Carbon footprint and biodiversity assessment in dairy production

Introduction

While the main focus of dairy farms is on milk production, they also have an impact on the environment. Cows emit methane; tractors produce carbon dioxide; manure releases nitrous oxide and ammonia; and nitrates are leached from fields. These emissions contribute to climate change and undesirable nutrient enrichment of water courses. Insects, plants and other biodiversity are also affected depending on, amongst other factors, the proportion of maize to grassland on the dairy farms. Grasslands are better for biodiversity, and also increase carbon levels in the soil – thereby contributing to the mitigation of climate change.

Fields of organically managed farms generally have higher biodiversity compared to comparable fields of conventional farms (Tuck *et al.*, 2014). In addition, organic farms generally have greater carbon sequestration in their soils (Gattinger *et al.*, 2012). These are the most important differences between organic and conventional farms.

When the environmental impact of milk production is assessed using Life Cycle Assessment (LCA), all important factors should be included in the calculations. However, up until now, when the environmental impact of organic and conventional milk has been compared biodiversity and carbon sequestration have generally not been included in the calculations. Given the differences between the two production systems, this is of course problematic. The actual effect of including these two factors is not straightforward. The environmental impacts in LCAs are given per litre of milk, and the milk yield is often slightly lower for organic dairy farms – which has an impact on the carbon footprint. It is therefore essential to examine the effect of different kinds of dairy farms on soil carbon sequestration and biodiversity.

During the SOLID project we have worked on developing methods in LCA so that soil carbon sequestration and biodiversity can be included in the calculations. This is especially relevant when assessing the environmental impact of organic milk. In the following text, we will show the results – specifically the effect of including these environmental parameters within LCA calculations.

Carbon footprint

The impact of milk production on climate change can be calculated as a 'Carbon footprint of a litre of milk'. The carbon footprint is the sum of all greenhouse gas emissions (methane, carbon dioxide and nitrous oxide) from the dairy farm and other related upstream processes, expressed as CO_2 equivalents, divided by the amount of milk produced on the farm. Currently, calculations for carbon footprints do not normally include soil carbon sequestration . Firstly, we followed a standard LCA procedure and calculated the carbon footprint for 23 organic dairy farms from the UK, Denmark and Finland without including soil carbon sequestration. The carbon footprint was also calculated for conventional dairy production as a comparison (see Figure 1). The carbon footprint of milk was found to be around 1 kg CO_2 eq. per litre of milk (ECM - energy corrected milk). The results also show that the carbon footprint of organic milk varies among farms, shows no clear differences between countries, and is comparable to the carbon footprint of milk produced by a typical, conventionally managed dairy farm in Denmark.

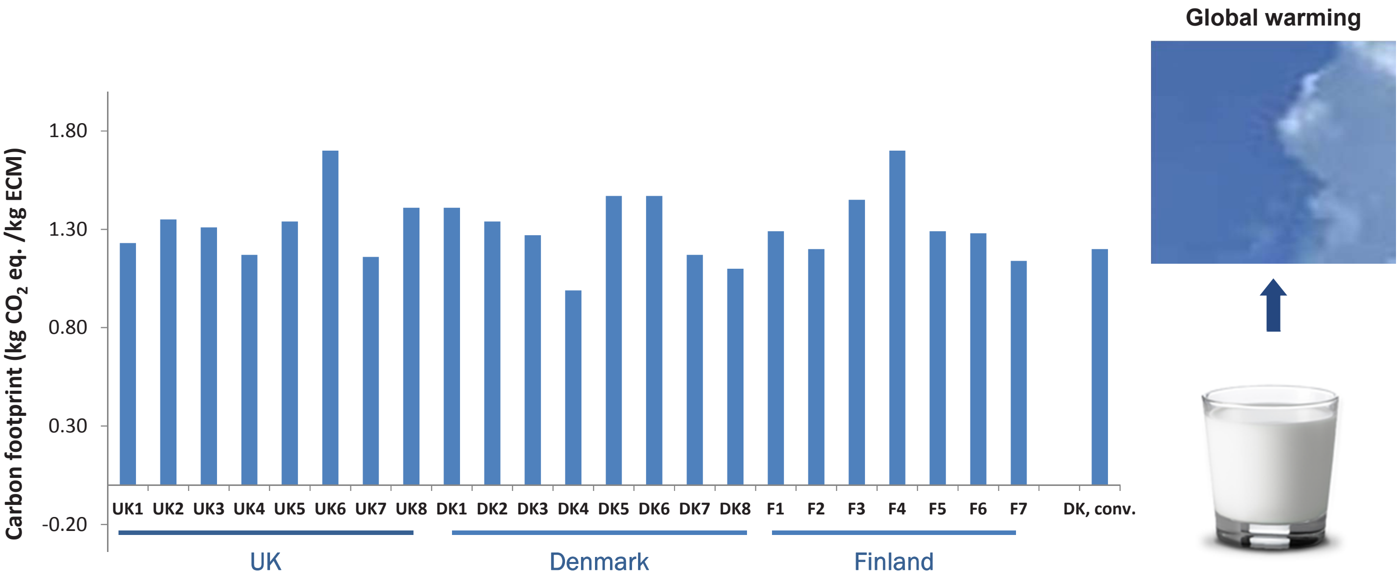


Figure 1: Carbon footprint of milk from 23 farms

As a second step, we then included the soil carbon sequestration in the calculations. In short, the methodology developed to include soil carbon sequestration in the LCA is based on the amount of carbon added to the soil through crop residues, roots, manure etc. and a certain percentage of this carbon will ultimately be sequestered in the soil (Petersen *et al.*, 2013; Mogensen *et al.*, 2014). The results (Figure 2) show that for all the organic farms, the carbon footprint is reduced when soil carbon sequestration is included in the calculations (green bars). The carbon footprint of conventional milk is not significantly affected. The main reason is that organic farms generally have a higher share of grassland relative to cereals/maize on their farms. The grasslands increase the carbon pool in the soil, whilst maize reduces it. Since a higher level of soil carbon is one of the main features of organic farming, it is crucial to include sequestration for accurate carbon footprint calculations.

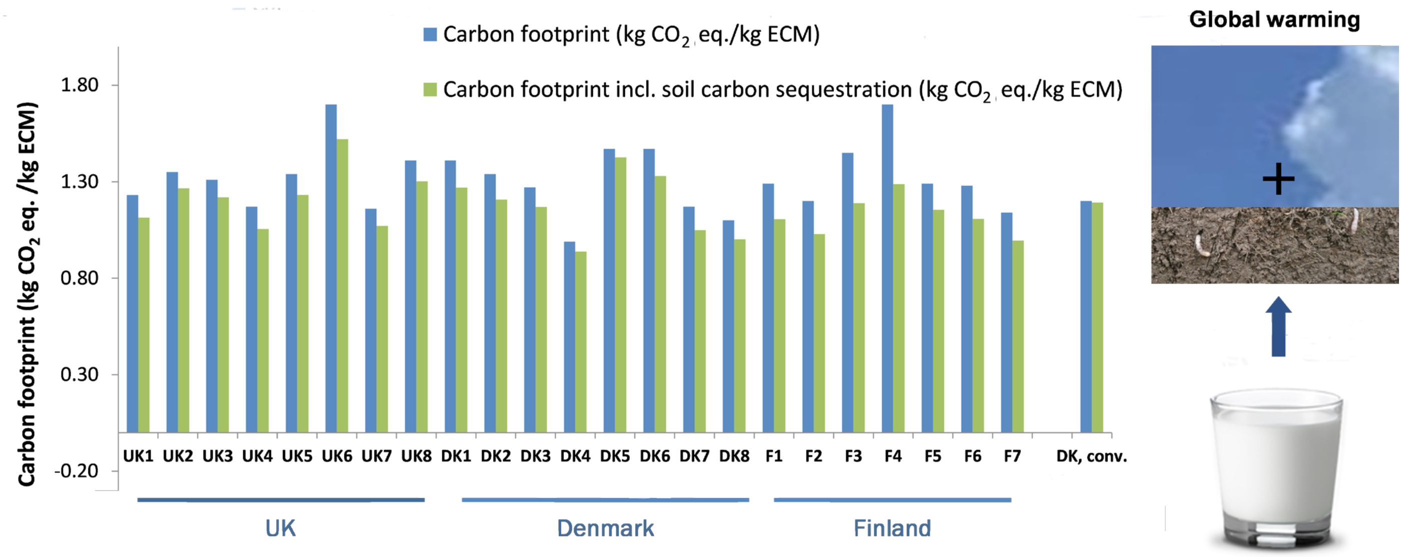
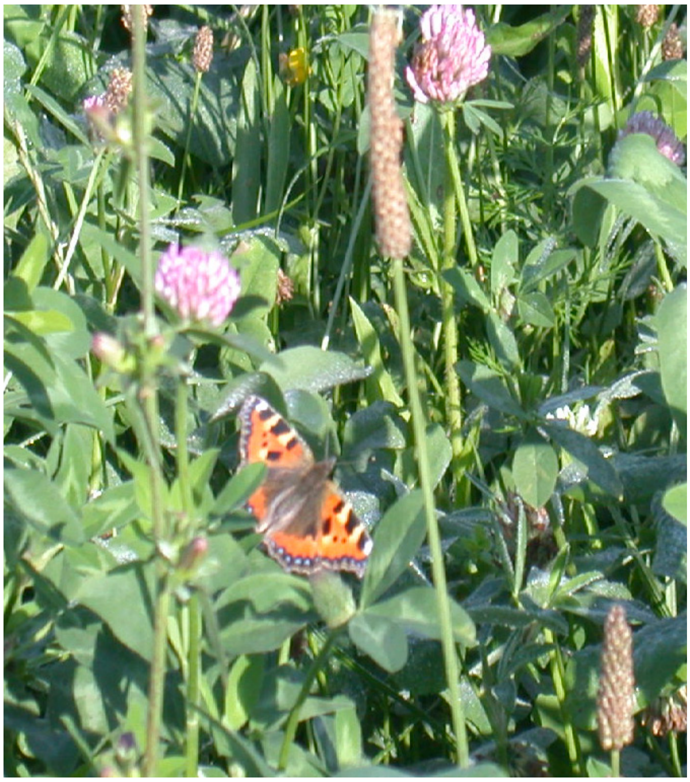


Figure 2: Carbon footprint of milk from 23 farms - including soil carbon sequestration

Biodiversity



Another key difference between organic and conventional farms is a higher biodiversity at the field level on organic farms. However, the impact on biodiversity is also not normally included in environmental LCAs due to methodological challenges. In this project, we have used biodiversity data from the EU funded BioBio project, which collected plant species data in more than seven European countries. We have used these data to develop and refine a method to include biodiversity assessment in environmental LCAs.

The method is based on the potential loss of plant species in a field as compared to natural vegetation (semi-natural forest). In a forest you might find 20 different plant species per 100 m^2 – whereas in a conventional cereal field you might only find six different species. The number of plant species is then used as an indicator of biodiversity, recognising that although this is not a fully comprehensive indicator of overall biodiversity, is a significant contributor. The potential disappeared fraction of biodiversity in, for example, a conventional cereal field compared to natural vegetation is then calculated. A loss from 20 to six plant species per 100 m^2 corresponds to a potential disappeared fraction of approximately 0.70 or 70% in conventional cereal fields. In organic cereal fields the loss is only approximately 0.20 or 20% and in conventional grasslands the loss is only approximately 0.10 or 10%. In organic grasslands you actually find a higher number of plant species than in the natural vegetation (semi-natural forest); so here the loss is approximately -0.30, meaning that you actually gain 30% more plant species compared to natural vegetation.

The calculated biodiversity losses for each crop type are based on registrations of plant species on different crops across Europe. The calculated numbers for each crop type are then used to calculate a Biodiversity Damage Potential for the milk production of the 23 farms in the UK, Finland and Denmark – depending on the share of grass, cereals and maize in the cows' feed rations. The Biodiversity Damage Potentials for each farm are shown with red dots (Figure 3). You can see that many of the organic farms have negative Biodiversity Damage Potential, which means that there is an overall increase in biodiversity. In comparison, the average Danish conventional milk production has a Biodiversity Damage Potential of approximately 0.40 per litre of milk. From the figure, it is also visible that for a farm, like the Finnish farm F4, that has a share of 84% grass in the feed ration (as compared to 37% in the Danish conventional), it is very important to include soil carbon sequestration and biodiversity in the environmental LCAs – in order to show the actual impact of the farm's milk production.

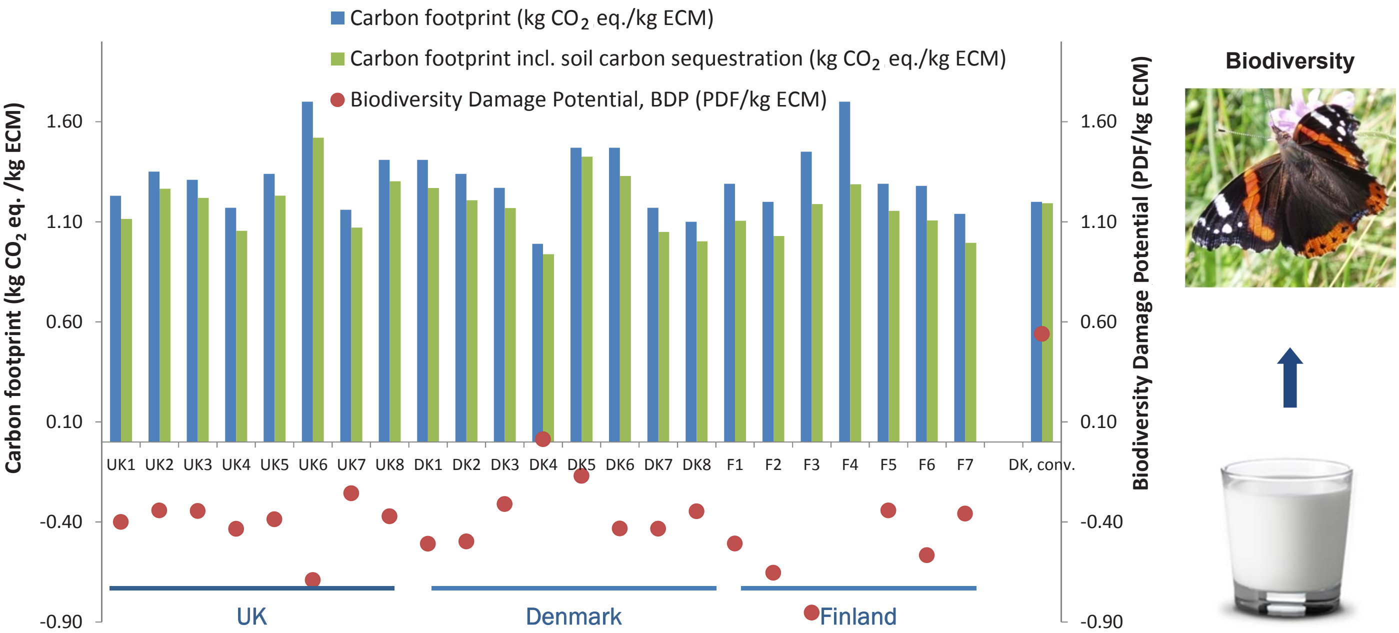


Figure 3: Biodiversity impacts of milk from 23 farms

Conclusions and recommendations

Organic farms generally have higher soil carbon sequestration, due to a higher proportion of grassland and greater use of manures, instead of synthetic fertilisers. Likewise, organically managed fields generally have higher biodiversity compared to conventional. These two factors – soil carbon and biodiversity – are not normally included in the environmental LCA of milk, resulting in a biased comparison of organic and conventional milk.

- In the SOLID project, a methodology has been developed to include soil carbon sequestration and biodiversity in the environmental LCA of milk. This will result in more comprehensive and less biased results in the assessment of the environmental impact of milk.
- The carbon footprint of organic milk is reduced when soil carbon sequestration is included in the assessment. The footprint of conventional milk remains unchanged.
- A higher proportion of grass in the cows' feed ration increases soil carbon sequestration and can also increase biodiversity, depending on the duration of the grassland and the structural characteristics of the grass sward.
- A method has been developed to distinguish biodiversity between organic and conventional fields and to include biodiversity in the life cycle assessment of milk through an indicator of biodiversity damage.
- Generally, milk from organic farms causes less biodiversity damage compared to milk from conventional systems.
- It is recommended that soil carbon sequestration and biodiversity is in future always included in environmental LCA of agricultural products.
- From an environmental point of view, it is recommended to include more grass in the feed rations of dairy cattle.

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SOLID e-learning tool: Life Cycle Assessment of dairy products – important differences of organic and conventional production.

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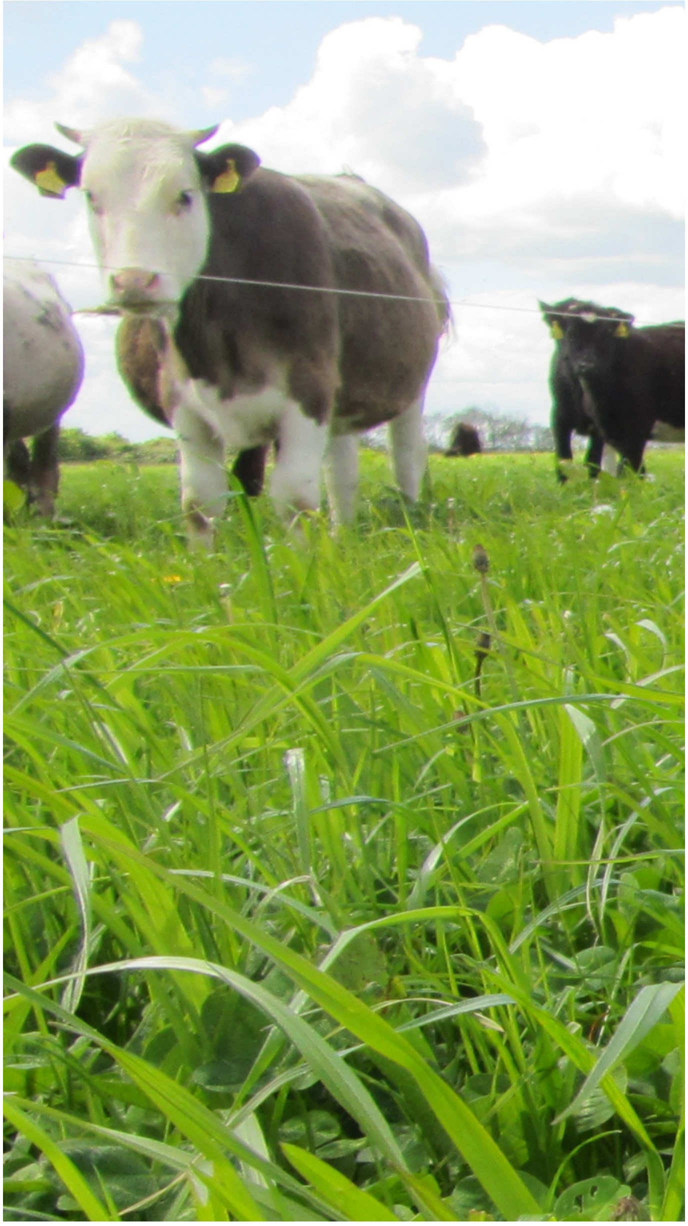

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