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Holistic environmental assessment of High Nature Value farming systems in Europe

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Abstract

Many Life Cycle Assessment (LCA) studies comparing environmental impacts of different beef production systems are incomplete as they exclude biodiversity impacts and soil carbon stock changes. This study aims to assess the environmental impact of ruminant production on semi-natural grasslands or so-called, High Nature Value (HNV) farms at the European level. We collected data of 24 HNV farms in five European countries: Finland, Estonia and France. The studied farms are extensive beef, sheep and goat production systems. We used LCA to assess the potential environmental impact of HNV farms according to global warming potential (GWP_{100}), eutrophication, fossil fuels and water use, by using the Solagro carbon calculator and OpenLCA software. Results showed that HNV farming systems have the potential to maintain unique biodiversity, act as carbon sinks, reduce greenhouse gas emissions and reduce nutrient loses and water use while producing animal derived food. There were significant differences between HNV farms along countries in GHG emissions at the farm level (tCO_2eq/ha) and N inputs (kg N/ha). Better regional understanding of the environmental impact performance of HNV farming systems in relation to sustainable ruminant production will be achieved as the undergoing study progresses.

Introduction

Livestock production systems vary greatly along the gradient of production intensity, which is likely to influence the overall environmental impact. Although intensive production has shown to result in lower greenhouse gas emissions (GHG) at the product level, extensive production is known to produce other environmental benefits such as biodiversity maintenance or carbon storage (Garnett, 2010), which are not commonly included in LCA-based studies. When livestock production sustainability discourse focuses mainly on the global warming potential (GWP) but biodiversity and carbon storage gains are not properly accounted for, there is a high risk of depreciating other mitigation opportunities alternative to intensifying production.

High Nature Value (HNV) farming systems are extensive production systems known for supporting farmland areas in Europe "where agriculture is a major land use and where that agriculture supports, or is associated with, either a high species and habitat diversity or the presence of species of European conservation concern or both" (Andersen et al., 2003). No research to date has estimated the potential of HNV production systems across the continent in sustainable ruminant production. The objective of the study is to assess the environmental impact of 24 HNV farms in three regions in Europe in terms of GWP_{100}, eutrophication and depletion of resources such as fossil fuels and water.

Material and methods

Our dataset corresponds to HNV type 1 farms (i.e., farms that utilise semi-natural vegetation for grazing and/or hay production). A total of 24 farms enrolled in the study: 18 beef cattle, 2 sheep, 2 dairy, 2 beef and sheep combined. The assessment of the environmental impact was based on a yearly cycle production system estimated upon 5-year average farm data.

We assessed the potential environmental impact of HNV farms by applying the LCA method using two types of software: the Solagro carbon calculator and OpenLCA 1.10. We applied the ReCiPe Midpoint 2016 (H) impact method to estimate GWP_{100}, fossil resource scarcity, land use, fresh water and marine eutrophication for the 24 farms in Finland, Estonia and France. We applied AWARE method for regionalised water use. The system boundary applied in this study was from cradle to farm gate. We estimate the contribution from farming practices such as manure management, and six environmental impact parameters: GHG emissions at the farm and product level (tCO_2eq/ha and tCO_2eq/t LW), total N inputs and outputs (N kg/ha), total C storage (tC). Biodiversity scores will be added as the study progresses. We will apply SALCA-BD approach to assess biodiversity in HNV farms. We ran ANOVA to test statistical differences between HNV farms within and between countries and Kruskal-Wallis test to assess the differences between farming practices among the conjoint of HNV farms.

Results and discussion

The environmental impact of HNV farms showed a wide variation between and within countries. There were significant differences in relation to GHG emissions at the farm level (kgCO2eq / ha), N inputs (kgN / ha) between countries ($P \leq 0.00$ and $P \leq 0.01$, respectively). Average values for GWP_{100} were marginally significantly different ($P \leq 0.08$) between countries. Similarly, there were no significant differences at the product level (kgCO2eq / kgLW).

Most of the environmental impact in terms of GWP_{100} occur at the farm (Garnett et al. 2017). Our results showed enteric fermentation to contribute most to the average overall emission of 46%, followed by mineral fertilisation, and indirect and direct N_2O emissions as 25%, 22% and 13%, respectively. HNV farming practices such as circulation of on-farm manure and utilisation of cover crops in temporary grasslands fields reduce nutrient loses. Therefore, the application of external inputs, i.e. mineral fertilizers, in HNV farms appeared to cause marginally significant differences between farms in the overall emissions ($P \leq 0.09$). However, HNV systems tend to have negative N balances compared to organic systems (Röös et al. 2018) resulting in low eutrophication values (2.4 kg Neq /kgLW). Similarly, our results showed low water use values (5.68 m^3 /kgLW) caused mainly by the use of natural water sources in HNV farming systems.

The utilisation of semi-natural grasslands and permanent grasslands reduces the requirements of purchasing feed. This reduces the overall emissions, as our results suggested ($P \leq 0.006$)

and also contributes to carbon storage (Torres-Miralles et al. *submit.*) Therefore, intensive practices such as application of mineral fertilizers or feed purchases tend to negatively influence the overall performance of HNV farming systems.

There is however a wide range of performance among the HNV farms. HNV beef and sheep production had average levels of GWP_{100} at 18.67 and 18.63 kg CO_2eq/kg LW, respectively. Farms with the highest GWP_{100} at the product level corresponded to those that have started their production recently or that retain the animals longer on farm premises, as is the case of two Finnish farms. When such farms (two out of eleven) are excluded, the average GWP_{100} falls to 2.3 kg CO_2eq/kg LW per t of LW, lower than the mainstream Finnish beef production systems, 32.1 kg CO_2eq/kg LW per kg of LW (Hietala et al. 2021). Compared to other farms under mainstream production, according to other European studies, HNV beef have lower GWP_{100} (Nguyen et al. 2010). However, GWP_{100} of beef products may not be comparable when livestock environmental assessments operate with different scopes and are potentially based on global averages.

Further analysis is required to reveal the nuances of the performance of HNV farms in relation to sustainable production. However, our results suggest that product-based environmental impact assessments alone may not reveal a complete sustainability picture of farming systems, HNV included. We demonstrate that, in order to assess sustainability for ruminant production systems, LCA assessments should account for biodiversity and carbon storage, and be framed in the sustainability discourse around farming practices. Assuming that a drastic reduction of animal products is necessary due to the unsustainability of western dietary patterns (Röös et al. 2017), HNV farms, despite their lower yields, have the potential to supply sufficient animal source foods while supporting environmental benefits.

Conclusion

The relationship between the environmental impacts and associated benefits in livestock production is not simple. HNV farms, due to its circularity practices, tend to act as carbon sinks, maintain biodiversity, perform with low eutrophication and water use while reducing the overall GWP and produce animal source food. This study contributes to attempts of quantifying the potential of extensive ruminant production to minimise GWP while maintaining biodiversity and other environmental benefits.

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