Project number: 6241
Funding source: Teagasc
Date: March 2017
Project dates: Dec 2012 – Dec 2016

Development and evaluation of Life Cycle Assessment technologies for the Irish Dairy Industry

Key external stakeholders:
Dairy Processors, dairy farmers, Bord Bia, ORNUA

Practical implications for stakeholders:

- Developed and parameterised dairy carbon footprint model according to British Standards Institute PAS 2050 specification and received Carbon Trust accreditation
- Integrated certified carbon footprint model with Bord Bia database that can be used to generate carbon footprint for Irish dairy farms
- Completed marginal abatement cost curve from both a life cycle assessment and national inventory perspective showing the potential of mitigation strategies to reduce emissions from Irish dairy farms while production increases in line with agri-food policy targets
- Conducted international comparison of carbon footprint of milk between Ireland, England and the USA and showed high performing Irish dairy systems footprints are amongst the best in the world

Main results:

- Carbon footprints of a sample of 124 Irish dairy farms, quantified using a PAS 2050 accredited footprint model in 2011 and 12, averaged 1.11 kg CO2-eq/kg of FPCM and ranged from 0.87 to 1.72 kg CO2-eq/kg of FPCM. The variation in farm footprints was strongly influenced by farm productivity, particularly nutrient use efficiency and soil fertility.
- Full adoption and implementation of strategies to increase farm productivity nationally was estimated via a marginal abatement cost curve to reduce greenhouse gas emissions from agriculture by 5.5% compared to the baseline year (2005) and allowed the sector to achieve it's 2020 production targets at little or no cost. Over 50% of this potential reduction was from improvements in the dairy sector.
- The mitigation potential of national emission reduction strategies was far greater using a life cycle approach, over double, but less than half this mitigation can be captured in the national inventory.
- An international case study in 2013 with UK and US researchers showed that the carbon footprint of a well-managed Irish pasture based system was 5% lower than a high performing UK system and 7% lower than a well-run US system using data averaged across a three-year period.

Opportunity / Benefit:

Lifecycle assessment (LCA) is the commonly accepted approach for the completion of carbon footprint assessment across industry. While lifecycle assessment is not new, this research in the context of agriculture could be defined as being in a state of flux, with most countries and systems taking their own nuanced approach to the completion of the assessments. This creates a situation where it is typically not a useful exercise to try to compare across LCA studies, because there are differences in the approaches taken as well as substantial differences in the assumptions and models used. This project developed LCA models that were independently accredited to recognized international standards to facilitate valid comparison between certified LCA models. The certified models were applied nationally, thereby providing the dairy industry with scientifically robust footprint estimates. Additionally, these models were used to project the potential to mitigate emissions from the industry as production increases.

Contact Laurence Shalloo Email: Laurence.Shalloo@teagasc.ie

Collaborating Institutions:
Teagasc project team: Dr. Laurence Shalloo (PL)
Dr. Donal O Brien
Teagasc GHG emissions working group
External collaborators: Padraig Brennan Bord Bia,
John Fitzgerald Glanbia
Sinead Treanor Carbery

1. Project background:

Carbon footprint is now widely used to report greenhouse gas emissions from food products. Leading supermarkets in the UK e.g., Tesco provide this information to their consumers on several products, including milk, using carbon labels. Supermarkets increasingly need carbon footprints from their suppliers to verify their sustainability credentials for their customers. To address this demand, this project developed a carbon audit system, using recognized LCA models, to provide robust estimates of greenhouse gas emissions from Irish dairy farms. Additionally, the models were developed to quantify emissions according to national inventory greenhouse gas guidelines. This was necessary given that the primary dairy industry is part of Ireland's non-emission trading sector, which has agreed as an EU member to reduce greenhouse gas emissions by 20% by 2020 relative to 2005 levels. This target is very challenging as Irish milk production grows to meet global demand post quota abolition. This project, therefore also modelled the potential to reduce dairy emissions as production volumes increase using LCA and national methods. These modelling or accounting approaches were compared to provide information to policy makers on how reducing national greenhouse gas emissions can change emissions outside our borders and effect farm carbon footprints.

2. Questions addressed by the project:.

- We addressed industry and supermarket questions regarding the carbon footprint of Irish dairy by quantifying the carbon footprint of dairy products based on present international standards (BSI, 2008; IDF, 2010; ISO, 2006). in conjunction with Bord Bia
- Developed a carbon audit system that addresses farmer and industry questions regarding the sources of greenhouse gas emissions and how they can be mitigated
- Provided information to policy makers on the effect of using the national inventory guidelines or life cycle assessment to estimate the potential of various strategies to reduce national greenhouse gas emissions from dairy and agriculture
- We compared carbon footprints of high performing grass-based and confinement dairy farms to address queries regarding the global performance of top grass-based milk producers in term of carbon footprint.

3. The experimental studies:

Direct measurement of agricultural emissions is difficult and cost prohibitive. Thus, simulation models of complex biological and technical processes are used within LCA to quantify greenhouse gas emissions from milk. The parameters and algorithms of these models are based on the outcomes of research studies and usually verified by the Intergovernmental Panel on Climate Change (IPCC) scientific body. Our initial study, developed an LCA model using the outputs of Irish and international field work approved by the IPCC and Carbon Trust. Greenhouse gas emissions were estimated with the LCA model in CO_2 equivalents (CO_2-eq) and allocated economically between dairy farm products. Carbon footprint of milk was estimated by expressing emissions attributed to milk per kg of fat and protein corrected milk (FPCM). The Carbon Trust tested the LCA model for non-conformities with PAS 2050. PAS 2050 certification was achieved when non-conformities were fixed or where the effect of all unresolved non-conformities on the footprint of milk was < ± 5%. The model was tested using data from research and commercial farms. Data was collected from 171 commercial farms in 2011-12 using annual surveys, milk processor records and national livestock databases. Information was successfully obtained electronically from 124 farms and fed into a cradle to farm-gate LCA model. A sub-sample of this group was used by the Carbon Trust to validate the LCA model.

In a subsequent modelling study, strategies to mitigate dairy farms greenhouse gas emissions were modelled with the LCA model after analyzing the factors that influenced commercial farms footprints. Improvements in farm performance or changes in technologies were based on industry reports and expert opinion. This analysis was also carried out according to the national inventory method. Both modelling methods were used to quantify mitigation estimates for primary dairy production. These estimates were used to generate national marginal abatement cost curves (MACC) for the different methods.

To further analyze the performance of Irish dairy production and grass-based systems in terms of carbon footprint, we compared the footprints of high performing farms located in Moorepark, Nottingham and using

Contact Laurence Shalloo Email: Laurence.Shalloo@teagasc.ie

the top 5% of herds in the US dairy metrics database. The analysis was completed with an expanded LCA model and compared different methods to attribute environmental impacts to dairy farms co-products.

4. Main results:

- The combined effect of LCA model non-conformities with PAS 2050 on carbon footprint of milk was < 1%. Consequently, PAS 2050 accreditation was granted and the model was embedded in national databases. The mean certified carbon footprint of milk from the sample of grass-based farms investigated in 2011-12 was 1.11 kg of CO_2-eq/kg of FPCM and ranged from 0.87-1.72 kg of CO_2-eq/kg of FPCM.
- Although, some farm attributes had stronger relationships with milk footprint than others, no attribute accounted for the majority of variation between farms. Milk carbon footprints could be reasonably predicted using N efficiency, the length of the grazing season, milk yield/cow and annual replacement rate (R^2 = 0.75). Management changes can be applied simultaneously to improve each of these traits allowing grass-based farmers to reduce carbon footprint of milk.
- A marginal abatement cost curve completed for the Irish agricultural sector, showed that even with a 50% increase in milk production by 2020 1.1Mt of annual abatement could be achieved at zero or negative cost, but the LCA approach suggested that the mitigation could be over twice that amount with the same mitigation strategies.
- The IPCC guidelines are typically used to carry out marginal abatement cost curves, but this method does not necessarily select the correct or optimum mitigation strategies and can cause carbon leakage as the IPCC method is constrained by national boundaries.
- Our comparison of top performing dairy systems showed that the carbon footprint of milk from a well-managed grass-based Irish system was 0.76 kg of CO_2-eq/kg of FPCM, which was lower than well run UK and USA confinement system (0.79-0.83 kg of CO_2-eq/kg of ECM). However, without grassland carbon sequestration, there was no difference in dairy systems carbon footprints. The analysis indicates that the top grass-based dairy systems are amongst the best in the world for carbon footprint and 25% lower than the average farms footprint.

5. Opportunity/Benefit:

The current project has developed scientific methodologies to aid the quantification of sustainability on dairy farms in Ireland. It has developed the models and methods to internationally recognized standards and integrated carbon footprint models in national databases. The project has demonstrated the technical capacity to reduce greenhouse gas emissions from Irish dairy even with strong milk production growth and demonstrated our top grass-based dairy systems carbon footprint perform as well or better than the best indoor primary milk production systems.

6. Dissemination:

Main publications:

O'Brien, D; Shalloo, L; Crosson, P; Donnellan, T; Farrelly, N; Finnan, J; Hanrahan, K; Lalor, S; Lanigan, G; Thorne, F; Schulte, R (2014). An evaluation of the effect of greenhouse gas accounting methods on a marginal abatement cost curve for Irish agricultural greenhouse gas emissions. Environmental Science and Policy. 39 107-118

O'Brien, D.; Capper, J. L.; Garnsworthy, P. C.; Grainger, C.; Shalloo, L. (2014). A case study of the carbon footprint of milk from high-performing confinement and grass-based dairy farms. Journal of Dairy Science 97, 1835-1851

O'Brien, D; Brennan, P; Humphreys, J; Ruane, E; Shalloo, L (2014). An appraisal of carbon footprint of milk from commercial grass-based dairy farms in Ireland according to a certified life cycle assessment methodology. International Journal of Life Cycle Assessment. 19 8 1469-1481

International conferences

Presented results at numerous conferences including Greenhouse Gas and Animal Agriculture conference in Dublin 2013, the SRUC Sustainable intensification conference in Edinburgh 2013, the European International Farming Systems Association Symposium in Berlin 2014 and the Animal Change Livestock, Climate Change and Food Security conference in Madrid 2014.

Open days:

Presented at Moorepark open days and events that were held on individual farms throughout the country.

Industry consultation

Different industry groups were collaborators on this project and therefore got first-hand knowledge of the results. For other national stakeholders there was meetings at different points throughout the project.

Contact Laurence Shalloo Email: Laurence.Shalloo@teagasc.ie

Farmer discussion groups

Results were presented and discussed at many farmer discussion groups and seminars. There was also intensive sessions completed with the farmers involved in the overall study on a number of occasions throughout the project to provide feedback on an on-going basis.

7. Compiled by: Dr Laurence Shalloo

Contact Laurence Shalloo Email: Laurence.Shalloo@teagasc.ie