AFCP Blog

Modelling Greenhouse Gas Emissions from UK Dairy Farms

Fern Baker recently submitted her PhD on 'Evaluating strategies to reduce greenhouse gas emissions from dairy production systems' based at the University of Nottingham's School of Veterinary Medicine and Science, supervised by Dr. Luke O'Grady and Prof. Martin Green. Fern is now a Lecturer in Sustainability at Bournemouth University. Earlier this summer, Fern joined an AFCP webinar to explain more about her research.

Fern's work was jointly funded by the Agriculture and Horticulture Development Board (AHDB) and four AgriFood Charities Partnership (AFCP) members: Dartington Cattle Breeding Trust, Perry Foundation, Seale-Hayne Educational Trust, and West Country Dairy Awards.

Background

Fern Baker

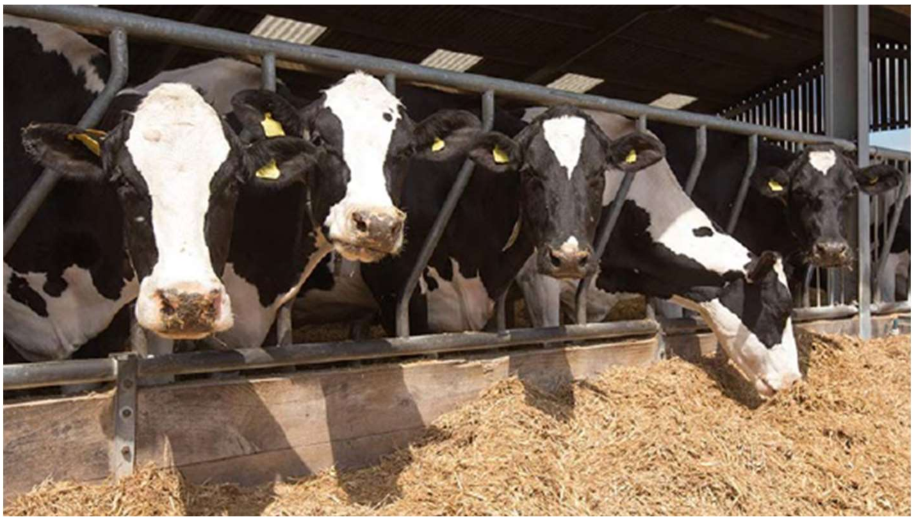
Globally, agriculture contributes to approximately 14.5% of greenhouse gas (GHG) emissions; this is estimated to be 10% in the UK. Cattle are the main cause of methane emissions from human activity. Within dairy cattle emissions, 71% of emissions are from enteric fermentation (fermentation which takes place in the digestive systems of animals).

Enteric fermentation occurs in the rumen of cattle, where feed is broken down by microorganisms including into hydrogen and carbon dioxide. Methanogens that live in the rumen then combine these gases to form methane. There are a variety of methods to directly measure enteric methane emissions; however these are generally expensive, time consuming, labour intensive and require specialised technology and training. Therefore, researchers have developed 'enteric methane prediction equations' based on characteristics of the cattle's diet as a more economic method.

PhD project

Fern's work is part of a wider project to build the Remedy Simulation Model which aims to show a holistic view of how changes to management strategies can help the UK to build a roadmap to achieve Net Zero. The evaluation of results from a range of enteric prediction equations was used to create a 'combined' enteric methane prediction equation using dietary composition variables. The results showed that an equation comprising of both Metabolised Energy and Neutral Detergent Fibre most accurately reflected the predictions across all equations.

With an agreed 'combined' equation, the model was used on a simulated farm. This simulated farm was designed to reflect the typical dairy farm in the UK and had 124 hectares with 140 dairy cows, mainly Friesians, but also Norwegian red and Normandy cross breeds. The cows yield more than 7,000 litres of milk/cow/year in a semi-seasonal system with grazing from April to November and an average first calving age of 25 months. Three scenarios were then simulated.



(Photo credit: Farmers Weekly)

Scenarios tested

The first was cattle replacement rates, where the typical farm simulated in the model was considered to be medium at 22%, and was compared to a low (10%) and high replacement rate (40%). Whilst the lower replacement rate yielded the lowest carbon dioxide equivalent (CO_2e) emissions, this also led to lower milk production, and therefore the model showed that an optimum replacement rate was the medium level, at 22%, see *Figure 1*.

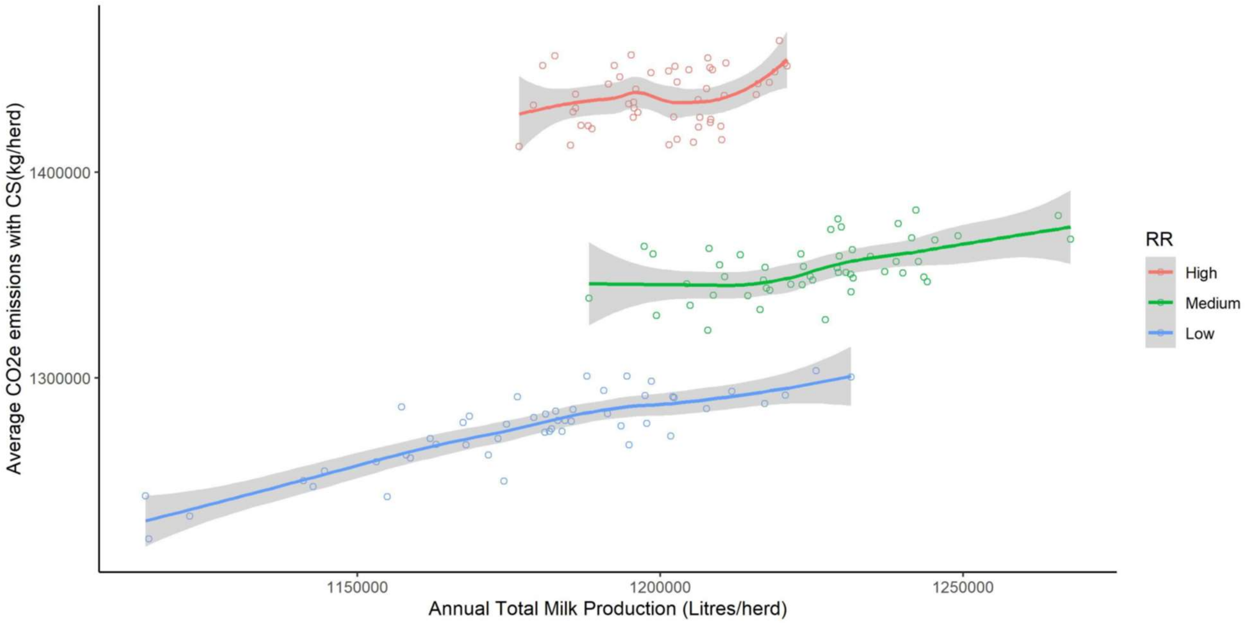


Figure 1: Simulated Total Annual Milk Production against Average CO_2e emissions, including carbon sequestration (CS) for a range of Replacement Rates (RR) [High = 40%, Medium = 22%, Low = 10%]

The second management strategy considered to reduce overall emissions of the milking herd was protein alternatives to soya bean meal in dairy cattle diets. This showed potential options to reduce the total annual farm emissions by up to 28%. Peas were the least emitting diet, with red clover second lowest of the options considered. Soyabean meal had the largest overall emissions compared to the 13 diets and when the source was linked to deforestation the emissions increased by 7%. The model assumed that feed was produced off-farm to evaluate both enteric emissions and those from feed production. The total emissions could be lower if the feed was produced on-farm.

In 2019, the NFU set an ambitious goal of reaching Net Zero GHG emissions across the whole of agriculture in England and Wales by 2040, as part of the UK's ambition of Net Zero by 2050. Based on the typical dairy farm simulated, the model was utilised to see whether and how Net Zero might be achieved by 2040. To examine the potential of carbon offsetting, the farm was simulated as a fully housed system, allowing the option to afforest the whole farm. Additionally, slurry manure management was compared to anaerobic digestion, an estimated reduction of 30% in methane emissions from feed additives, increased efficiency of 10,000 litres of milk/cow/year, as well as reducing the milking herd size by 10 and 20%.

(Photo credit: Earth Overshoot Day).

The model demonstrated that afforestation of a mixed tree species alongside the use of feed additives, and anaerobic digestion, was required to reach Net Zero. Anaerobic digestion reduced total emissions by 70% compared to slurry, *see Figure 2.* A reduction in milking herd size was not needed due to the increase in efficiency and total milk production (35 litres/day/cow). Given that trees require time to grow before they can significantly contribute to GHG emissions absorption, 20 years was considered necessary to reach a stabilised point. This takes to beyond the 2040 target, however, it could be possible to meet the 2050 target if management strategies are implemented before 2030.

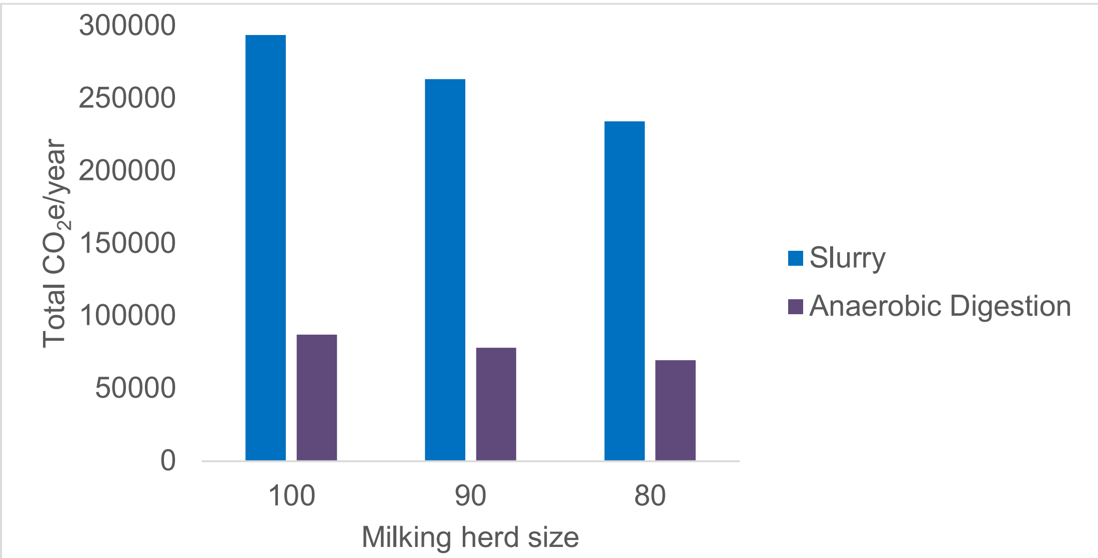


Figure 2: The total CO_2e emissions from anaerobic digestion compared to slurry as a manure management system for a milking herd size of 100, 90 and 80 cows.

Next steps

The discussion actively noted that these conclusions need to be considered in a wider context for a national scale. Further research should be considered into aspects such as silvo-pastoral systems, which could not be accurately modelled in the current study, cattle in woodlands, the carbon offsetting potential of a wider variety of tree species, biodiversity, and land availability to meet our needed tree cover, carbon reduction and food stability goals.

It was noted that this PhD research started in 2020 when the COVID pandemic was in full flow, thus limiting the ability to work with farmers. Addressing this would be important to supporting future recommendations to reduce GHG emissions in the UK dairy herd to examine feasibility, willingness and determine the required policy and subsidies needed to reach Net Zero.

AHDB expressed that modelling, such as this research project, provide potential strategies for the UK dairy sector and carbon sequestration. Such research contributes to the UK Dairy Roadmap, a pioneering cross-industry initiative which brings together the entire dairy community to continuously improve environmental sustainability of the sector; the Dairy Roadmap, which started in 2008, involves Dairy UK, AHDB, the NFU alongside dairy farmers, milk processors and the wider industry. Additionally research supported by AHDB contributes to work on margin abatement cost curves looking at how different practices are cost effective considering their abatement potentials on farm at a national level. AHDB are currently undertaking an Environment Baselining Pilot which will use on-farm data to assess the net carbon balance for up to 170 farms.