in terms of production and/or maintenance of the ecosystem services provided by the same activities and the consequent protection of the quality and environmental health of the district.

To the author's knowledge, the project is still ongoing and currently there are no "production districts" in which this mechanism has been officially activated, nor have voluntary exchanges of carbon credits based on these guidelines ever been carried out.

This paper intends to test this methodology by applying the guidelines in a case study of a dairy farm; measuring through the online GHG accounting tool (i) the company's emissions in current operations; (ii) the credits that can be generated through some of the mitigation strategies proposed by the guidelines; and finally (iii) make some economic considerations considering the current market price of carbon credits. The novelty of the contribution is to provide an overview of a carbon credit accounting mechanism applied in the agricultural sector, in particular to the dairy sector. Surely there may be differences with respect to the directives that will be issued by the European Union, however the methodology used here is still based on a recognized method for carbon accounting, that is the life cycle assessment. The results therefore offer the possibility of making considerations both as regards the production sector and as regards the policies, with respect to the implementation of a carbon credits trading system in agriculture.

2. Methods

This study takes as its reference a dairy farm located in the Po Valley, in northern Italy. This region is known for its marked specialization in the intensive rearing of dairy cattle which typically takes place with a mixed crop-livestock management, where farmers directly manage land destined for forage self-production, which they usually integrate with feed purchased externally.

The data needed to account for the farm's GHG emissions were collected by means of on-farm surveys and interviews with management staff. These correspond to the so-called inventory data necessary for an LCA study, and therefore concern the technical-productive characteristics of the farm in question. The data collected was fed into the online calculation tool developed in the context of the carbon credit trading mechanism presented in the introduction. These are shown in Table 1. The tool, currently available only in Italian, is accessible free of charge on the ISMEA website (https://emissionizero.ismea.it/?page_id=2, accessed on) and has a user-friendly interface that guides data entry. The emissions calculation is done through a life cycle analysis (LCA), according to a TIER 2 approach. The compilation of the questionnaire allows to estimate the tons of CO_2 eq emitted by livestock activities. More details on the methodology used to develop the tool can be found in the Guidelines [1].

Table 1. Data relating to the dairy farm under study entered in the online tool for GHG emission calculation–livestock characteristics and management data. Data refer to 2020.

Item Required by the Tool (Unit of Measure)	Input for the Analyzed Dairy Farm
Reared species and breed	Dairy cattle; holstein
Adult female heads (n°)	1200
Months with access to pasture (n°)	0
Percentage of the herd that has access to pasture (%)	0
Percentage share of concentrate in the ration of cows (% of DM)	48

Percentage share of concentrate in the ration of heifers (% of DM)	16
Does the farm practice anaerobic biodigestion of livestock waste?	yes
Does the farm practice solid-liquid separation of livestock waste?	yes
Does the farm practice slurry aeration?	no
Annual energy consumption (kWh)	1,008,003
Amount of feed purchased per year (t/year)	17,000
Diesel fuel used for agricultural operations (kg)	238,000

In addition to the information requested on the characteristics of the farm from the livestock point of view, the online tool expects to be able to enter information about any forage produced internally. The data entered regarding this aspect are shown in Table 2.

Table 2. Data relating to the dairy farm under study entered in the online tool for GHG emission calculation–crop cultivation practices. Data refer to 2020.

On-Farm Forage Production	Unit of Measure	Maize, Silage	Alfalfa, Hay	Wheat, Silage	Permanent Grass, Hay
Arable land	ha	332	113	53	41
Seeds, conventional	kg/ha	20	40	70	80
Seeds, organic	kg/ha	0	0	0	0
Fertilizers–N	kg/ha	150	0	100	100
Fertilizers–P_2O_5	kg/ha	0	0	0	0
Fertilizers–K_2O	kg/ha	0	0	0	0
Pesticides	kg/ha	0.5	0	0	0
Fungicides	kg/ha	0	0	2	1
Herbicides	kg/ha	3	2	0	2

Therefore, the first section of the tool allows to calculate the impact according to current management. In a second section, on the other hand, it is possible to simulate the credits that can be generated thanks to actions to reduce or offset emissions.

According to the mechanism developed, the sustainable management activities to offset livestock farms GHG emissions essentially refer to three different areas of action, summarized in Table 3. The mitigation activities included in the "emission reduction" intervention area were not considered here as the aspects concerned, and the consequent emissions, were not considered relevant for the farm under study because considered to be already in an optimized management condition. The other mitigation activities, on the other hand, have all been tested, albeit some entirely ideally as in fact the farm under study does not manage land with permanent tree or forest crops, nor has land where it is possible to plant orchards and/or reforestations.

Table 3. Areas of intervention and related mitigation activities for the generation of carbon credits according to the under-study mechanism.

Area of Intervention	Mitigation Activity	Applied in This Study
Emission reduction	Reduction of enteric emissions by improving feeding management	No
	Improving manure management	No
	Reduction in the use of mineral fertilizers	No

Increase in carbon sinks	Reduction of agricultural soil tillage	Yes
	Conservation of grass cover in permanent crops	Yes
	Management of agricultural residues of tree crops (burial)	Yes
	Planting of new orchards	Yes
	Realization of reforestation	Yes
Replacement or reduction of fossil fuel emissions	Management of agricultural residues of tree crops for energy purposes	Yes

3. Results and Discussion

The total emissive output of the farm under study calculated by the tool was 18,587.69 t CO_2 eq/year. The tool does not provide information regarding the breakdown of these emissions in terms of different gases (CH_4, N_2O and CO_2). Instead, information is given about the breakdown by emission source, commonly called contribution or 'hotspot' analysis in LCA studies (Table 4).

Table 4. Total greenhouse gas emissions of the dairy farm under study calculated by the online tool, and their breakdown by emission source in absolute and relative terms.

Emission Source	Absolute Emissions (t CO_2 eq/year)	Relative Contribution
Enteric fermentation	5854.22	31.5%
Manure management	678.77	3.7%
Soil management/feed production	11,768.42	63.3%
Energy consumption	286.27	1.5%
Total	**18,587.69**	**100%**

Considering that in 2020 the company produced 12353.792 t of milk with an average fat and protein content of 4.04% and 3.51% respectively, equal to 12611.166 t of fat and protein corrected milk (FPCM), the emission intensity for unit of product results 1.47 kg CO_2 eq/kg FPCM. This value is in line with the literature for milk in Italy [2], even if not directly comparable due to methodological differences, for example regarding allocation and/or system expansion, not considered via the tool.

As regards the credit generation, considering the factors provided by the tool appears that the agricultural area that would be necessary for the total compensation of the farm current emissions is impressively high (Table 5), regardless of the mitigation activity. At the moment, of the techniques considered, the farm could put into practice the minimum or zero tillage, which applied to their available arable land (the one destined for annual crops, i.e., 385 ha for maize and wheat) could generate credits for 315.7 and 492.8 t CO_2 eq respectively. This would mean a reduction of the total GHG emission of only −1.7% and −2.7%. Even under realistic assumptions that, in addition to the livestock activity, the farm managed for example 50 ha of vineyards and decided to (i) keep the grass cover on the soil and (ii) use the pruning residues for energy purposes; it would generate credits for 189 t CO_2 eq/year. Or if the farm treated the reforestation an area of 100 ha could generate between 270 and 305 t CO_2 eq/year. In any case, although these would be costly projects in terms of manpower, commitment and resources, only a small part of the total emissions would be mitigated. For a cattle farm, given these preliminary results, it would seem very unlikely to achieve net zero emissions. And even less for a group of farms or for an entire production district. The objectives of the Green Deal seem perhaps too ambitious, and agriculture alone does not currently seem to be able to achieve them. If a farm were to compensate by purchasing credits to reach net zero emissions, even under active mitigation scenarios such as those exemplified above, the cost of purchasing credits to reach net zero emissions would be much more than that obtained from the sale of credits generated thanks to their own actions (the price for a ton of CO_2 eq is currently in the order of a few tens of euros).

Table 5. Carbon credits that can be generated per hectare per year according to the various mitigation techniques according to the under-study mechanism (over a period of 20 years) and hectares that would be consequently needed for a complete compensation to reach net zero CO_2 eq emission.

Mitigation Activity	Carbon Credits Generated (t CO_2 eq/ha/year)	Hectares to Reach Net Zero CO_2 eq Emission
Reduction of agricultural soil tillage-minimum tillage	0.82	22,667.9
Reduction of agricultural soil tillage-zero tillage	1.28	14,521.6
Conservation of grass cover in permanent crops	1.68	11,064.1
Management of agricultural residues of tree crops (burial)	1.03	18,046.3
Management of agricultural residues of tree crops for energy purposes	2.1 [a]	8851.3
Planting of new orchards	2.4 [a]	7744.9
Reforestation-High forest management	3.05 [a]	6094.3
Reforestation-coppice management	2.7 [a]	6884.3

[a] the tool provides diversified values for a number of tree species. Only the average value has been considered here as example.

4. Conclusions

In this paper, the concept of carbon accounting for a livestock activity was discussed and a tool developed for this purpose by Italian bodies in the sector was tested, applying it to a dairy farm case study. Quantifying the emissions of a company proved to be relatively simple once the necessary data on the technical-productive characteristics had been collected. And it is also easy to create mitigation scenarios and calculate the credits that can be generated by them. What appears complicated is being able to put these mitigation actions into practice for companies and above all to do it on a large scale to such an extent as to be able to completely offset the farm's emissions, or at least to get close to do it. If the sale of a few hundred carbon credits would certainly benefit the farm, the purchase of the remaining portion of credits necessary to achieve net zero emission appears economically unsustainable. Certainly, in the future these economic aspects of the mechanism that the European Union wants to launch must be investigated, considering other problems of the application of this system such as the concepts of additionality of mitigation actions. As for proximity, however, the European Commission has not yet commented on this concept, while in the Italian guidelines this was emphasized. This study is a starting point for the development of more in-depth studies that consider different contexts (farms of different size and production specialization, consortia, agro-forestry activities, etc.) and different possible mitigation and carbon credit exchange scenarios.

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