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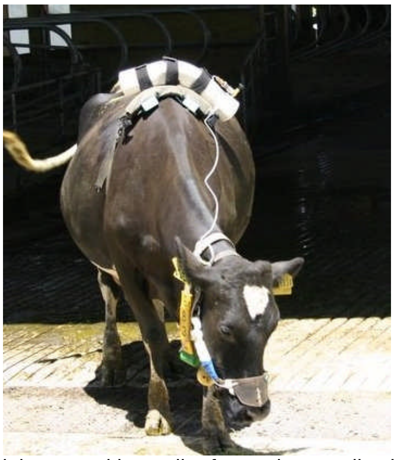
Greenhouse gases mitigation and agriculture



A dairy cow with a collar for methane collection

Key external stakeholders:

Farmers
Department of Agriculture, Food & the Marine
Environmental Protection Agency

Practical implications for stakeholders:

This research shows that Irish agriculture has decoupled greenhouse gas emissions from production since 1990. Future climate change will marginally impact on summer grass yields but total annual production should be less affected. Greenhouse gas emissions will increase with soil C release and higher N_2O emissions

- **Farmers:** This research demonstrates that Irish beef and dairy production has become increasing C efficient. Future sustainable intensification should reduce emissions intensity further.

- **Policymakers:** This research shows that considering the relative efficiency of Irish agriculture, future climate policy should not result in carbon leakage.

- **Scientific:** This research demonstrates that nitrous oxide and soil organic carbon emissions in arable and grassland systems are likely to increase. This may eventually result in many grassland C sinks turning into sources.

Opportunity:

This research demonstrates that current and future Irish agriculture is carbon efficient and that any policy that restricts production may lead to perverse outcomes (i.e. an increase in global agricultural emissions.) Also, it identifies that climate change will result in an increase in emissions, particularly nitrous oxide, without climate-proofed abatement strategies.

Main results:

The C footprint of beef has reduced by 20% reduction from 1998 to 2009 and, milk production has also lowered its C intensity by 25%. Future climate policy should ensure that agricultural production is optimized in these regions where efficiencies are greatest (Europe and North America). Future climate change will inevitably lead to an increase in farm greenhouse gas emissions due to a decrease in pasture carbon sinks and an increase in nitrous oxide emissions. Abatement strategies should be 'climate-proofed' before being recommended to farmers.

Collaborating Institutions:

Trinity College Dublin.

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Dr. Rogier Schulte
External collaborators: Prof. Mike Jones (TCD)

1. Project background:

The EU has set a long-term climate protection target to limit increases in mean global temperatures to no more than 2°C which will require a projected 20% reduction in emissions by 2020 and an 80% cut in global emissions by 2050. In this context, Ireland has been set a target of 20% reduction in greenhouse gas (GHG) emissions by 2020. However these reductions apply only to the agriculture, transport, residential and waste management sectors as heavy industry and energy generation are being administered directly by the European Commission.

Although one of the largest sectoral GHG emitters, comprising 30.5% of the national total agricultural emissions have decreased by 9% since 1998. To date the sector has been relatively unaffected by government policy but post-Kyoto scenarios will put agriculture under pressure to deliver reductions. Hence there is a pressing need to assess agricultural GHG emissions in the context of higher production demand, a reduction in quota's and a more stringent limit on national emissions. This study seeks to address the current state of agricultural emissions, current and future research requirements, assess future policy structures that are required and suggest options for climate change mitigation and adaptation that will serve Irish agriculture post 2012.

2. Questions addressed by the project:

What is the current 'state of play' as regards GHG emissions (i.e. current legislation, policy and agricultural GHG inventory data) and climate change (rates of increase, scenario predictions and predicted effects)?
What are the future climate change effects on greenhouse gas emissions from agriculture?
Can we make stakeholders more aware of greenhouse gas issues and impending legislation?

3. The experimental studies:

An analysis of greenhouse gas emissions and their relationship with agricultural production over time was conducted using the methodologies laid down by the Intergovernmental Panel on Climate Change (IPCC). This methodology allowed us to generate 'carbon footprints' for Irish agricultural produce over time (years 1990 -2007). This subsequently enabled us to explore whether agricultural emissions were 'decoupling' from production.

A process model (DAYCENT) was used in order to assess future climate impacts on GHG emissions from both arable and grassland systems. Weather data was generated from the A1 climate scenario using outputs from the HadCM4 climate prediction model up to 2070. The basic assumptions of this model were a 20% increase in winter rainfall, a 20% decrease in summer rainfall and a 1.4^{o}C temperature increase. Outputs from DAYCENT included carbon sequestration, N_2O emissions, leached N and grass/crop production.

Workshops were held in order to raise awareness of the issue of greenhouse gases and contributions were also made to national reports (see below).

4. Main results:

Irish emissions and production have decoupled.

Agricultural emissions were 9.1% lower than the reference (1990) levels and 17.1% lower than the 1998 maximum by 2009. This reduction was driven by decreases in both methane (60% of emissions) and nitrous oxide (38.5% of emissions).

Methane

The reduction in total methane emissions has been driven primarily by decreases in the total number of beef cattle and sheep. However, whilst sheep emissions have decreased linearly with ovine meat production (30%), there has been a decoupling between cattle emissions and total production. Methane emissions for beef and dairy cattle fell by **10%** and **13%** respectively between 1998 and 2006, whilst beef and milk production remained static. This decoupling was mainly driven by improved efficiency of production, specifically reduced finishing times in the beef sector and increased milk production per head in the dairy sector. An important caveat in this observation is that further improvements in production efficiency will be incrementally more challenging to obtain. As a result, this historic decoupling of livestock numbers and GHG emissions cannot and should not be symmetrically projected into future scenarios.

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Nitrous oxide
Nitrous oxide (N_2O) emissions arise as a result of the deposition of urine and faecal nitrogen (N) from livestock, the application of chemical and organic nitrogen fertilizers and, indirectly, from ammonia volatilisation and leached N. Total agricultural N_2O emissions have decreased by **11%** relative to 1990 and over **20%** relative to 1998 peak emissions. Decreased N_2O emissions arising from animal deposition, termed pasture, paddock and range (PPR) emissions, have followed a similar trend to methane emissions, with the principal reductions arising from sheep (38%) and non-dairy cattle (11%). Similarly, reductions in the application of mineral fertilizer resulted in a **28.9%** decrease in associated emissions between 1998 and 2008, associated with a 30% increase in fertilizer costs since 2000. Whilst inputs of mineral N have decreased, the use of organic fertilizer (and associated emissions) has remained constant despite decreases in the total livestock numbers.

Impact on carbon footprint
These reductions in both methane and nitrous oxide emissions have resulted in a decrease in the C footprint of beef reducing from 26 kg CO_2-equivalents kg^{-1} beef in 1998 to 19 kg CO_2-equivalents kg^{-1} beef in 2009. This represents a 20% reduction and is due to decreases in animal finishing times. Similarly, milk production has lowered its C intensity by 25% for 1.6 kg CO_2-equivalents kg^{-1} milk to 1.2 kg CO_2-equivalents kg^{-1} milk in 2009.

Impact of carbon leakage
Carbon leakage results in a global net increase in GHG emission if the region where production is displaced to has a higher 'emissions intensity' (GHG emissions per unit product) than the region where production had contracted. This anomaly could have potentially significant impacts on net global GHG emissions. Figure 1 shows the emission intensity of dairy and beef production for a range of geographical locations, calculated using IPCC-defined agricultural emissions (Lanigan et al., 2011). It shows that emissions from South America and South Asia were almost double those of Irish, EU and New Zealand emissions, even without taking into account the effects of land use change, i.e. expansion of the agricultural area at the expense of natural habitat. If land-use emissions were to be included (with only residue burning and soils emissions allocated to the land-use change), the emissions per unit product would double for South America.

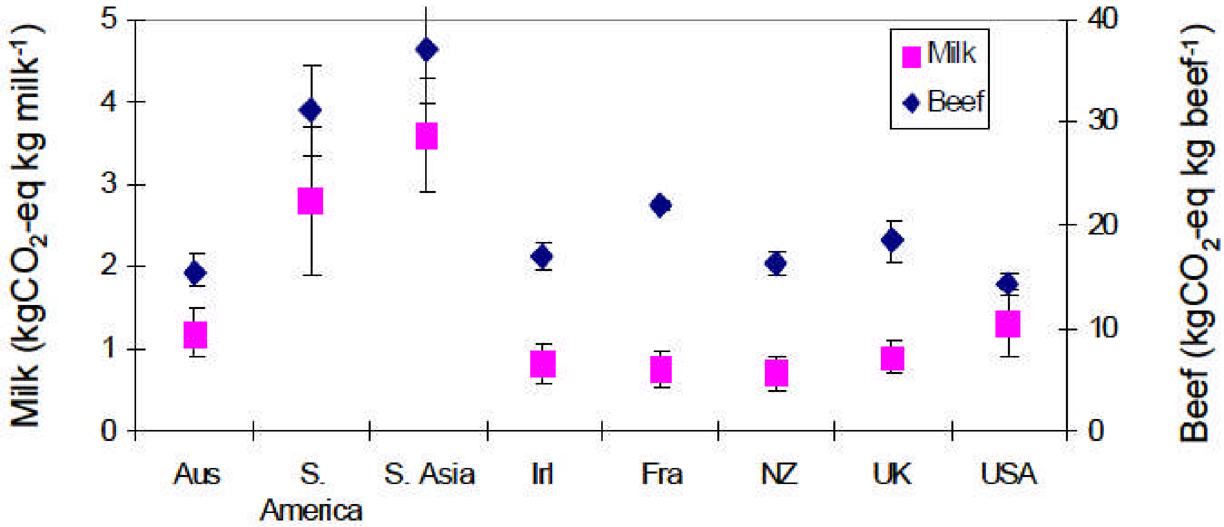

Figure 1: Total agriculture-based emissions intensity for beef and dairy produce across a range of geographical locations

Simple calculations based on the values presented in Figure 1 show that displacement of 50% of current Irish beef exports to South America would result in a net increase of global emissions by between c. 3.6 Mt CO_2eq per annum, equivalent to c. 20% of total current Irish agricultural emissions. This conservative estimate disregards emissions associated with landuse change; if these emissions were to be taken into consideration, the estimated value would be two to three times higher.

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Impacts of future climate change on agricultural emissions
Outputs from the DAYCENT process model showed that net carbon balance of grasslands may fall by over 50% from 3.7 tonnes C ha^{-1} yr^{-1} to 1.5 tonnes C ha^{-1} yr^{-1}. This is due to a significant increase in ecosystem (soil and plant) respiration relative to photosynthesis. Based on this rate of decrease, grassland sinks may convert to net sources by 2100. Seasonally, summer growth was shown to decrease relative to present-day conditions by 10% due to moisture deficits, while winter growth increased by 8%. Nitrous oxide emissions increased by 17% relative to present day for grassland systems and 11% for arable systems. This is principally due to increased spring and winter losses associated with higher soil moisture during these periods. Higher indirect N_2O emissions are also likely to result from increases in winter leaching of N and summer volatilization.

5. Opportunity/Benefit:

The primary stakeholders for this research are both farmers and policy makers. This research demonstrates that current and future Irish agriculture is carbon efficient and that any policy that restricts production may lead to perverse outcomes (i.e. an increase in global agricultural emissions). Irish agriculture should look to exploit its low C footprint in terms of market strategy and defending the sector in future climate negotiations. Also modelling may be an efficient tool in terms of decision-support for 'climate-proofing' abatement measures.

6. Dissemination:

Awareness of the project and relevant results were, and continue to be disseminated via scientific peer-reviewed journals as well as the popular press and media.

Main publications:

Journal article:

Smith, P .,Lanigan, G., Kutsch, W., Buchman, N., Eugster, W., Aubinet, M. and Osborne, B. A. (2010). Measurements necessary for assessing the net ecosystem carbon budget of agricultural systems.' Agriculture, Ecosystems and Environment 139: 302-315

Schulte, R.P.O. and Lanigan G.J. (2011) *Irish Agriculture, Greenhouse Gas Emissions and Climate Change: opportunities, obstacles and proposed solutions*. Carlow, Teagasc Report.

Popular publications:

Lanigan, G.J. (2009) Greenhouse gas emissions form agriculture. TResearch,

Lanigan G.J. '*Mitigation strategies for Irish Agriculture'* IIEA Conference, Dublin Castle, January 2009. http://www.youtube.com/watch?v=sLHQc1IvUf0

Lanigan G.J. '*Greenhose gases from Irish Agriculture'*
http://www.youtube.com/watch?v=kjklpr_uYwg

Lanigan, G.J. Pat Kenny Show, Six-One News and TV-3 News, Farmfest 20 June 2008.

7. Compiled by: Dr Gary J. Lanigan

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