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Including soil carbon and land use changes to comparison of carbon footprints of beef production systems

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Abstract

Dairy beef production of major Finnish importer countries, namely Denmark and Germany, to Finnish production was compared taking into account the effect of emissions due to carbon stock changes and from land use changes. Also, uncertainties of the comparison were estimated.

The carbon footprints of beef from Danish and German dairy bulls are significantly lower than Finnish, when compared without including emissions from carbon stock and land use changes. This is mainly due to the average efficiency of feed production and the structure of production. There does not seem to be significant differences in carbon sequestration of the home-grown feeds on mineral soils between the three countries, and the inclusion of those emissions does not change conclusions of the comparison. In all countries, feed production seems to release carbon from the soil instead of sequestrating.

In contrast, the inclusion of emissions caused by changes in land use of soybean meal seems to alter the comparison between countries, and in particular, the emissions from Danish and German bull, while in Finland no soy is used for cattle. There are various methods available for the assessment of emissions of land use changes, and depending on the method used also the conclusion of comparisons between countries differ.

This study shows challenges in comparison of different LCA studies with evolving methodologies, but can still indicatively shed light on the differences of greenhouse gas emissions of the studied beef production systems and the causes for differences between them including the effect on emissions of changes in carbon stocks and land use.

Keywords: Soil carbon change, land use change, greenhouse gas, beef production, LCA

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1. Introduction

Comparison of individual Life Cycle Assessment studies on beef is challenging and includes always significant uncertainties because greenhouse gas emissions are estimated using different methods, system boundaries, data sources and the studies might have different objectives (Corson, et al. 2011). In addition, there are no general, acknowledged methods to assess the greenhouse gas emissions of changes in carbon stocks and land use, and they are included in very few studies (see for example Brandão et al. 2013).

The aim of this study was to compare dairy beef production of major Finnish importer countries to Finnish production. The goal was to use as comparable methods as possible based on the literature, contacting the researchers of the other studies and some adjustments to the methods in the Finnish study to gain insights for real differences in the systems. In addition, the effect of emissions due to carbon stock changes and from land use changes in soya cultivation in comparison to different production systems were estimated. Also, uncertainties of the comparison were estimated.

2. Material and methods

The comparison was made between Finnish, Danish and German studies (Pulkkinen et al., 2016; Mogensen et al., 2015; Zehetmeier et al., 2012). The Danish study represents only one production method typical in Denmark, and not the average Danish production, the German study should describe fairly typical production method in Germany, but still not necessarily the average production, while the Finnish study aimed at national average production method based on national statistics, but naturally also there, several expert assumptions on 'the most typical' practices were made. The researchers of the compared original published studies were contacted, but there are still uncertainties in the results.

An estimate of the most common feed crop rotations of feeds grown on farm and their effects on soil carbon stock change was done very roughly on only mineral soils, as the used Yasso07 (Tuomi ym. 2009) and ICBM (Andrén & Kätterer 1997) models are limited on mineral soils. Carbon inputs to soil included manure, above ground crop residues, roots and rhitzodeposition. Land use change emission were estimated based on available literature for soy production in South America. A minimum additional estimated greenhouse gas emissions to soy cultivation (kgCO2-eq/kg soy meal) due to land use change was taken from Leip et al. (2010) and maximum from Gerber et al. (2010).

3. Results and discussion

The carbon footprints of beef from Danish and German dairy bulls are significantly lower than Finnish, when compared without including emissions from carbon stock and land use changes (see Figure 1). This is due to the average efficiency of feed production, i.e. the harvest yield in proportion to the used nitrogen fertilizer levels, and also the structure of production, as in Denmark part of the dairy bulls are grown only to 9.4 months of age, because of the national milk production supplies male calves for rearing in abundance, and the lower slaughter age leads to lower enteric fermentation emissions.

3.1.Effect of including emissions from soil carbon change

There does not seem to be significant differences in carbon sequestration of the home grown feeds on mineral soils between the three countries, and the inclusion of those emissions does not change conclusions of the comparison (see Figure 1). In all countries, feed production seems to release carbon from the soil instead of sequestrating. In the Finnish crop rotation maybe somewhat less on mineral soils than in the Danish or German rotations, but in fact, carbon release from organic soils is excluded here, and if included, it would increase Finnish emissions most likely significantly.

3.2.Effect of including emissions from land use change

In contrast, the inclusion of emissions caused by changes in land use of soybean meal seems to alter

the comparison between countries, and in particular, the emissions from Danish and German bull, because soy covers 15-18% of their dry matter intake, while in Finland no soy is used for cattle (see Figure 1). There are various methods available for the assessment of emissions of land use changes, and depending on the method used also the conclusion of comparisons between countries differ. Depending on the model used the greenhouse gas emissions of a Danish dairy bull were about one-third smaller or slightly larger compared to Finnish dairy bull, and emissions of a German dairy bull, in turn, one-fifth lower or one-third higher.

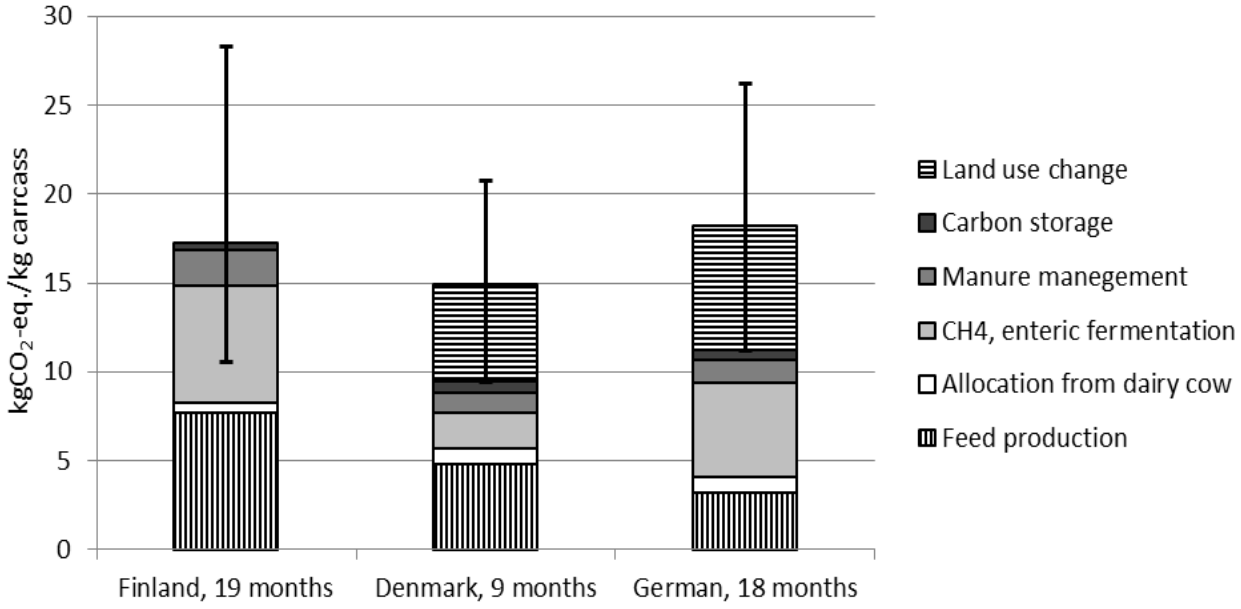

Figure 1 Greenhouse gas emissions of dairy bulls by different sources with the emissions from changes in carbon stocks and land use, and without carbon temporarily sequestrated in feeds. Emission caused by the change in carbon stocks is the average of the results of Yasso and ICBM models, and for Finland, the average of Northern and Southern Finland. Emission caused by land use change are average of the minimum and maximum estimates. Error bars represent most important sources of uncertainties in the comparison.

3.3.Uncertainties

The most significant sources of known uncertainties of this study are relating to e.g. the data sources used, i.e. how well the sources used in Danish and German studies describe the national average feed production and fertilizer application levels, as well as national average cattle slaughter age and -weight. In particular, the dry matter intake of German dairy bull in relation to its carcass weight seems very low compared to Finnish dairy bull. In addition, the differences in calculation methods, in particularly of methane emission from enteric fermentation, which was partly different for different countries, cause uncertainty. Emission factors used to estimate emissions also contain uncertainties, and especially the simple emission factor for main emission source for feed production, the direct nitrous oxide emissions from soil, which is unable to take into account for example the differences of single and multi-annual crops or in detail the properties of soil.

All the results of this study contain a lot of uncertainties and should be interpreted with caution. Yet, this study indicatively sheds light on the differences of greenhouse gas emissions of the studied beef production systems and the causes for differences between them, as well as on the potential effect on emissions of changes in carbon stocks and land use. It should be remembered that only the greenhouse gas emissions, i.e. climate impact, of beef production was assessed and that the production has also others, positive and negative, effects on the environment, which are likely also different in the countries in question.

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