



How UK farmers could reduce greenhouse gas (GHG) emissions

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Section Science and Environment Section

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- It is generally accepted that the emissions of greenhouse gases (GHG) need to be sharply reduced. This note considers how agriculture could contribute to this objective. A related note [Agriculture and Climate Change](#) (SN/SC/3763) covers the effect of climate change on agriculture. Another note deals with [Biofuels](#) (SN/SC/3691). That note covers arguments about how far farmers can help to reduce overall carbon emissions by planting crops that replace petrol or other fuels.
 - A report by Stanford University in 2010 concluded that intensive farming contributed to reduction in carbon emissions, because the alternative would be to use much more land at a lower productivity. The researchers found that agricultural advances between 1961 and 2005 spared a portion of land larger than Russia from development and reduced emissions by the equivalent of 590 Gigatonnes of carbon dioxide – roughly a third of the total emitted since the start of the Industrial Revolution (Nature, 17 June 2010)
 - Some people argue that a vegan diet is necessary to reduce emissions of methane from ruminants. Others argue that changes to feeding practices can achieve considerable reductions.
 - In November 2010 the Government announced increased funds for research into measuring the effect of specific agricultural practices on GHG emissions.
 - On 29 March 2011, the UK farming industry launched a Greenhouse Gas Action Plan.

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1 Farming contribution to GHG

Policy on climate change almost entirely relates to carbon emissions. That includes the targets in the Kyoto agreement and policies on carbon trading developed by the European Union. For agriculture, however, the most important GHGs are methane and nitrous oxide. The Rural Development Programme for England 2007-2013 notes:

294. In terms of climate change mitigation, the agriculture and forestry sector is unique in having the ability both to produce and to sequester greenhouse gases, as well as to provide biomass-derived renewable energy. Agriculture and forestry currently account for about 7% of UK's total greenhouse gas emissions. The focus is on non-CO₂ emissions, with this sector accounting for around 36% of methane emissions in the UK and 67% of nitrous oxide emissions. About 86% of this methane comes from enteric fermentation in the digestive system of animals and 14% from manure management. The nitrous oxide emissions arise from manures and artificial fertiliser. Methane and nitrous oxide have global warming potentials that are greater than carbon dioxide by 21 and 310 times respectively. Emissions of carbon dioxide are from direct energy use, such as diesel in tractors, gas to heat greenhouses, and electricity in livestock buildings. Although agriculture is only directly responsible for around 1% of CO₂ emissions, the sector can help to mitigate CO₂ emissions from other sources through carbon sequestration in soils and timber, and by producing energy crops to replace fossil fuels.¹

A report in 2010 gives a much higher figure for food consumption as a whole:

The food we eat accounts for 30% of the UK's carbon footprint, according to a new report published today by WWF-UK and the Food Climate Research Network. Previous estimates put the figure closer to 20%, but this study is the first to incorporate land use change overseas, increasing the estimate of emissions attributed to food consumption in this country from 152MtCO₂ to 253MtCO₂.

Land use change, mainly deforestation, is a major source of climate changing emissions. Each year world-wide, an area of forest equivalent to half of England is lost. The expansion of the food system is the biggest driver behind this as land is cleared to grow crops and rear animals. (..)

¹ Defra, [Rural Development Programme for England 2007-13 Document](#), 3-94

In terms of the impacts of food consumption the report found:

- The food chain's contribution to overall UK consumption-related emissions is 20%. However, when land use change is included this increases to 30%.
- All stages of the UK food chain give rise to emissions, with the breakdown as follows: production and initial processing (34%); manufacturing, distribution, retail and cooking (26%) and agriculturally-induced land use change (40%).
- Livestock farming accounts for 57% of agricultural emissions and is also responsible for three quarters of land use change emissions.²

However, agriculture and forestry also have the potential to reduce the level of carbon dioxide in the atmosphere by carbon sequestration. This can be in the form of trees or crops. At one time people were very optimistic about the scope for carbon sequestration by planting trees, but it is now clear that there are considerable problems. Soil has to be disturbed to plant a tree and that disturbance can result in a release of carbon dioxide. In addition, trees themselves can die in higher temperatures. Efficient carbon sequestration is not simply a matter of planting trees in large numbers.

On the other hand, in many parts of the world the destruction of forests in order to allow expansion of agriculture is a major cause of increasing carbon emissions. For obvious reasons that is not an issue in the UK.

A report in late 2009 indicates the scale of the problem for European farming:

Nitric oxide and methane emissions from livestock and intensive arable farming are so bad that they virtually negate the positive contribution of European forests as carbon sinks, according to Germany's Max-Planck Association. (...) Up to now, Europe's greenhouse gas balance has been viewed too positively, the scientists say, because people have concentrated on carbon dioxide emissions and overlooked emissions of nitric oxide and methane. The only way to put this right, according to [leader of the international research team] Schulze, is to make changes to European methods of farming.³

The Natural England Carbon Baseline assessment produced a comparison of average CO₂-equivalent emissions from individual farms in 2008.

Cereals	2.8
Dairy	10.7
General Cropping	3.2
Horticulture	4.2
Less Favoured Area Grazing Livestock	2.5
Lowland Grazing Livestock	5.5
Mixed	4.2

² WWF News Release, *New report finds technology and behavioural changes required to cut emissions from food*, 18 January 2010

³ "European farming 'upsets climate balance', *Agra Europe*, 27 November 2009

Over all the farms studied (with the exception of horticulture, nature reserves and excluding carbon sequestration in or emissions from soil), nitrous oxide contributed 54 per cent of emissions per ha (CO₂e), methane contributed 26 per cent and carbon dioxide 20 per cent. These proportions are as close as could be expected to the UK averages for agriculture (51 per cent, 35 per cent and 14 per cent - where this CO₂e figure excludes land use, land use change and forestry).⁴

In November 2010 Defra stated that:

From 1990 – 2008, the agriculture sector accounted for:

- 76 per cent of UK nitrous oxide (N₂O) emissions, mainly from the use of nitrogen fertilisers
- 38 per cent of the UK's methane (CH₄) emissions, mainly from the digestive systems of livestock and from manure
- 1 per cent of the UK's carbon dioxide (CO₂) emissions

(from 2010 DECC publication of GHG emissions)⁵

In November 2010 DEFRA announced £12.6m for research into better measurement of the effect of changes in agricultural practices on GHG emissions.⁶

2 The Greenhouse Gas Action Plan

On 29 March 2011, the farming industry launched the [Greenhouse Gas Action Plan](#). The NFU explained:

Commitment

The Greenhouse Gas Action Plan (GHGAP) sets out how the agriculture industry in England is responding to this challenge. It shows a commitment to playing our part in tackling climate change by reducing our greenhouse gas emissions by three million tonnes of CO₂ equivalent per year from 2018-2022. The GHGAP is one of a range of initiatives that are already helping farming produce more whilst impacting less. Organisations from across the industry have been involved in the GHGAP.

What are we going to do?

We aim to meet this challenge without compromising domestic production. It's too simple a solution to produce less and import more. This just "exports" our emissions to other parts of the world. So our Action Plan focuses on how farmers, across all sectors and farming systems, can become more efficient to help reduce greenhouse gas emissions and make cost savings per unit of production.

Agriculture can also make a big contribution to mitigating climate change by storing carbon in soils and vegetation and by generating renewable energy. We are determined to show that farming is part of the solution.

How are we going to do this?

⁴ Natural England, Carbon Baseline Survey Project, April 2008

⁵ Defra Press Release, *New research will help farmers reduce greenhouse gas emissions*, 3 November 2010

⁶ Defra Press Release, *New research will help farmers reduce greenhouse gas emissions*, 3 November 2010

We're going to make the most of what's already in place and what new science tells us, so that we get better at what we do. We're going to use trusted routes of influence to help farmers and land managers carry out the GHGAP's priority actions - by improving their use of energy and nutrients, their management of crops and livestock and reducing their own carbon footprint.

This is an unprecedented partnership of sixteen organisations (and the number is likely to grow) representing the breadth of the agricultural industry in England. We're going to focus on how we can work better together, with Government and with the food supply chain. We will regularly report on progress so that farmers and land managers can be confident that their changes in farm practice are leading to lower emissions.⁷

The Executive Summary of the first phase explains the priority of promoting production efficiency:

The agriculture sector is committed to playing its part in contributing to meeting the national target of an overall 80% reduction in greenhouse gas (GHG) emissions by 2050. In response to the last Government's Low Carbon Transition Plan, published in July 2009, this Greenhouse Gas Action Plan (GHGAP) has been progressively developed by an industry partnership to deliver an initial reduction of 3Mt CO₂e GHG emissions by 2020. Building upon an earlier Framework for Action published in February 2010, the first phase of this delivery plan sets out the process that will be implemented by a broad-based industry-led partnership, to encourage farmers and growers to take actions that will reduce their emissions over time.

There are significant challenges in implementing this plan, not least the technical complexities involved in reducing emissions that are an inevitable consequence of food production systems, and the fact that the agriculture sector is highly diverse in nature, served by many different organisations and networks. Nevertheless, this plan has identified a suite of priority actions that can be progressively implemented on-farm.

The initial focus of the delivery plan is to promote production efficiency, since this will both yield significant GHG savings and result in more robust farm businesses. The plan will also complement other environmental priorities, such as the protection of water resources, soils and biodiversity. It uses existing trusted delivery routes where possible, for example, recently published sector Roadmaps will be important vehicles for changing farm practices to improve production efficiency. This will minimise the potential proliferation of initiatives, simplify the task of delivery and minimise the duplication of effort across the partnership. Lastly, it sets out how the use of science and technical advice will be improved to influence and motivate behaviour change, and how the partnership will work with Government to develop a means of monitoring progress in the sector over time.

It is envisaged that this plan will be taken forward in three phases, using as far as possible existing initiatives and networks. Specific details are set out for how Phase 1 (2010 – 2012) will be put into practice. The plan will be reviewed and details for the implementation of Phase 2 (2012 – 2015) will be published in 2012. In Phase 1, particular emphasis will be given to establishing a foundation on which to consolidate further progress. More specifically, the feasibility of an Information Hub (iHub) and how it helps advisors deliver consistent messages will be explored, with a decision about piloting an iHub made in early 2011. A number of actions to establish a communications strategy are set out that will enable a prioritised approach to how messages are delivered, and to which farming sectors. This will enable finite resources

⁷ NFU Press Release, *GHG emissions – agriculture's action plan*, 29 March 2011

to be used to make the biggest differences in awareness and uptake of on-farm actions.

Finally, a simple governance structure has been established that ensures a strategic approach to prioritised actions set out in this delivery plan, under the joint chairmanship of the officeholders of the CLA and NFU.

Farm Minister Jim Paice called on farmers to live up to their commitments. The Press Release explained Government action:

The Government is supporting the agricultural sector to reduce its emissions by:

- investing £12.6m to improve science base and measurement of on-farm emissions (Agriculture GHG Inventory);
- launching a pilot scheme to offer integrated advice to farmers on land management and reducing emissions;
- working with supply chains to reduce their emissions; and
- looking at other ways that policy can support the industry, for example through reform of the Common Agricultural Policy.⁸

3 Ruminants and methane

Research

In August 2008, French researchers announced an advance:

A new study claims to have discovered an animal feed composition which can reduce methane emissions from cattle by as much as 30%. Research from France's Institut National de Recherche Agronomique (INRA) contends that by incorporating the right levels of vegetable oil rich in polyunsaturate fatty acids into dairy cow feed, methane emissions through eructation and flatulence can be cut by nearly a third.⁹

Scientists have proposed a simpler solution:

Two Australian biologists say there is a sure-fire way to reduce methane emissions without resorting to complex biotechnology: cut the number of cattle and sheep being reared and meet the demand for meat with marsupials. Kangaroos produce barely any methane as their dominant gut flora are acetogens, not methanogens. George Wilson and Melanie Edwards, based at Australian wildlife services in Canberra, have calculated that replacing a third of Australia's sheep and cattle with kangaroos would slash cattle emissions and reduce the nation's entire greenhouse gas emissions by 3%.¹⁰

On 30 November 2009, EBLEX, the meat industry body, published a report on what can be done to reduce emissions from cows and sheep:

The roadmap looks at the current position for emissions from the beef and sheep meat production processes and what can be done to improve performance. It has been put together by EBLEX over 12 months, working closely with organisations like Defra, NFU, British Retail Consortium, British Meat Processors Association, Association of

⁸ Defra Press Release, *Farming industry must act to reduce greenhouse gas emissions*, 5 April 2011

⁹ "New feed cuts cattle emissions 'by 30%'", *Agra Europe*, 22 August 2008 EP/3

¹⁰ "Kangaroos to the rescue", *New Scientist*, 20/27 December 2008

Independent Meat Suppliers, National Sheep Association and National Beef Association.

It is an industry reaction to challenges like that posed by the UK Low Carbon Transition Plan which requires English farmers to make and maintain a reduction in GHG emissions to a level at least 11 per cent lower than currently predicted by 2020. Based on current emissions, that equates to a reduction of around 1kg CO2 equivalents per kg of beef and sheep meat produced.

Research shows that the three main areas of breeding, feeding and management all offer opportunities to meet the targets. For instance, an increase in feeding efficiency, shown by an increase in daily liveweight gain of 0.32kg, together with an increase of around 0.05 calves per cow per year by 2020, would achieve 11 per cent emissions reductions.¹¹

The former chief executive of the UK National Beef Association defended livestock production in areas where rain forest is not being removed to create pasture:

[I]n temperate latitudes, where there are vast areas of natural grass cover which cannot make any direct contribution to human nutrition through crop production, it is much more sensible in carbon balance terms to continue to use this land to produce meat than it is to bring in the plough and ill-advisedly release the results of untold decades of carbon sequestration.¹²

In March 2011, more research results on greenhouse gas emissions and ruminants:

A change of diet could help flatulent farm animals reduce their greenhouse gas emissions, a study has said.

Government funded research aimed at helping farmers cut their contribution to climate change shows how to reduce the amount of methane produced by cows and sheep belching and breaking wind.

Researchers at Reading University and the Institute of Biological, Environmental and Rural Sciences found that dairy cows could emit 20% less methane for every litre of milk if fed crushed rapeseed.

Increasing the proportion of maize silage in cows' diets from 25% to 75% could reduce methane emission by 6% per litre of milk, while high-sugar grasses could reduce an animal's methane emissions by 20% for every kilo of weight gain. And a diet including a particular variety of oat could cut sheep's methane emissions by a third, the researchers said.¹³

Possible methane tax in Europe, 2009

Ireland and Denmark have planned to counter the environmental impact of livestock by a "cow tax". However, the European Commission does not support the plans.

The Commission is said to agree on the need to tackle livestock-related emissions – but does not back the use of a "cow tax" for doing so. "We should avoid solutions that will just export the problem and not curb the emissions at source" DG Agriculture officials said.

¹¹ EBLEX, [EBLEX beef and sheep roadmap points the way to livestock emissions reductions](#), 30 November 2009

¹² "Livestock and climate change – the industry must fight back", *Agra Europe*, 23 December 2009

¹³ "Gas emissions reduced by changing farm animal diet says study", *Guardian*, 30 March 2011

In response to [EU emissions reduction targets], the Danish Tax Commission (DTC) had announced proposals for new climate change taxes and levies, including levies on methane production from ruminants such as cattle, sheep and goats – although it is now backing away from these proposals. According to the DTC, a cow produces the methane equivalent of 4 tonnes of CO₂ annually, compared with 2.7t of CO₂ from the average car. As car emissions of CO₂ are highly taxed in Denmark, the DTC had claimed it would be logical to introduce a green levy on cattle.¹⁴

4 Are human diet changes needed?

A report in 2008 from Tara Garnett of the Food Climate Research Unit at the University of Surrey assessed GHG emissions from the UK's agricultural production, food processing and distribution sectors. It concluded that while technical change would partially reduce the food and agriculture sector's contribution to GHG emissions, only a radical change in food consumption in Europe and other developed countries would make any major difference. The report calculated that the meat and dairy sectors together accounted for over half of total food sector emissions. It downplayed the role of packaging in creating carbon emissions. A vegetarian diet including milk was not necessarily less GHG-intensive than a meat-based diet.¹⁵

A German report reached a similar conclusion. Agriculture was emitting almost as much GHG as road traffic in Germany, and if consumers wanted to see this output fall, the best thing they could do would be to reduce their consumption of milk and beef – particularly organic beef.

Consumers often believe that they are benefiting the climate by choosing organic products, but this is not always the case, the researchers found. For example, organic crop production can emit up to 60% more CO₂ than non-organic. Organic crop production is some 60% lower in greenhouse gas emissions, due to the avoidance of artificial fertilisers, and if all German agriculture were converted to organic, there would be a 15-20% drop in emissions. However, this is not a practical possibility, as it would require 70% more land – some 10m hectares – which is not available either in Germany or Europe.

The report stresses the need to reduce consumption of milk and beef. In addition:

The biggest contribution to reducing CO₂ emissions, however, would be to restore German wetlands which have been dried out and used for farming. These areas account for 30% of all agricultural emissions, although they occupy only 8% of the total agricultural area. Organic farming has a greater detrimental effect in these areas because it uses more land per kilogram of food produced.¹⁶

Meat production could be ecologically acceptable

In September 2010, George Monbiot said that he no longer considered a vegan diet necessary to reduce GHG emissions, because of Simon Fairlie's book *Meat: A Benign Extravagance*. The current agricultural system is ecologically unsound, but a different system could be viable:

¹⁴ "“Cow tax” not supported as methane solution”, *Agra Europe*, 13 March 2009

¹⁵ “Radical diet changes would be needed to reduce global warming”, *Agra Europe*, 3 October 2008

¹⁶ “Germans urged to eat less beef, milk to save climate”, *Agra Europe*, 29 August 2008

If pigs are fed on residues and waste, and cattle on straw, stovers and grass from fallows and rangelands - food for which humans don't compete - meat becomes a very efficient means of food production. (...)

[D]aft assumptions underlie the UN Food and Agriculture Organisation's famous claim that livestock are responsible for 18% of the world's greenhouse gas emissions, a higher proportion than transport. Fairlie shows that it made a number of basic mistakes. It attributes all deforestation that culminates in cattle ranching in the Amazon to cattle: in reality it is mostly driven by land speculation and logging. It muddles up one-off emissions from deforestation with ongoing pollution. It makes similar boops in its nitrous oxide and methane accounts, confusing gross and net production. (Conversely, the organisation greatly underestimates fossil fuel consumption by intensive farming: its report seems to have been informed by a powerful bias against extensive livestock keeping.)

Overall, Fairlie estimates that farmed animals produce about 10% of the world's emissions: still too much, but a good deal less than transport. (...) The meat-producing system Fairlie advocates differs sharply from the one now practised in the rich world: low energy, low waste, just, diverse, small-scale. But if we were to adopt it, we could eat meat, milk and eggs (albeit much less) with a clean conscience. By keeping out of the debate over how livestock should be kept, those of us who have advocated veganism have allowed the champions of cruel, destructive, famine-inducing meat farming to prevail. It's time we got stuck in.¹⁷

The English Beef and Lamb Executive (EBLEX)

EBLEX published the first part of its roadmap for the livestock sector, countering the argument that the only way to reduce greenhouse gas emissions farming is to reduce meat eating. The Press Release summarised the issue:

It is an industry reaction to challenges like that posed by the UK Low Carbon Transition Plan which requires English farmers to make and maintain a reduction in GHG emissions to a level at least 11 per cent lower than currently predicted by 2020. Based on current emissions, that equates to a reduction of around 1kg CO₂ equivalents per kg of beef and sheep meat produced.

Research shows that the three main areas of breeding, feeding and management all offer opportunities to meet the targets. For instance, an increase in feeding efficiency, shown by an increase in daily liveweight gain of 0.32kg, together with an increase of around 0.05 calves per cow per year by 2020, would achieve 11 per cent emissions reductions.¹⁸

5 GM crops and climate change

Researchers are working to develop GM crops to reduce emissions of greenhouse gases, such as nitrogen and to cope better with conditions that are consequences of climate change:

Already the giants of the plant biotech industry are working on traits, such as tolerance to drought and salt, which may be crucial for maintaining yields in a world gripped by climate change. And...they want to produce crops that require less fertiliser...

¹⁷ "Comment: I was wrong about veganism. Let them eat meat - but farm it properly", *Guardian*, 7 September 2010

¹⁸ EBLEX Press Release, *EBLEX beef and sheep roadmap points the way to livestock emissions reductions*, 30 November 2009

The first of this new generation of GM crops will be varieties of maize that can survive periods of drought, or make do with less water during the growing season...Engineering plants to tolerate water shortage is more complicated than simply inserting a gene for herbicide resistance to an insecticidal protein...[However] The first commercial varieties could be available soon after 2010. Drought-tolerant versions of other plants are not far behind.¹⁹

The article notes concerns that traits like drought-resistance or salt-resistance might be accidentally transferred to weeds that might gain a considerable advantage in sensitive environments. However, it also notes the scope for benefits as a result of reducing nitrogen intake, because of the importance of nitrous oxide as a greenhouse gas:

Indeed, cutting fertiliser use by about a third would reduce greenhouse emissions by more than grounding every single aircraft in the world. There are other ways to reduce nitrous oxide emissions. Changes in farming practices, such as in the timing or way fertilisers are applied, can make a difference...However, even if all these things were done, nitrogen-efficient crops would allow still greater reductions in fertiliser use.²⁰

6 Agriculture and the Committee on Climate Change

The Committee on Climate Change is an independent body established under the *Climate Change Act 2008* to advise the Government on setting carbon budgets, and to report to Parliament on the progress made in reducing greenhouse gas emissions. It published a report, *Building a Low Carbon Economy*, on 1 December 2008. The report made some tentative, but research-based, estimates of the cost of reduction of greenhouse gases in the agricultural sector. These are mostly not CO₂, but are expressed in tonnes of CO₂ equivalent:

The technical potential that we have identified at up to £40/tCO₂e comprises:

• **9 MtCO₂e from measures that decrease N₂O emissions from crops and soils, including:**

- reducing fertiliser application where it is applied in excess
- matching the timing of application with the time when the crop will make most use of it
- using organic rather than synthetic fertiliser where possible
- improving drainage of land
- selectively breeding plants that need less fertiliser.

• **3 MtCO₂e from measures that reduce methane emissions from livestock, including:**

- selecting animals with particular traits for breeding, in order to improve the efficiency of milk and beef production or fertility. The impact of selection both reduces the number of animals required to produce a fixed level of output, and decreases the finishing period of animals, therefore reducing emissions per unit of output.

¹⁹ "Genes for greens", *New Scientist*, 5 January 2008

²⁰ "Genes for greens", *New Scientist*, 5 January 2008

— increased use of additives named ionophores that increase productivity and decrease methane production. These are currently banned in the EU but are routinely used as growth promoters in some non-EU countries.

- **1 MtCO₂e from the installation of anaerobic digestion plants (converting agricultural waste to renewable energy) either in a centralised location or on farm.**²¹

In December 2008, the agricultural sector's joint Climate Change Task Force welcomed the report

The potential for reductions quoted in the CCC report was seen as a realistic starting point, and the intention to carry out further work on the sector was noted with interest. However, the Task Force believes the full potential for agricultural mitigation of climate change will not be realised without:

- An increase in research, covering soil and nutrient management, livestock diets and refinement of the UK GHG inventory
- The removal of regulatory barriers restricting the uptake of anaerobic digestion and other renewable energy opportunities in agriculture, horticulture and land management
- Allowing agriculture to play its full role in low-carbon production, by balancing its greenhouse gas emissions through carbon storage and the export of renewable energy services alongside the provision of food and feed.²²

²¹ Committee on Climate Change, *Building a Low Carbon Economy*, December 2008

²² NFU Press Release, *Report on Climate Change Welcomed*, 2 December 2008