

Agricultural Statistics and Climate Change

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2.10, 2.11

Section 3 - Farmer attitudes and up take of on-farm mitigation measures

3.1 (excludes all sections except Views about climate change)

3.2 (excludes data from the British Survey of Fertiliser Practice which is currently being assessed for National Statistics status)

Section 4 - Emerging Evidence

The underlying data used for the exploratory analysis in this section are from the Farm Business Survey which is categorised as National Statistics.

Section 5 - International Comparisons

No data in this section are National Statistics

Further information on National Statistics can be found on the UK Statistics Authority website at: <http://www.statisticsauthority.gov.uk/>

Introduction

This is the fourth edition of Agricultural Statistics and Climate Change. This edition includes the latest results from the 2013 Farm Practices Survey, 2012 British Survey of Fertiliser Practice and updates the indicator framework monitoring greenhouse gas emissions from agriculture. Other charts and tables have also been updated where new data are available.

In line with the requirements set out in the Climate Change Act 2008 and as part of international obligations, the UK Government is committed to adopting policies that will reduce greenhouse gas (GHG) emissions across the economy by at least 80%, from 1990 levels, by 2050. Agriculture will need to play its part in this reduction, but is more complex than other sectors in that action to reduce GHG emissions has to be considered in the context of long-term policy debates around food security, land use and natural resources. A decline in agricultural activity in the UK may well lead to a decline in domestic GHG emissions (and vice versa), but such activity is also driven by a complex interaction of subsidies, regulation, and international markets, as well as by producer, retailer and consumer preferences. As in other sectors, it would not make sense to drive down emissions from UK agriculture by relying more on the import of products that are at least as GHG intensive: this would effectively export the emission effect of food consumption, causing “carbon leakage”.

However, there are measures that farmers can adopt now that would drive down GHG emissions at minimal or no extra cost and indeed would also be positive from a farm business case. The Government believes that it is right for the agricultural industry to take responsibility for reducing its emissions and, rather than resort to regulation, has encouraged an industry partnership to lead in tackling the challenge. The Agriculture Industry GHG Action Plan: Framework for Action (published in February 2010) outlined how reductions could be made through more resource efficiency, generally involving changes in farming practice which are also good in terms of business operations whether through more efficient use of fertilisers or more efficient animal husbandry. The industry partnership published a Delivery Plan in April 2011¹, setting out how it will begin to implement the Action Plan followed by a progress report in April 2012². This draws together information on the knowledge transfer and other activities being undertaken by the partners responsible for delivering the action plan. Going forward the GHG Action Plan will be working within the new Campaign for the Farm Environment³ structure.

The individual sector-bodies are also taking action to drive down emissions through environmental product roadmaps⁴. The Dairy, Beef and Lamb, and Pig meat product roadmaps all encourage farmers to employ better management techniques and farming practices.

¹ Meeting the Challenge: Agricultural Industry GHG Action Plan - Delivery of Phase I: 2012 - 2012' was published on 4 April 2011, by the Industry Delivery Partners Group

² <http://www.nfuonline.com/science-environment/climate-change/ghg-emissions--agricultures-action-plan/>

³ <http://www.cfeonline.org.uk/>

⁴ Testing the Water - The English Beef and Sheep Environmental Roadmap:

<http://www.eblex.org.uk/publications/corporate.aspx>

Dairy Roadmap - our route towards environmental success, DairyCo. 9 May 2011

<http://www.dairyco.net/news/press-releases/may-2011/dairy-industry-on-route-to-environmental-success.aspx>

Dairy Roadmap – Environmental Sustainability Report 2013

<http://www.dairyco.org.uk/resources-library/research-development/environment/dairy-roadmap-2013/>

Advancing together - a roadmap for the English Pig industry - The British Pig Executive (BPEX). 27 April 2011

<http://www.bpex.org.uk/environment-hub/climate-change/PigIndustryRoadmap.aspx>

During 2012 Defra, working collaboratively with a range of stakeholders, carried out a review of progress in reducing GHG emissions from agriculture. The final report, published in November 2012, acknowledged the progress made by the industry so far and concluded that the overall ambition of reducing annual GHG emissions from agriculture by 3 Mt carbon dioxide equivalent by the third carbon budget was achievable, subject to continued focus and effort by the industry. The 2012 review report and supporting papers are available on the internet at:

<https://www.gov.uk/government/publications/2012-review-of-progress-in-reducing-greenhouse-gas-emissions-from-english-agriculture>

Advice provision remains important to improve farm practices and one of the key actions in Defra's Business Plan (May 2012) was to "*publish plans for a streamlined framework of advice, incentives and voluntary initiatives to enable farmers and land managers to be more competitive and yield better environmental results*". The Review of Environmental Advice, Incentives and Partnership Approaches for the Farming Sector in England was published in March 2013⁵. This sets out how Defra intends to meet the challenge to deliver a more integrated, streamlined and efficient approach to providing advice on the environment in England, including how Government, the farming industry and farming-focused advice providers will work together to ensure better knowledge transfer of new and existing best practices and technologies.

As part of this work a review was published that covered the effectiveness of voluntary and industry-led approaches, such as the GHG Action Plan⁶. Voluntary and industry led approaches are key to delivery, encouraging both effective environmental outcomes and efficient farm businesses, and the report identified examples of successful practice.

Drawing on these reviews and also building on the pilot project for integrated environmental advice (including how to reduce GHG emissions)⁷, there is also a commitment from government, industry and environmental partners to establish prioritised environmental messages. This work is now a core part of the Campaign for the Farmed Environment which brings together a range of industry, advice and environmental partners and establishes a coherent approach across the key industry-led initiatives including the GHG Action Plan.

Government continues to carry out work to improve the science base: in partnership with the Devolved Administrations, the Government is investing £12.6 million, over a four and half year period, to strengthen our understanding of on farm emissions. When complete, this work to develop the UK agricultural GHG inventory (due to be delivered in 2015) should enable greater precision in reporting GHG emissions from the sector, so that positive changes made to farming practices to reduce GHG emissions will be properly recognised in the inventory.

⁵ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181835/pb13900-review-incentives-partnership-approaches.pdf.pdf

⁶ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181836/review-partnership-approaches-farming-environment-policy-delivery.pdf.pdf

⁷ The Integrated Pilot Project final report has been published on Defra's Science and Research website – see project FF0204 at <http://randd.defra.gov.uk/>

Purpose of this publication

This publication brings together existing statistics on agriculture in order to help inform the understanding of the link between agricultural practices and GHG emissions. It summarises available statistics that relate directly and indirectly to emissions and includes statistics on farmer attitudes to climate change mitigation and uptake of mitigation measures. It also incorporates statistics emerging from developing research and provides some international comparisons.

Data sources

Data sources are shown on charts/referenced in footnotes. The [Appendix](#) gives confidence intervals for data in Section 3, while the [Glossary](#) provides links to methodology details of the original data sources.

Geographic coverage

Climate change mitigation in agriculture is a devolved issue, and Defra has policy responsibility for England. This publication aims to provide measures based on England, however this is not always possible and in some instances measures are GB or UK based.

Comparisons over time

Data series are shown from 1990 onwards wherever possible. In some instances comparable data is not available from 1990, and in these cases the closest available year is shown. In summarising the data 'long term' and 'short term' comparisons are made⁸.

⁸ Here, long term refers to comparisons back to 1990 or the closest year, and short term refers to changes within the last 5 years

Summary: greenhouse gas emissions from agriculture - a framework of leading indicators

The indicator framework aims to assess progress in reducing greenhouse gas (GHG) emissions whilst research is undertaken to improve the UK agricultural GHG inventory (completion expected in 2015).

The framework, initially developed as part of the 2012 review of progress in reducing GHG emissions from English agriculture⁹, consists of ten key indicators covering farmer attitudes and knowledge, the uptake of mitigation methods and the GHG emission intensity of production¹⁰ in key agricultural sectors. As far as possible, it reflects the farm practices which are aligned to the Industry's Greenhouse Gas Action Plan¹¹ and acknowledges the indicators set out in the Committee on Climate Change annual progress reports¹².

A brief overview of the revised methodology used in 2013 for indicators 2, 9 and 10 is available at the end of this summary. Detailed indicator assessments which include more information on data sources, methodology and statistical background can be found on the internet at:

<https://www.gov.uk/government/statistical-data-sets/greenhouse-gas-emissions-from-agriculture-indicators>

Overview

For some indicators (such as farmer attitudes) there are limited data currently available to assess long or short term change. Where longer term data are available, a current assessment shows the overall picture to be mixed. Over the last 10 years there is a positive long term trend for the soil nitrogen balance (a high level indicator of environmental pressure) and for the derived manufactured nitrogen use efficiency¹³ for barley, oilseed rape and sugar beet. However, for intermediate outcomes relating to GHG emission intensity⁶ for the livestock sector there has been either little overall change in the longer term trend (e.g. feed conversion ratios for poultry) or some deterioration (e.g. feed conversion ratios for the pig fattening herd). When assessed over the most recent 2 years, the indicators suggest either little change or positive trends in the case of intermediate outcomes relating to poultry, pigs, oilseed rape and sugar beet.

Indicators focusing on the uptake of particular mitigation methods, including those relating to organic fertiliser management, application and use within anaerobic digestion provide a measure of progress towards achieving the industry's ambition to reduce agricultural production emissions by 3 MtCO₂ equivalent by 2020 compared to a 2007 baseline. Together these indicators suggest that, by early 2013, a 1.08Mt CO₂ equivalent reduction in GHG had been achieved, around 31% of the estimated maximum technical potential¹⁴. A key component has been the uptake of practices relating to nutrient management, such as the use of fertiliser recommendation systems.

⁹ <https://www.gov.uk/government/publications/2012-review-of-progress-in-reducing-greenhouse-gas-emissions-from-english-agriculture>

¹⁰ GHG produced per tonne of crop or litre of milk or kilogramme of meat produced.

¹¹ <http://www.nfuonline.com/science-environment/climate-change/ghg-emissions--agricultures-action-plan/>

¹² <http://www.theccc.org.uk/reports/3rd-progress-report> <http://www.theccc.org.uk/reports/2012-progress-report>

¹³ Calculated as the quantity of crop produced per unit of applied manufactured nitrogen fertiliser.

¹⁴ Maximum technical potential is the amount that could be saved if all mitigation potential was enacted regardless of cost assuming no prior implementation of measures.

The current status of each of the individual indicators has been summarised below. Symbols have been used to provide an indication of progress:

Clear improvement	✓	Little or no change	≈
Clear deterioration	✗	Insufficient or no comparable data	...

2013 Methodology

Indicators 2, 9 and 10 use estimates of potential and achieved GHG emission reductions that have been calculated using the FARMSCOPER tool developed by ADAS for Defra¹⁵. The data feeding into this model are drawn from a variety of sources including land use and livestock population data from the June Agricultural Survey. The majority of the data relating to the uptake of the mitigation methods within these indicators are from Defra's Farm Practices and the British Survey of Fertiliser Practice. In 2013, in order to gain a more refined picture of the level of uptake of mitigation measures, responses from these surveys have, wherever possible, been divided into those from farms within Nitrate Vulnerable Zones and those outside. This was not done for the initial assessment in November 2012 and changes seen here reflect this improved method rather than any marked variation in uptake.

Livestock indicators

The indicators focused on livestock give an insight into the efficiency of production where this can impact on GHG emissions and are intended to be viewed within the context of animal welfare regulations and legislation. To examine the wider potential implications of GHG mitigation measures, including animal health and welfare, Defra has commissioned research project AC0226 - Quantifying, monitoring and minimising wider impacts of GHG mitigation measures¹⁶

¹⁵ Cost-curves for mitigating multiple water pollutants, ammonia and greenhouse gas emissions on farms – FARMSCOPER decision support tool, USER-GUIDE and economic analysis for pollution mitigation methods - WQ0106

<http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14421>

¹⁶ <http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17780&FromSearch=Y&Publisher=1&SearchText=AC0226&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description>

Table 1: Indicator summaries

Overarching indicators			
1 Attitudes & knowledge			
<p>Assessment: behaviour change can be a long process. Measuring awareness of the sources of emissions and intentions to change practice can provide a leading indicator of uptake of mitigation methods and help to highlight motivations and barriers. However, changing attitudes are not a pre-requisite for adoption of mitigation methods; research suggests that business sustainability and financial implications are important drivers for change.</p> <ul style="list-style-type: none"> • When farmers were asked about the sources of GHG emissions there was a high level of understanding for some practices, for example methane from livestock and slurry storage, carbon dioxide from heating / vehicle fuel and nitrous oxide from manufactured nitrogen fertiliser. However, even for these practices there were a sizeable minority (between 12% and 26%) that answered ‘don’t know’. • 8% of farmers reported that it was “very important” to consider GHGs when making decisions relating to their land, crops and livestock and a further 39% thought it “fairly important”. However, just over half of respondents placed little or no importance on considering GHGs when making decisions. • Overall, 62% of farmers were taking actions to reduce emissions. Of these, larger farms were more likely to be taking action than smaller farms. <p>More details on farmer attitudes can be found in Section 3.1.</p>			
Current Status	Long term (last 10 years):	...	Short term (last 2 years): ...
2 Uptake of mitigation methods			
<p>Assessment: there are a wide range of farm practices that, if implemented, will reduce GHG emissions from agriculture. Monitoring the uptake of these mitigation methods provides an indicator of progress towards achieving the industry’s ambition to reduce agricultural production emissions by 3 MtCO₂ equivalent (e) by 2020 compared to a 2007 baseline.</p> <ul style="list-style-type: none"> • By February 2013, approximately 1 Mt CO₂e reduction in GHG emissions had been achieved from the uptake of the key mitigation methods within this indicator. This compares to an estimated maximum technical potential¹⁷ reduction of 3.1Mt CO₂e were all of these methods to be fully implemented on relevant farms. • Mitigation methods related to nutrient management (e.g. fertiliser spreader calibration) collectively provide the greatest potential emissions reduction (1.4 Mt CO₂e). By 2012, uptake of these methods has been assessed to have delivered an estimated GHG reduction of 0.5Mt CO₂e, around 35% of the maximum technical potential reduction. <p>More details on uptake of mitigation methods can be found in Section 3.2.</p>			
Current Status	Long term (last 10 years):	...	Short term (last 2 years): ...

¹⁷ Maximum technical potential is the amount that could be saved if all mitigation potential was enacted regardless of cost assuming no prior implementation of measures

Overarching indicators

3 Soil nitrogen balance

Assessment: whilst a shortage of nutrients can limit the productivity of agricultural soils, a surplus of these nutrients poses a serious environmental risk. The soil nitrogen balance is a high level indicator of potential environmental pressure providing a measure of the total loading of nitrogen on agricultural soils. The balances do not estimate the actual losses of nutrients to the environment (e.g. to water or to air) but significant nutrient surpluses are directly linked with losses to the environment.

- Over the longer term, the nitrogen surplus in England has fallen by 15% since 2000. The main drivers have been reductions in the application of inorganic fertilisers (particularly to grass) and manure production (due to lower livestock numbers), partially offset by a reduction in the nitrogen offtake (particularly forage).
- Provisional figures show that the nitrogen balance has increased by 4% between 2011 and 2012. This has been driven by reduced offtake via harvested crops and grazed pasture (due to poor weather in 2012). This has more than offset a reduction in inputs from manufactured nitrogen fertilisers.

For more details of the soil nitrogen balance see [Section 2.9.1](#).

Current Status

Long term (last 10 years):



Short term (last 2 years):



Sector specific indicators

4 Pig sector: feed conversion ratio for fattening herd

Assessment: the feed conversion ratio (FCR) is a measure of the amount of feed required to increase pig live weight by 1kg. It is used here as a proxy measure for on-farm greenhouse gas emissions intensity¹⁸ (see **Livestock indicators** note at the beginning of summary).

- Following improvements during the early 1990s, the FCR for the pig fattening herd has deteriorated (i.e. more feed required per unit increase in pig weight), albeit with some fluctuations, particularly in recent years.
- This would imply a reduction in feed efficiency and increased emissions intensity. However, achieving and maintaining heavier weights, relative changes in production systems and disease could be explanatory factors. Since 2010 there has been some improvement in the FCR, although with the fluctuations in recent years it is too early to tell if this is a change to the longer term trend.

More details on the on the pig sector can be found in [Section 2.7](#).

Current Status

Long term (last 10 years):



Short term (last 2 years):



¹⁸ GHG emitted per tonne of crop, litre of milk or kilogramme of meat produced.

Sector specific indicators

5 Grazing livestock sector: beef and sheep breeding regimes

Assessment: the selection of useful traits can help improve herd and flock productivity and efficiency which can in turn influence GHG intensity. The Estimated Breeding Value (EBV) is an estimate of the genetic merit an animal possesses for a measured trait or characteristic. The EBV is used here as a proxy measure for on-farm GHG emissions intensity¹⁹ (see **Livestock indicators** note at the beginning of summary).

- Overall in 2013, bulls and rams with a high EBV were used at least “most of the time” on 34% of farms breeding beef cattle and 27% of those breeding lambs. This was a slight, but not significant, reduction on 2012.
- Whilst there is little difference between lowland farms and those in Less Favoured Areas there are differences between farm sizes, with uptake greatest on larger farms.

For more details on the beef and sheep sectors see [Section 2.5](#) and [Section 2.6](#).

Current Status	Long term (last 10 years): ...	Short term (last 2 years): ≈
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6 Dairy sector: ratio of dairy cow feed production to milk production

Assessment: considering milk yields in conjunction with trends in inputs (such as feeds) provides an indication of GHG intensity in the dairy sector. The ratio of dairy cow compound and blended feed production to milk production is used here as proxy measure for on-farm GHG emissions intensity (see **Livestock indicators** note at the beginning of summary). It is recognised that this indicator is not ideal. Firstly, it considers production of feed rather than overall dry matter consumption but perhaps more importantly it does not attempt to assess the consumption of concentrates produced by on-farm mixing, or of grazed or conserved forage. We will continue to investigate other data sources such as survey data and farm benchmarking data to improve this indicator.

- The ratio is currently at the highest level since 1990. There have been some fluctuations over the period; the indicator has increased since 2005 as the rate of increase of compound and blended feed production has been greater than the rate of increase in average milk yields. In the shorter term, the ratio has remained little changed.
- There has been an upward trend in both the average milk yield and in the production of compound feed per cow over the period.

More details on the dairy sector can be found in [Section 2.4](#).

Current Status	Long term (last 10 years): ✘	Short term (last 2 years): ≈
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¹⁹ GHG emitted per tonne of crop, litre of milk or kilogramme of meat produced.

Sector specific indicators

7 Poultry sector: feed conversion ratio for table birds

Assessment: more efficient use of feed has the potential to increase productivity and reduce GHG intensity. The feed conversion ratio (FCR) is a measure of the amount of feed required (kg) to produce 1kg of poultrymeat (dressed carcass weight). The indicator provides an overall measure of feed efficiency. Within this there are differences between production systems and species. It is used here as a proxy measure for on-farm GHG emissions intensity²⁰ (see **Livestock indicators** note at the beginning of summary).

- There was a slight upward trend in the overall FCR for table birds between 2001 and 2008, suggesting a possible increase in emissions intensity.
- There has been some recent improvement in the FCR, although the change is well within the year on year variation. The improvement has been greater and for a longer period for turkeys than for broilers.

For more details on the poultry sector see [Section 2.8](#).

Current Status	Long term (last 10 years): ≈	Short term (last 2 years): ✓
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8 Cereals and other crops: manufactured fertiliser application

Assessment: more efficient use of nitrogen fertilisers has the potential to increase productivity and reduce risks to the environment. The ratio of the weight of crops produced to the weight of manufactured nitrogen fertiliser applied provides a proxy measure for the intensity of GHG emissions⁸.

- There has been an increase in the quantity of wheat produced per unit of manufactured nitrogen in the last 20 years, although much of this increase occurred in the 1990s as yields increased whilst fertiliser application rates remained stable. Since 2000, there has been little overall change in the apparent nitrogen use efficiency of wheat; average yields have remained relatively stable over the period, and changes in the intensity measure have largely been due to fluctuations in fertiliser application rates.
- For winter barley, spring barley, winter oilseed rape and sugar beet there has been an overall upward trend in production per unit of applied manufactured nitrogen fertiliser over the last 10 years.

More details on crop production can be found in [Section 2.3](#) and [Section 2.9](#).

Current Status	Long term (last 10 years)	Short term (last 2 years)
Wheat	≈	✗
Winter barley	✓	≈
Spring barley	✓	≈
Winter oilseed rape	✓	✓
Sugar beet	✓	✓

²⁰ GHG emitted per tonne of crop, litre of milk or kilogramme of meat produced.

Sector specific indicators

9 Slurry and manure

Assessment: systems for the management of manure and slurry are relevant to the control of environmental risks to air and water including GHGs. Monitoring uptake of relevant mitigation methods provides an indicator of progress towards achieving the industry's ambition to reduce agricultural production emissions by 3 MtCO₂ equivalent (e) by 2020 compared to a 2007 baseline.

- Estimates indicate that the maximum technical potential GHG reduction from uptake of mitigation methods relating to slurry and manure (which include types of storage and use of liquid/solid manure separation techniques but exclude anaerobic digestion (AD) systems) is around 0.018 Mt CO₂e².
- Uptake of these mitigation methods by February 2013 suggests that the GHG reduction achieved has been around 0.004 Mt CO₂e.
- The use of slurries for anaerobic digestion has a significant GHG reduction potential, far outweighing that from improved storage of slurries and manures. However, there are significant start-up and running costs leading to very low levels of current uptake. In 2013, survey data indicated that just 1% of all farms processed slurries for AD, little changed from 2008.

For more details on slurry and manure see [Section 2.9.2](#) and [Section 3.2](#).

Current Status **Long term (last 10 years):** ... **Short term (last 2 years):** ...

10 Organic fertiliser application

Assessment: the form, method and timing of application for organic fertilisers can influence GHG emissions. Monitoring these factors provides an indicator of progress towards achieving the industry's ambition to reduce agricultural production emissions by 3 MtCO₂ equivalent (e) by 2020 compared to a 2007 baseline.

- By February 2013, approximately 0.08 Mt CO₂e reduction in GHG emissions had been achieved from the uptake of the mitigation methods (which include the timing of applications and application methods) within this indicator. This compares to an estimated maximum technical potential²¹ reduction of 0.33 Mt CO₂e were all of these methods to be fully implemented on relevant farms.

For more details on organic fertiliser application see [Section 2.9.2](#) and [Section 3.2](#).

Current Status **Long term (last 10 years):** ... **Short term (last 2 years):** ...

²¹ Maximum technical potential is the amount that could be saved if all mitigation potential was enacted regardless of cost assuming no prior implementation of measures.

Section 1: Emissions from agriculture

UK agricultural sector recorded emissions

For the UK, between 1990 and 2011:

- Total greenhouse gas emissions from agriculture are estimated to have fallen by 20% to 51.2 million tonnes CO₂ equivalent²² in 2011.
- Emissions of methane reduced by 20% to 17.9 million tonnes CO₂ equivalent.
- Emissions of nitrous oxide reduced by 19% to 29.2 million tonnes CO₂ equivalent.
- Emissions of carbon dioxide reduced by 20% to 4.2 million tonnes CO₂ equivalent.

Drivers of emissions

Drivers of recorded sector emissions: The methodology currently used to report agricultural sector emissions is predominantly based on the number of livestock animals and the amount of nitrogen based fertiliser applied to land. A variety of important factors influence emissions which are not captured in the current methodology (see “Other drivers of emissions” below for details); research²³ is underway to better reflect the position. The results of this research will be incorporated into an upgraded greenhouse gas inventory for agriculture to be delivered in 2015.

Other drivers of emissions: There are other factors which are not captured in recorded emissions, but which are likely to affect the true level of emissions. For example, some areas of farming practice will have an impact, e.g. timing of fertiliser application, efficiency of fertiliser use, feed conversion ratios, genetic improvements. Some of these relate to efficiency: there have been productivity gains in the sector, through more efficient use of inputs over the last twenty years and some of these gains will have had a positive impact, though some may have had a negative impact on emissions. Soil moisture and pH are also highly important to soil emissions. On a national basis these drivers are expected to have a subtle, but significant impact, rather than a dramatic impact on the true level of emissions over the period. On a regional basis, the drivers of soil emissions are likely to have a more dramatic impact for some land use types.

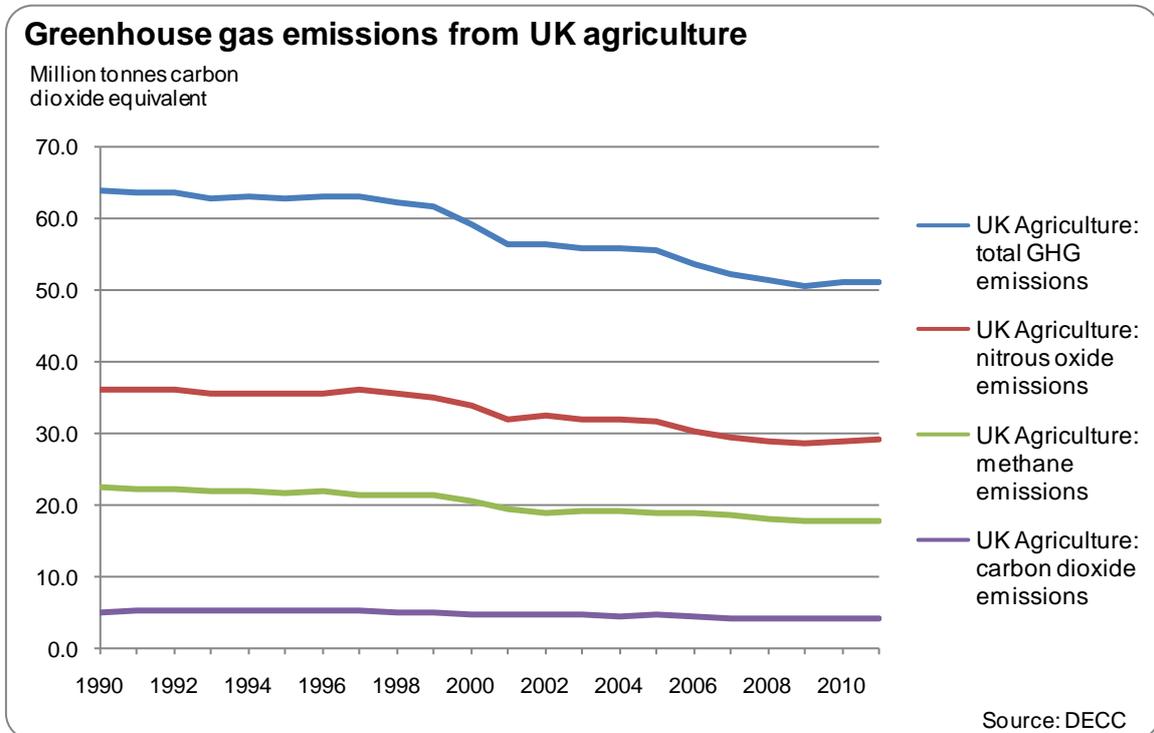
²² Carbon dioxide (CO₂) equivalents use CO₂ as a standard unit for reference allowing comparison of emissions from various greenhouse gases. They show the amount of carbon dioxide that would give the same warming effect as the greenhouse gases being emitted.

Carbon dioxide equivalent estimates are derived by applying a factor of 21 for methane, and 310 for nitrous oxide. These factors are in accordance with international reporting. These factors denote methane as having a 100-year global warming potential 21 times more powerful than carbon dioxide, and nitrous oxide 310 times more powerful.

²³ www.ghgplatform.org.uk

1.1 Total recorded emissions

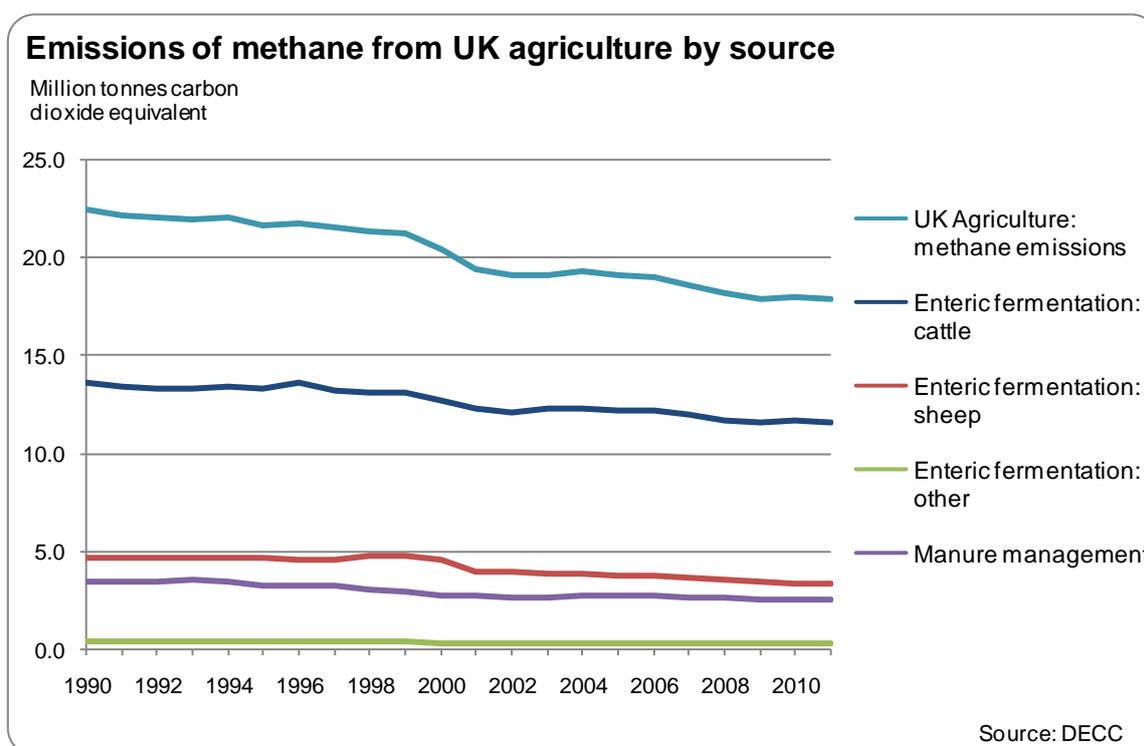
The chart below provides an overall picture of the level of recorded greenhouse gas (GHG) emissions from agriculture. In 2011, agriculture was the source of 9% of total GHG emissions in the UK (43% of total methane emissions, 84% of total nitrous oxide emissions and 0.9% of total carbon dioxide emissions).



1.2 Methane emissions

Agriculture is estimated to have been the source of 43% of the UK's methane (CH₄) emissions in 2011. CH₄ is produced as a by-product of enteric fermentation and from the decomposition of manure under anaerobic conditions. Enteric fermentation is a digestive process whereby feed constituents are broken down by micro-organisms into simple molecules. Both ruminant animals (e.g. cattle and sheep), and non-ruminant animals (e.g. pigs and horses) produce CH₄, although ruminants are the largest source per unit of feed intake. When manure is stored or treated as a liquid in a lagoon, pond or tank it tends to decompose anaerobically and produce a significant quantity of CH₄. When manure is handled as a solid or when it is deposited on pastures, it tends to decompose aerobically and little or no CH₄ is produced. Hence the system of manure management used affects emission rates.

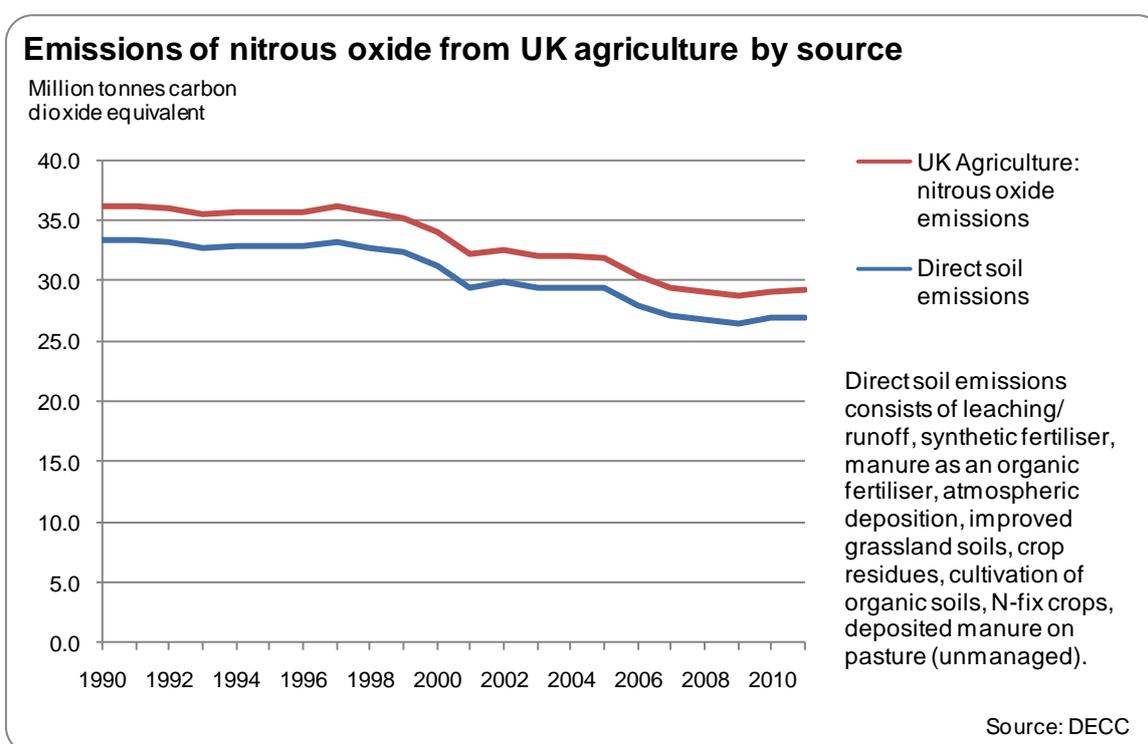
The majority of the fall in recorded CH₄ emissions since 1990, is due to significant reductions in the numbers of cattle and sheep in the UK. Measures relating to the greenhouse gas intensity of agriculture are explored in [Section 2](#).



1.3 Nitrous oxide emissions

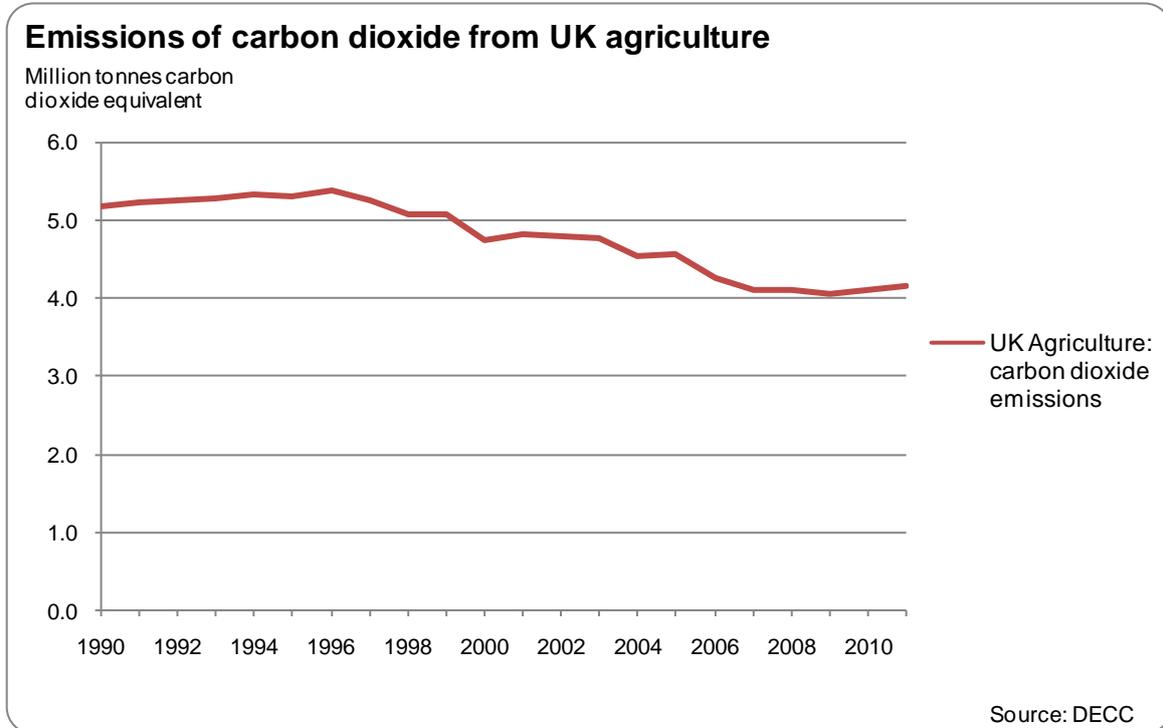
Direct emissions of nitrous oxide (N₂O) from agricultural soils are estimated for the following: use of inorganic fertiliser, biological fixation of nitrogen by crops, ploughing in crop residues, cultivation of histosols (organic soils), spreading animal manures on land and manures dropped by animals grazing in the field. In addition to these, the following indirect emission sources are estimated: emission of N₂O from atmospheric deposition of agricultural nitric oxide (NO_x) and ammonia (NH₃) and the emission of N₂O from leaching of agricultural nitrate and runoff. Also, N₂O emissions from manures during storage are calculated for a number of animal waste management systems.

The fall in recorded N₂O emissions over the last twenty years has been driven by substantial reductions in the overall application rate for nitrogen fertilisers, particularly to grassland; whilst arable application rates have remained relatively stable, grassland application rates have reduced. Over this period, wheat yields have increased, suggesting that the UK is producing more wheat for the same amount of nitrogen. Further measures relating to the intensity of emissions are covered in [Section 2](#).



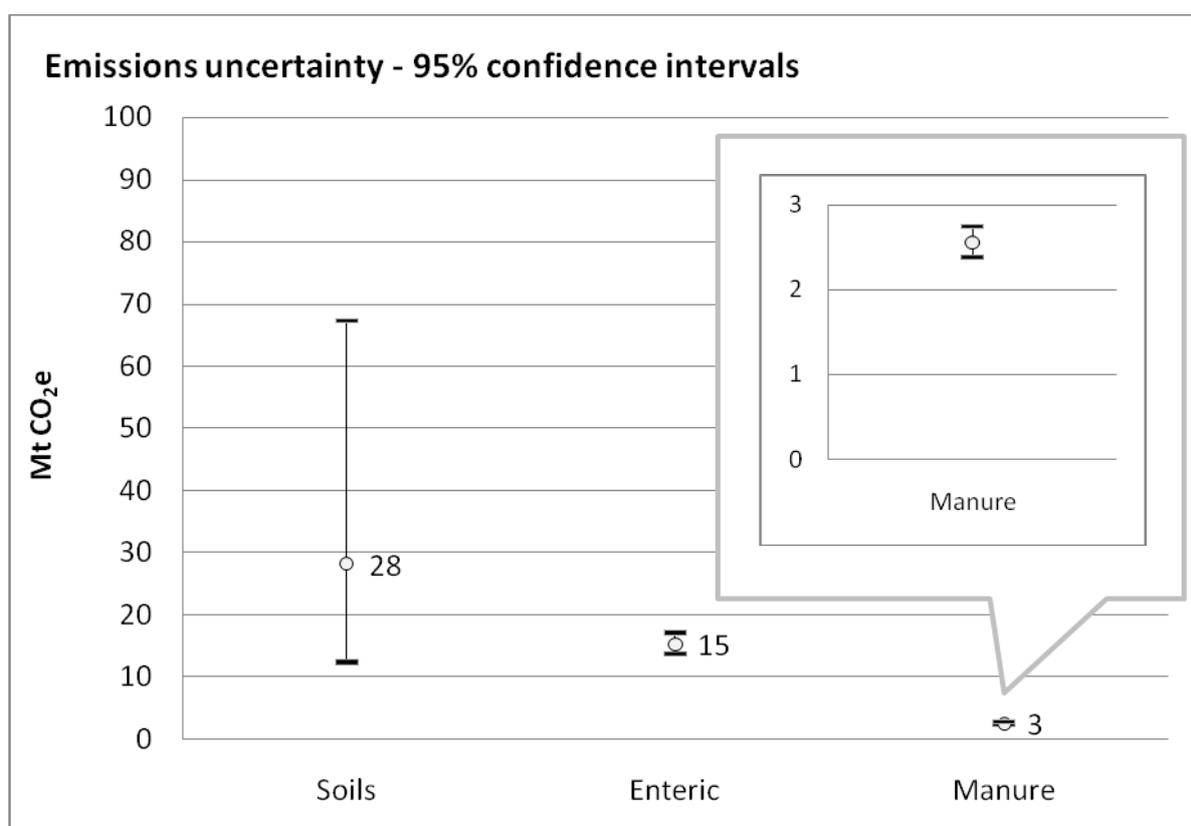
1.4 Carbon dioxide emissions

Only around 1% of carbon dioxide (CO₂) emissions in the UK are attributed to agriculture, these relate mainly to fuel use. Since 1990 there has been an overall decline in recorded CO₂ emissions from agriculture.



1.5 Uncertainty in emissions²⁴

There are relatively large uncertainties in estimating agricultural emissions as they are generated by heterogeneous natural systems for which we do not have precise measures. The chart below illustrates the uncertainties in the current methodology. Uncertainties around N₂O emissions are particularly large. These uncertainties incorporate spatial and temporal variation in emissions factors (e.g. soil texture variations etc), and more structural uncertainties relating to the way the farming industry and biological processes are represented in the current model. Some of these uncertainties are already understood to some extent, whilst others will require further research under the current inventory improvement programme. Research to improve the inventory will make the position clearer, by unpicking some of the regional and sectoral variation and by providing more accurate measures of key emissions factors. However it will not be possible to remove all uncertainty.



[Section 2](#) summarises a range of statistics which provide an indication of changes in the intensity of emissions from agriculture in terms of the quantity of greenhouse gas per unit of output.

²⁴ A. E. Milne et. al. (in preparation) "Analysis of uncertainties in the estimates of nitrous oxide and methane emissions in the UK's greenhouse gas inventory for agriculture"

Section 2: Intermediate outcomes and contextual factors

This section provides statistics and commentary on some of the key intermediate outcomes and, where possible, proxy measures for greenhouse gas (GHG) intensity, i.e. GHG per tonne of crop or litre of milk or kilogramme of meat produced (Sections 2.1, 2.2 and 2.4 to 2.10). Some examples of the intermediate outcomes covered are productivity, animal longevity and fertility, application rates of manufactured nitrogen and soil nitrogen balances.

The section also covers some of the main contextual factors, such as crop areas, numbers of breeding livestock, prices of agricultural inputs (i.e. animal feed and fertiliser) and prices of agricultural products received by farmers (Sections 2.3, 2.11 and 2.12). Crop areas and the number of breeding livestock provide information about the overall levels of activity, whilst prices help to explain some of the drivers for changes in activity.

Background information

By applying best practice, farmers can reduce their GHG intensity (GHG produced per tonne of crop or litre of milk or kilogramme of meat produced) and make a positive contribution to climate change mitigation by:

- improving the efficiency and effectiveness of nitrogen use in cropping systems,
- improving the efficiency of feed conversion in livestock systems,
- storing manures in ways that reduce emissions, and
- protecting and enhancing carbon stores in soils and trees.

It is important to recognise that reducing the GHG intensity of production may not necessarily reduce total UK GHG emissions. All other things being equal, this would increase the competitiveness of the sector, making it more able to compete in international markets, possibly encouraging an increase in the numbers of livestock or area under crops, which in some circumstances might result in an overall increase in UK agricultural emissions, even where unit intensity has decreased. However, as noted in the introduction, agricultural activity in UK emissions has to be viewed in the broader policy context, including the demand for food. Avoiding action to reduce emissions in the UK could result in “carbon leakage”, where production moves abroad. This would not reduce global GHG emissions and could put pressure on sensitive landscapes or habitats.

Improved nitrogen use efficiency in cropping systems can be achieved through improved crop nutrient management; for example by:

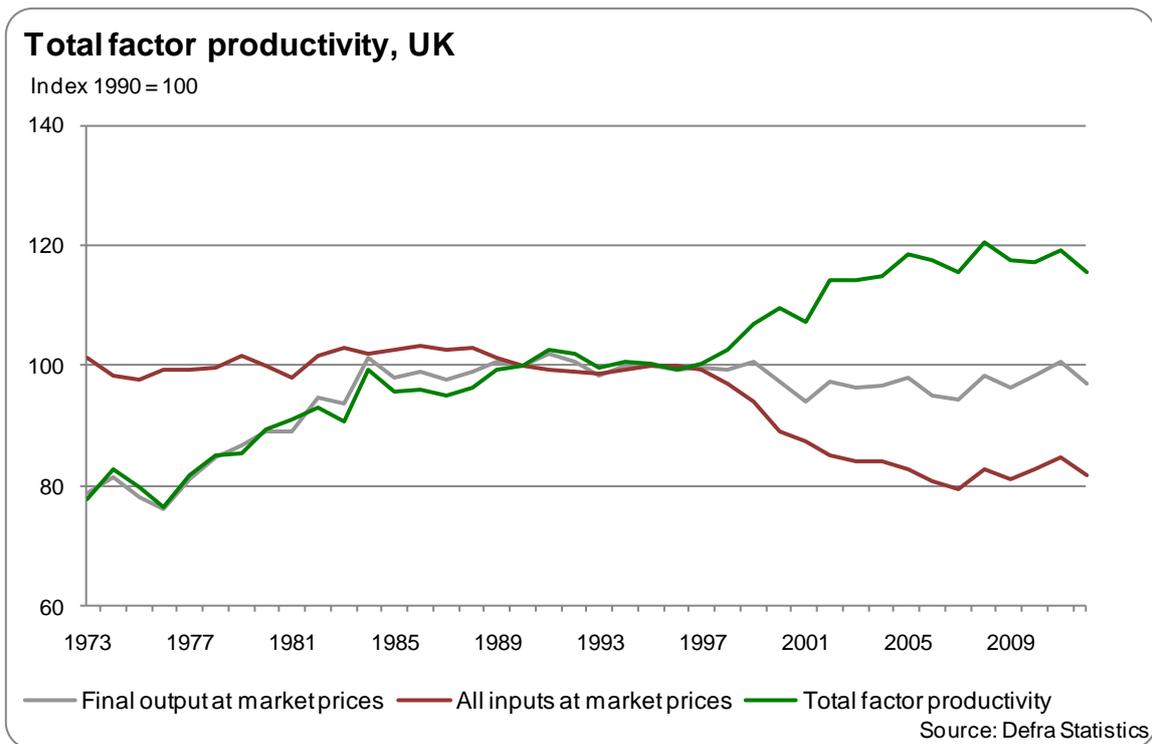
- ensuring that all nutrients are in balance to ensure maximum uptake by the crop,
- ensuring that the correct quantity of nitrogen (manufactured and organic) is applied to match crop needs,
- ensuring that nutrients are applied to the crop at the right time and in a manner most likely to ensure uptake (e.g. using band spreaders),
- minimising nutrient requirements through selecting the right crop, cultivar and nutrient regime for its intended end use.

Improved feed conversion can be achieved in livestock systems by:

- ensuring that livestock diets are well-matched to animal needs,
- providing better quality diets,
- breeding animals that produce more offspring or milk and that are less likely to suffer from lameness or mastitis,
- ensuring all animals are healthy (e.g. not subject to endemic diseases and conditions such as Bovine Viral Diarrhoea, liver fluke, mastitis or lameness which reduce yields).

2.1 Headline measures of agricultural input, output and productivity²⁵

This section provides a brief summary of headline measures of input, output and productivity, in other words, the change in how efficiently the agricultural industry uses resources. In the chart below this is represented by “total factor productivity”. Total factor productivity measures the volume of agricultural output per unit of input, where the input measure includes fixed capital and labour and covers all businesses engaged in farming activities, including specialist contractors.



Trends

Total factor productivity has risen consistently since the early 1970s. Over the earlier part of this period, productivity rises were linked to increases in the volume of final output which rose by around 25%, while since the late 1990s reduced inputs have been a driving factor. Some of the change in productivity, although not all of it, will have a bearing on greenhouse gas intensity, and this is explored in the following section.

²⁵ Measuring productivity is not straightforward and comparisons need to be interpreted carefully because of both practical problems in obtaining robust data and because performance is often shaped by factors outside farmers' control, such as climate, topography and location. These are estimates of an underlying reality, based on statistical surveys, administrative data, forecasts and models. Volatility in the price and volume of inputs and the limitations of the data used to generate the estimates has led to lesser certainty in the results in recent years.

Defra are working on methodological changes to improve the quality of the results and these may lead to revisions. Users should use these estimates of total factor productivity to assess the overall pattern of change over time, to discern whether the level of total factor productivity has increased or decreased over time, and if it has, how quickly or slowly the increase or decrease has occurred.

2.2 Drivers of change in productivity in the context of greenhouse gas emissions

Table 2 shows the main agricultural outputs and inputs based on volume indices²⁶. This broadly illustrates the main drivers of change in the headline measures.

Animal feed forms the greatest contribution to inputs; the reduction seen between 2010 and 2012 is linked to price pressures from high cereal prices. Some inputs are more clearly related to greenhouse gas (GHG) intensity (animal feed, fertiliser, energy) than others (maintenance, equipment), whilst others are unlikely to be associated with emissions (other goods and services).

This information is useful for providing an aggregate picture of the productivity of the industry. However, in the context of emissions this information has its limitations, but it can help inform understanding when used together with information from the rest of this publication. Productivity gains may be related to overall improved GHG intensity given that fertiliser and energy inputs have decreased, however the increase in animal feed is likely to have offset some of this improvement.

Table 2: Main drivers of change in productivity

		Volume indices 1990=100				
		1990	2000	2005	2010	2012
Headline measures						
Output		100.0	97.5	98.0	98.1	96.9
Input		100.0	89.1	82.7	83.7	83.9
Total Factor Productivity		100.0	109.4	118.5	117.2	115.4
<hr/>						
		Approx. contribution to output (based on 1990 - 2012 average)				
Main outputs						
Output of cereals	12%	100.0	110.7	98.9	99.9	92.8
Output of vegetables & horticultural products	10%	100.0	79.5	76.0	73.4	71.3
Livestock output primarily for meat	28%	100.0	94.6	94.0	91.9	94.4
Milk	17%	100.0	94.6	94.3	90.8	90.8
<hr/>						
		Approx. contribution to input (based on 1990 - 2012 average)				
Main inputs						
Energy	6%	100.0	91.3	74.7	81.9	80.7
Fertiliser (manufactured)	8%	100.0	77.7	65.4	56.8	55.2
Animal feed	25%	100.0	103.1	109.6	116.4	108.0
Maintenance	9%	100.0	81.6	69.3	75.8	74.9
Equipment	10%	100.0	92.4	84.7	89.8	98.4
Other goods and services	18%	100.0	97.4	96.3	93.8	97.7

Source: Defra statistics

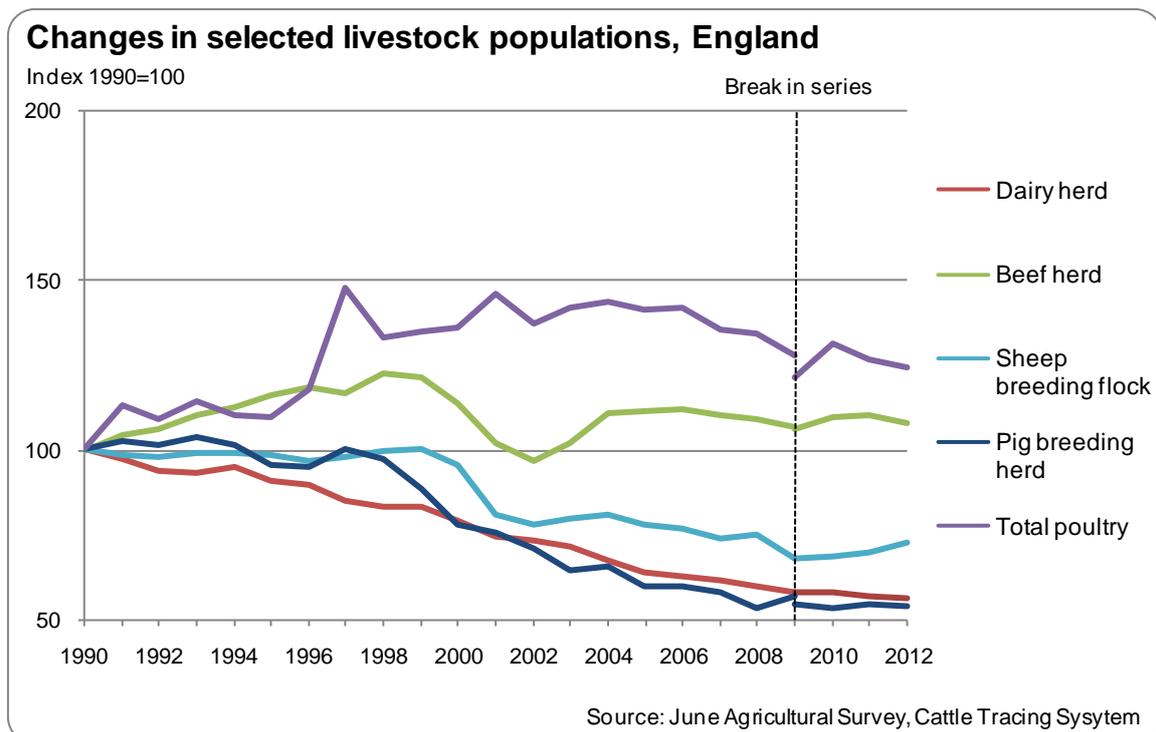
²⁶ Volume indices are calculated by taking a weighted average of volume relatives (volume relatives are the volume in year n / volume in year n-1) using the monetary values of components of the aggregated index as weights.

2.3 Contextual factor: livestock numbers and areas of key crops and grasses

Indices of breeding livestock

Rationale

Livestock, particularly cattle, are a major source of greenhouse gas (GHG) emissions and a direct determinant of levels of methane (from enteric fermentation²⁷) and nitrous oxide emissions (from organic fertiliser applications and deposits from grazing animals). Trends in livestock populations are presented to illustrate changes in the basic drivers of emissions. GHG intensity is explored in the sections which follow.



Notes: Cattle population changes are based on the June Agricultural Survey up to 2004 and Cattle Tracing System data from 2005 onwards. Dairy and beef herds are cows and heifers that have calved.

Estimates for 2009 onwards are not directly comparable to earlier years. This is due to (1) a large number of inactive holdings being removed from the survey register following the 2010 census and (2) the introduction of a survey threshold. Further details can be found in the June Survey methodology report at:

<https://www.gov.uk/structure-of-the-agricultural-industry-survey-notes-and-guidance>

Trends

There has been a long term downward trend in the number of dairy cows since the introduction of milk quotas in 1984.

The beef (or suckler) herd increased during the 1990s linked to headage based payments for suckler cows and switches from milk production. Changes to subsidy schemes in 2000 and the 2001 Foot and Mouth (FMD) outbreak led to substantial reductions in the number of beef cows. However, numbers recovered to some extent and have remained relatively stable since.

²⁷ Enteric fermentation is a digestive process whereby carbohydrates are broken down by micro-organisms into simple molecules. Methane is produced as a by-product of enteric fermentation.

There was little overall change in the size of the sheep breeding flock during the 1990s, largely due to quota limits. As for the beef herd, changes to subsidy schemes in 2000 and the FMD outbreak in 2001 resulted in a substantial reduction in ewe numbers. There was a further decline following the last CAP reforms in 2004 but ewe numbers have increased in each of the last three years linked to improved prices.

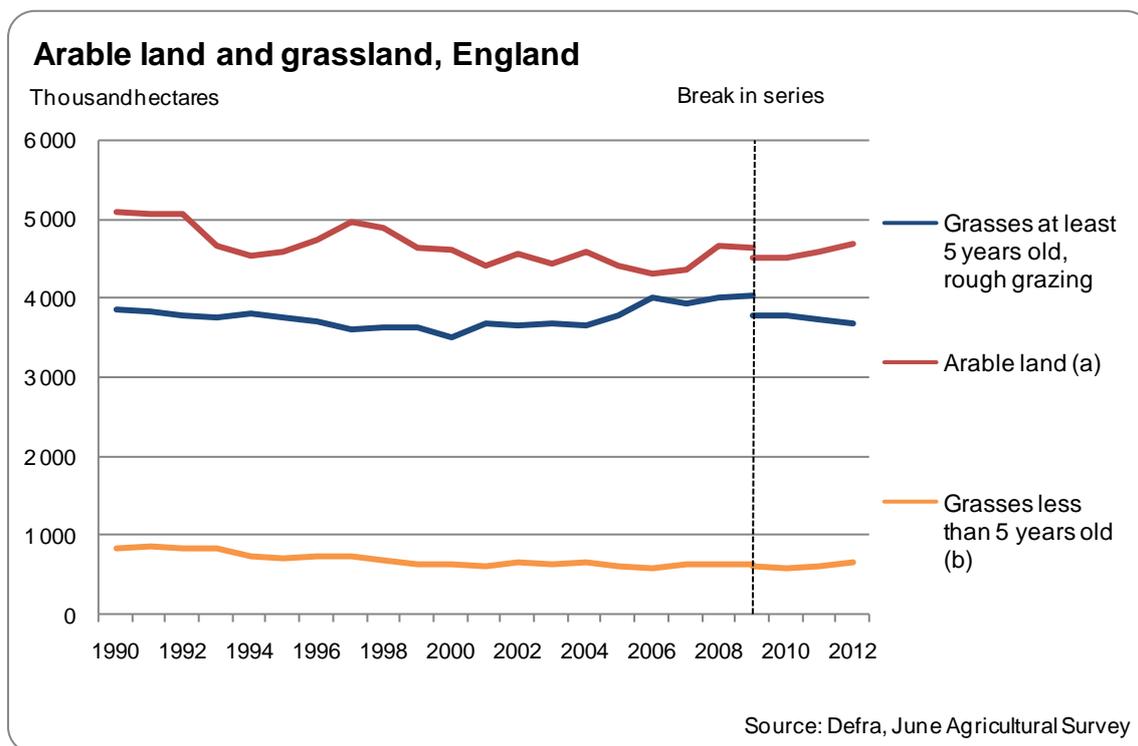
The breeding pig population shows an overall downward trend, particularly since the mid 1990s. This is due to a number of factors including problems with disease, high feed prices and the strength of Sterling.

Poultry numbers generally increased between 1990 and 2004, but have since tended to decline influenced by a number of factors; rising input costs (particularly for feed but also lighting, heating and labour) have led to reduced profit margins or even losses with some producers leaving the industry. The introduction of new legislation (preparation for the conventional cage ban in 2012 and the Integrated Pollution Prevention Control rules) over the period also increased input costs. Outbreaks of Avian Influenza between 2006 and 2008 may also have been an influencing factor.

Crops and grasses

Rationale

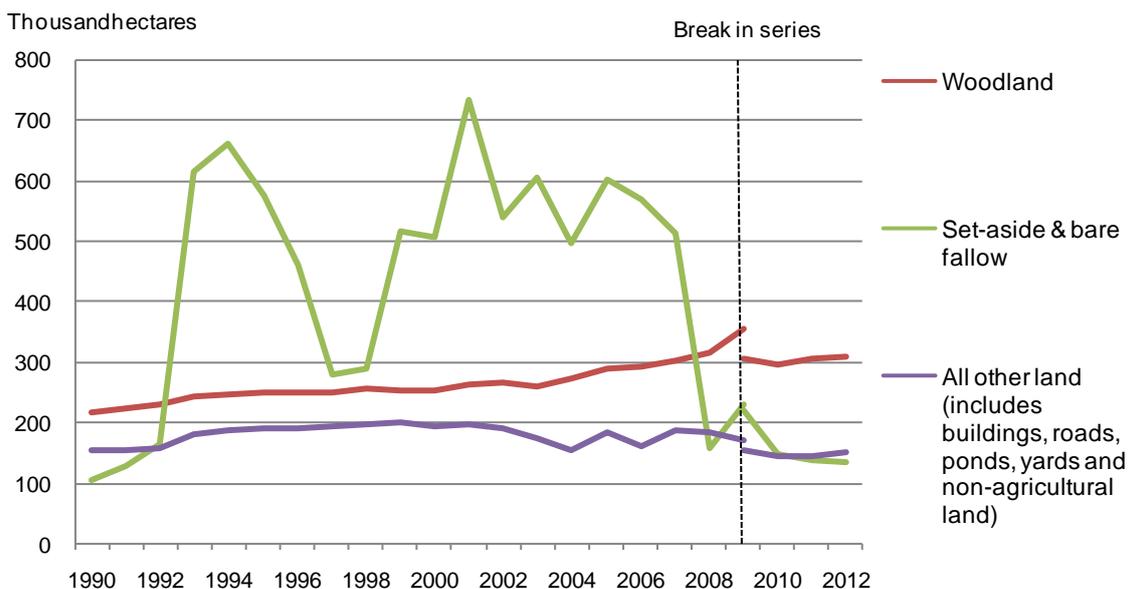
Trends in crop and grass areas are shown to illustrate the basic drivers of emissions. Levels of emissions are dependent on a range of factors including the nitrogen quantity applied, timing and application method used. Nitrogen requirements differ between the type of "crop" grown (including grass).



(a) Excludes fallow and set-aside land. Includes grasses less than 5 years old.

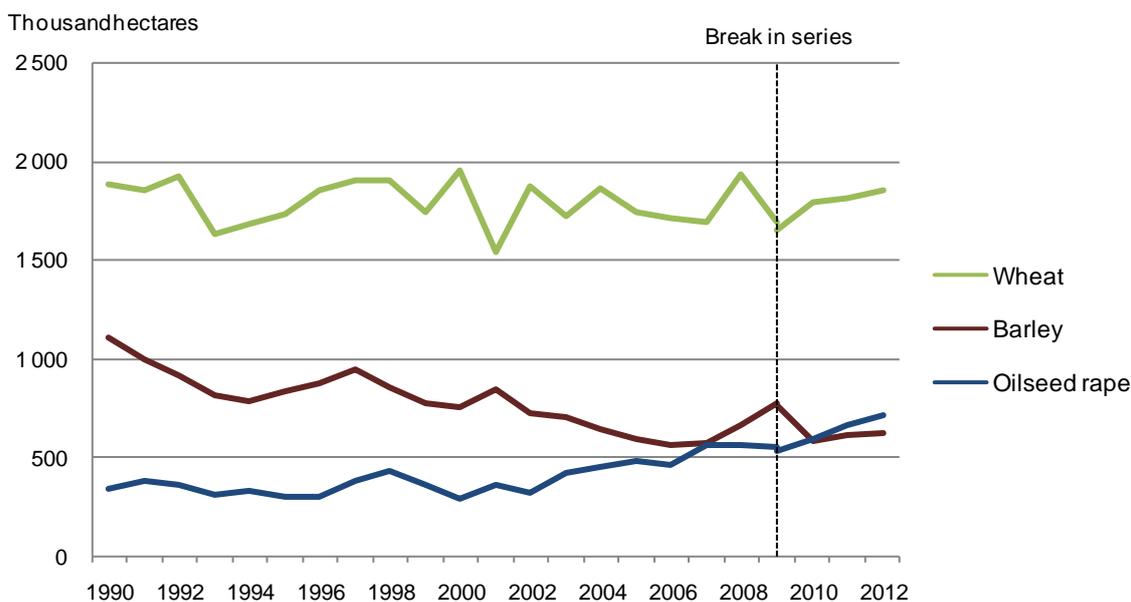
(b) Grasses less than 5 years old are shown separately but are also included within "Arable land".

Woodland, bare fallow, set-aside and other land, England



Source: Defra, June Agricultural Survey

Wheat, barley and oilseed rape areas*, England



* Excludes areas grown on set-aside land

Source: Defra, June Agricultural Survey

Note: estimates for 2009 onwards are not directly comparable with earlier years. This is due to (1) a large number of inactive holdings being removed from the survey register following the 2010 census and (2) the introduction of a survey threshold. Further details can be found in the June Survey methodology report at: <https://www.gov.uk/structure-of-the-agricultural-industry-survey-notes-and-guidance>

Trends

The total area of cropped land increased (by 14%) in 2008 following the removal of set-aside requirements as farmers responded to high global cereal prices by planting more wheat. The main crops grown in England are wheat, barley and oilseed rape; together these accounted for 36% of agricultural land in 2012.

There was a gradual increase in the area of permanent grassland (grass at least 5 years old) from 2000 which peaked in 2008. The reasons for this are unclear but it could be due, in part, to increased survey coverage of agricultural holdings rather than actual increases in grassland areas. Following the FMD outbreak in 2001 an increased number of farms were registered with holding numbers for animal health and disease control purposes. The introduction of the Single Payment Scheme (SPS) in 2005 may also have resulted in an increase in registered holdings and may have led some farmers to reclassify grassland on their June Survey returns to reflect SPS requirements for recording grass.

The area of (primarily forage) maize increased from 116 thousand hectares in 2000 to 143 thousand hectares in 2012. Whilst there have been some fluctuations across this period, the overall trend is upwards. Although largely grown on holdings with dairy cows, in recent years there have also been increases on holdings without dairy cows²⁸.

Within this section we have shown that there have been changes in the number of livestock and in agricultural land use in England. This has had an impact on the total level of emissions. Additionally, any changes in productivity may have had an impact on the intensity of emissions - that is, the amount of GHG per tonne of crop or litre of milk or kilogramme of meat produced. Because it is not currently possible to calculate emissions on farms directly, proxy measures are required to help understand intensity; these include for example, ratio of feed production to milk produced. Sections 2.4 to 2.10 consider proxies for intensity and some other key measures.

²⁸ <http://webarchive.nationalarchives.gov.uk/20130315143000/http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-envirom-obs-research-cattle-dairy09-jun09.pdf>

2.4 Dairy

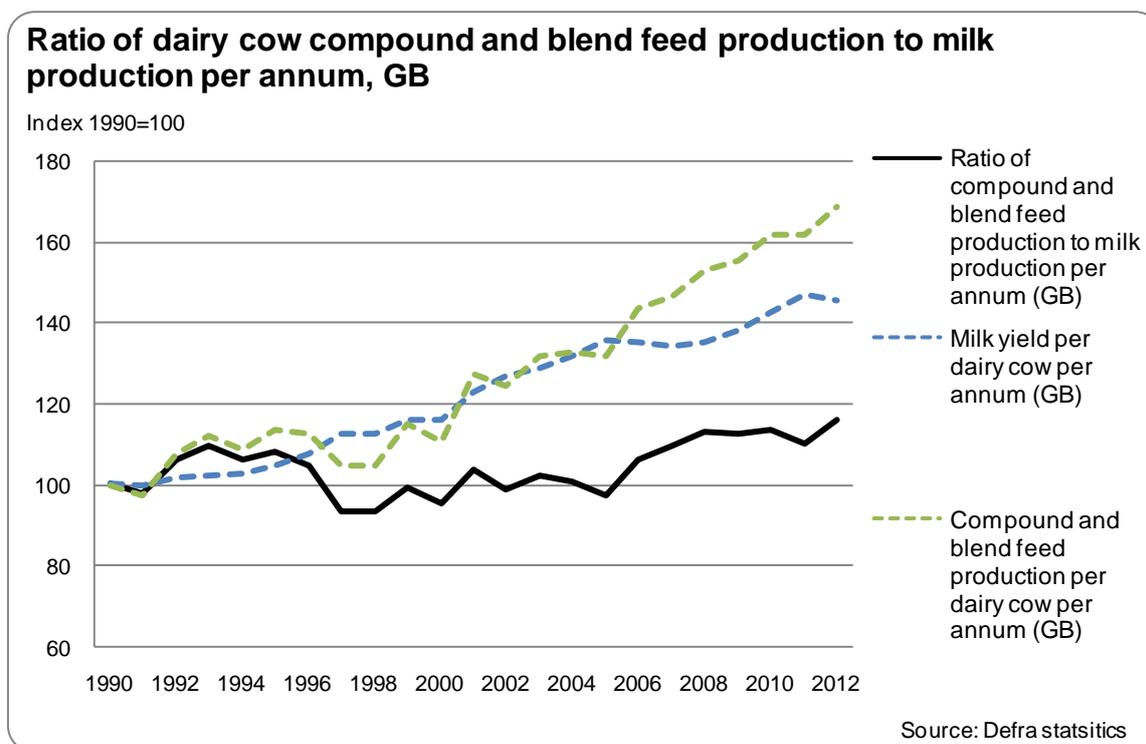
Since the introduction of milk quotas in 1984 there has been a significant reduction in the number of dairy cows in England overall, an important driver in the reduction in greenhouse gas (GHG) emissions. It is not possible to calculate emissions or emissions intensity on farms directly. For this reason proxy measures have been developed which are associated with emissions; these include output per unit of feed, longevity, fertility and mortality. In this section we explore productivity in the dairy sector and how this relates to GHG intensity.

2.4.1 Dairy: efficiency of output

Ratio of dairy cow feed production to milk production

Rationale

Considering milk yields in conjunction with trends in inputs (such as dry matter feed) provides an indication of GHG intensity in the dairy sector. The ratio of dairy cow feed production to milk production is used here as a proxy measure for on-farm GHG emission intensity.



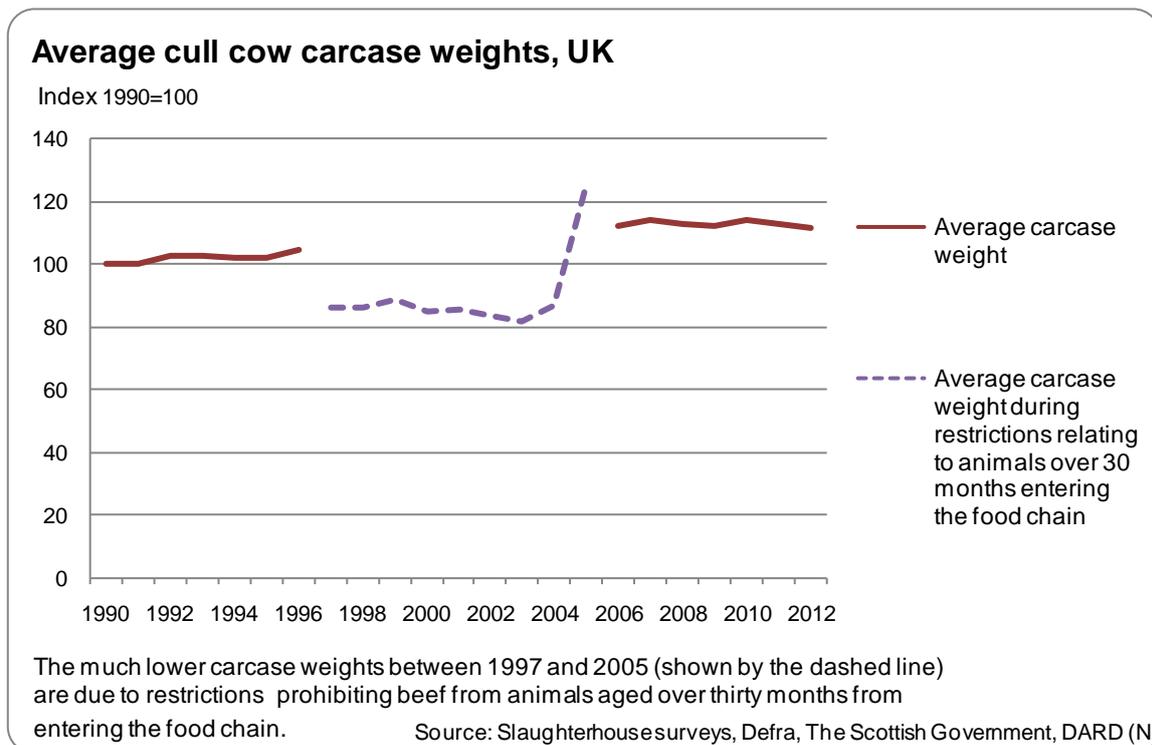
Trends

The ratio of compound and blended feed production to aggregate milk production is currently at the highest level since 1990. There have been some fluctuations over the period but since 2005 the rate of increase of compound and blended feed production has been greater than the rate of increase in average milk yields. This might suggest that overall there has been a reduction in feed efficiency and an increase in GHG intensity. However, the picture is complex because the quantity of compound and blend feed produced (shown in the chart) will be influenced by changes in the availability of on-farm feeds, forages and grazed grass (which are likely to have been adversely affected by weather conditions in recent years) but for which data are not currently available.

Weight of cull cows

Rationale

Live weight can also be used as a proxy for milk yield; all other things being equal, a heavier cow will produce more milk than a lighter one. As limited information is currently available on live weight, the carcass weight of cull cows (cows culled at the end of their productive life) is considered here as a proxy for live weight. The chart below provides an index of cull cow carcass weights. This includes cull cows from both the dairy and suckler (beef) herds.



Note: it is not possible to distinguish between dairy and beef cows from the slaughter statistics.

Trends

On average, cull cows are now heavier than in the 1990s. Genetic selection for milk yield has increased the mature weight in dairy cattle leading to the overall increase, despite there being relatively fewer dairy cows now than 20 years ago.

Figures since 2006 (by which time the restrictions prohibiting beef from animals aged over thirty months from entering the food chain had been lifted) do not show any clear upward (or downward) trend. Milk yields have increased more than the carcass weight of cull cows.

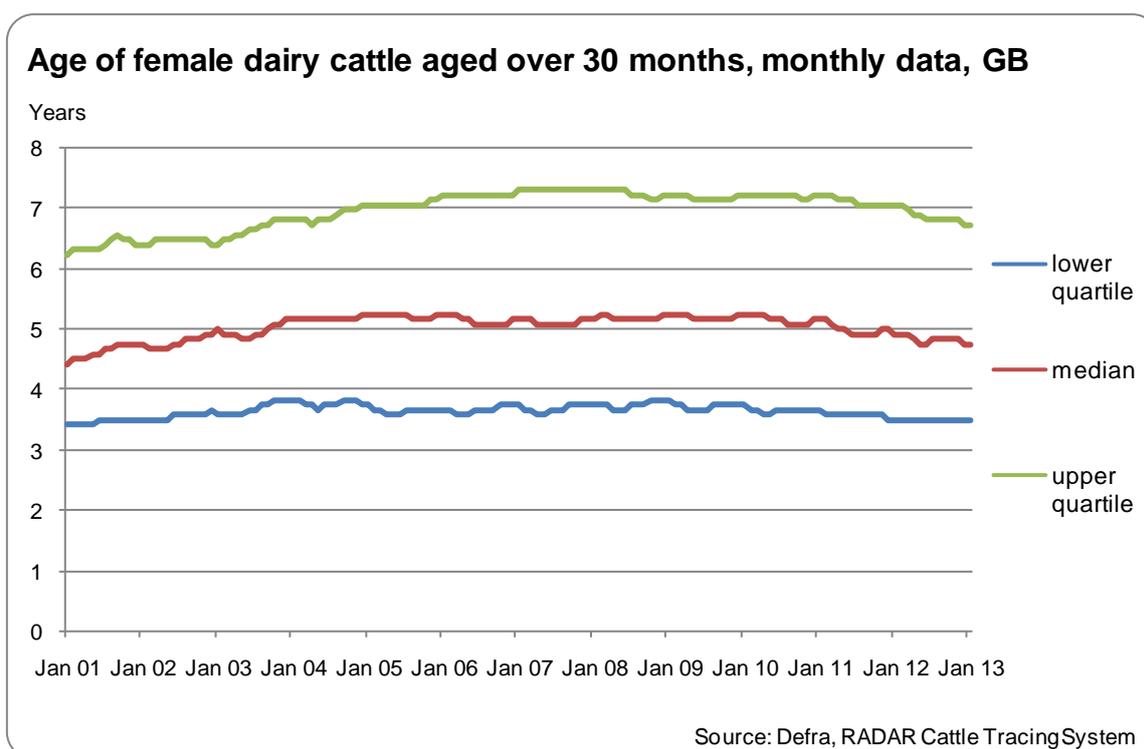
2.4.2 Dairy: longevity and fertility

Rationale

Increased fertility rates and longevity of breeding animals will help secure reductions in GHG emissions as fewer replacement females will be required to deliver the same level of production. This would also reduce an 'overhead' cost of milk production.

Age of dairy herd (breeding animals)

The chart below shows the median age and inter quartile range of female dairy cattle aged 30 months and over.



Trends

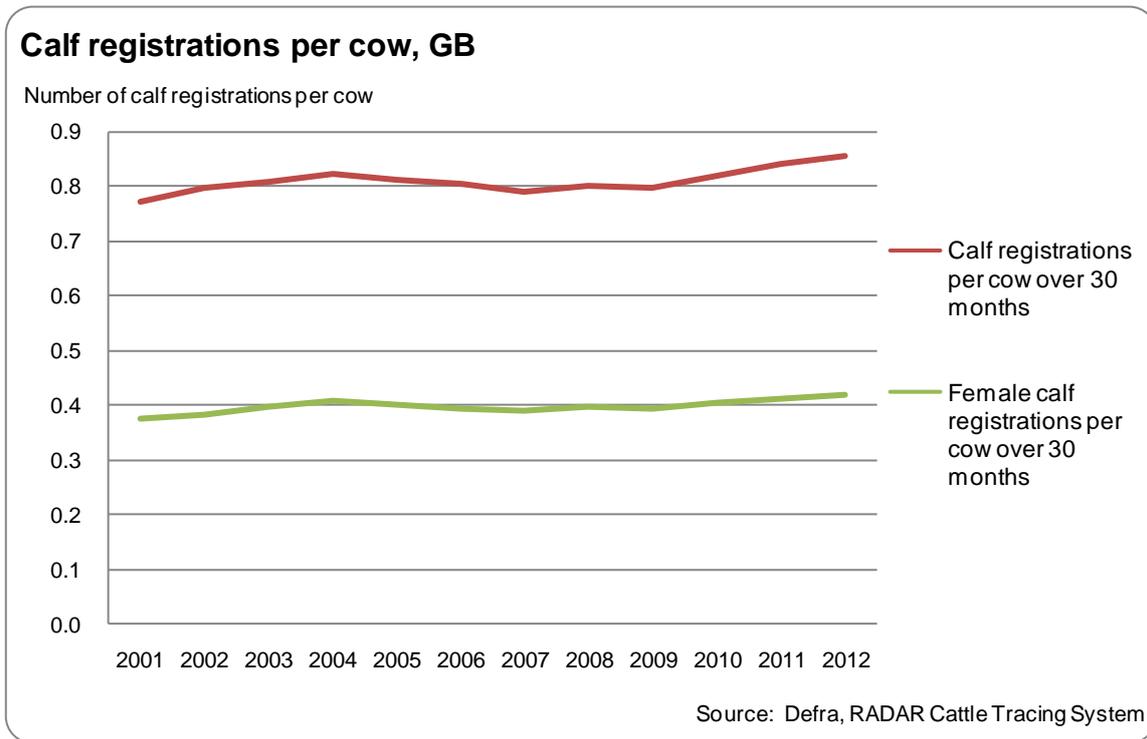
The median age of the dairy breeding herd (cows aged over 30 months) is greater than in 2001, but has declined gradually over the last three years. The increase between 2001 and 2004 is thought to be due to a recovery following the 2001 outbreak of Foot and Mouth Disease (FMD) and changes to restrictions associated with Bovine Spongiform Encephalopathy (BSE) where Over Thirty Month scheme and Older Cattle Disposal scheme impact on the trends. The current situation does not suggest any significant increase in the age of breeding herds above levels prior to FMD and BSE restrictions.

The inter quartile range (IQR) is given to assess the spread of the age of cattle. An increase in longevity will be demonstrated by an increase in the median or an increase in the IQR, such that the upper quartile increases by more than the lower quartile.

The IQR for dairy cattle ages has been relatively stable since 2007 although recent decreases in the upper quartile suggest a slight reduction in longevity.

Further information on the distribution of dairy cows by age in months can be found at (ii) in the [Appendix](#).

Calf registrations per cow (at present data are not separately available for dairy and beef cattle²⁹)

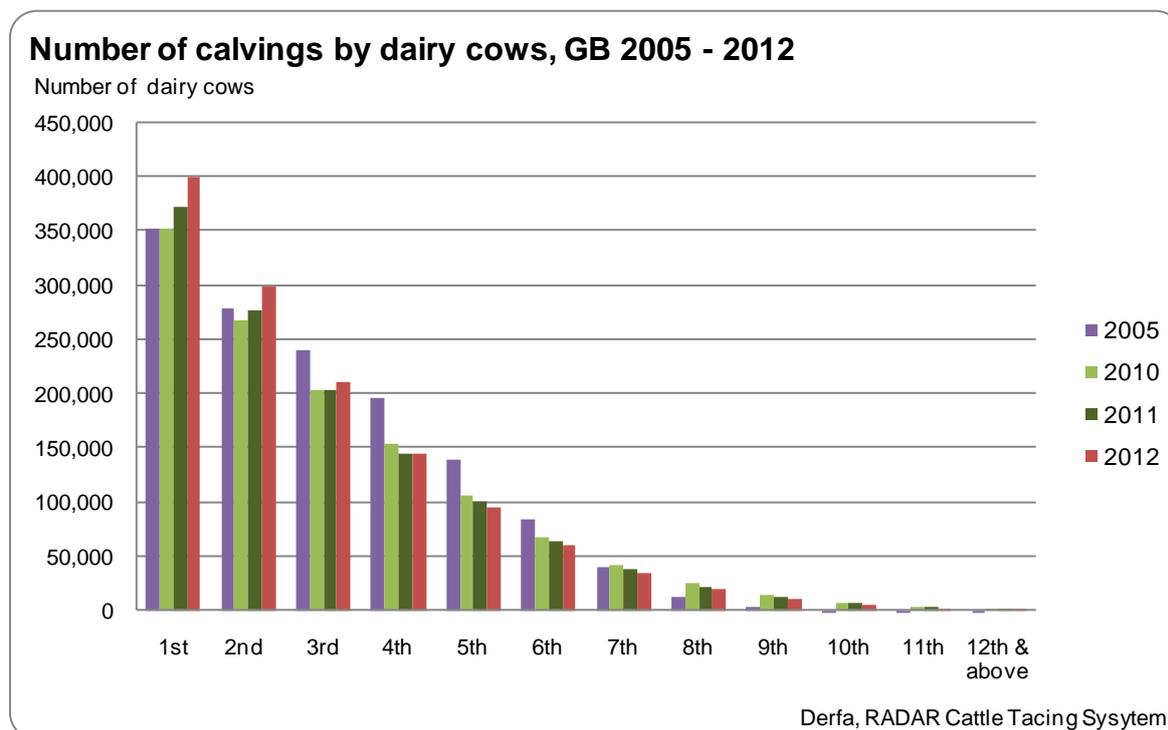


Trends

Overall, the numbers of calf registrations per cow have remained relatively stable over the 10 year period for which data are available. Initial indications suggest a recent increase in the number of calf registrations per cow, but it is too early to interpret this as a change in the longer term trend.

²⁹ No distinction is made between dairy and beef animals. Male dairy calves are under reported in CTS and in the 'Calf registrations per female cow over 30 months' measure the number is modelled on beef calf registrations. The approach taken is consistent with Agriculture and Horticulture Development Board (AHDB) methodology.

Number of calvings



Trends

In 2012, 1.29 million dairy cows had calves compared to 1.35 million in 2005. Of these, the proportion of dairy cows that calved for the first time (the effective replacement rate) was 31% in 2012 compared to 26% in 2005, while the proportion calving for a second time remained virtually unchanged between 2005 and 2012 at 21% and 23% respectively.

Data for 2012 suggest a slight decrease in the number of dairy cows having 4 or more calves compared to the previous years.

2.4.3 Dairy: animal health

On-farm mortality

Rationale

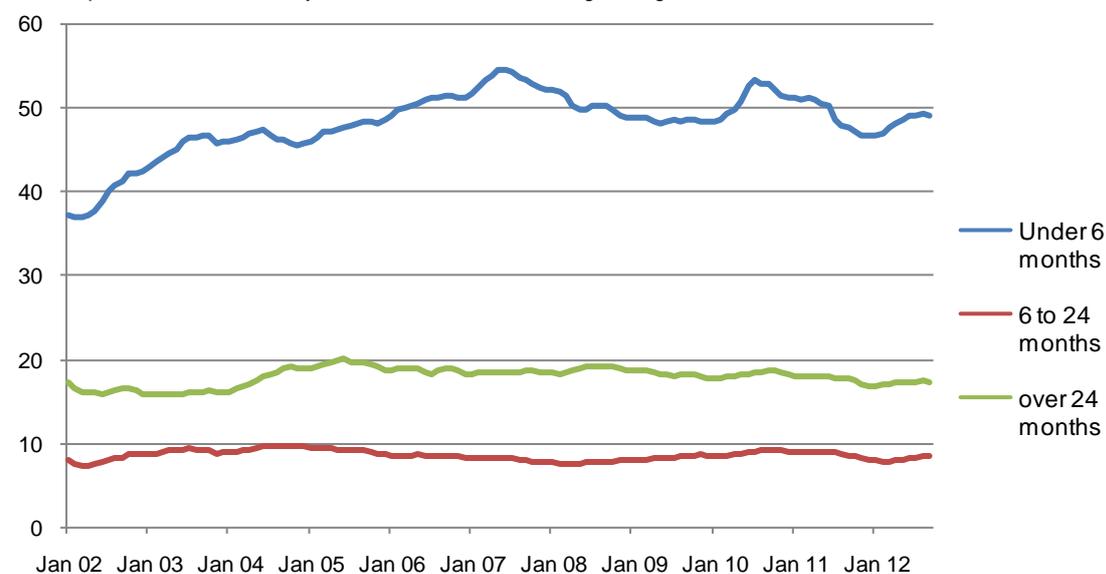
Reductions in on-farm mortality³⁰ will lead to less wastage. Reduced disease will lead to greater productivity. For cattle, overall mortality may be a better indicator than the incidence of specific diseases for which we do not have full data.

³⁰ On-farm mortality rate is defined as the number of deaths per 100,000 days at risk on agricultural premises. It is calculated using the number of cattle deaths divided by the number of cattle days in the period. The number of cattle days in the period represents 1 day for each animal each day. For example, if 5 animals were present on a location for 20 days the sum of the animal days would be 100. Conversely, if 20 animals were present on a location for 5 days the sum of the animal days would also be 100. This means, for any specified risk to the cattle in an area, that areas with a high density of cattle can be compared directly with areas with a low density of cattle.

On-farm mortality was calculated by analysing only those premises that were registered as being agricultural and therefore excludes deaths at slaughter houses.

On-farm mortality for dairy cattle, GB

Deaths per 100,000 animal days - 13 month centred moving averages



Source: Defra, RADAR Cattle Tracing System

Trends

There was an overall reduction in on-farm mortality for registered dairy calves (under 6 months) between 2007 and early 2010. This was followed by an increase during 2010. It is not clear why this increase occurred as there were no obvious causes, such as a disease outbreak or adverse weather conditions. Levels have now dropped back to below those seen at the start of 2010. For dairy cattle age 6 to 24 months there has been little change in on-farm mortality since 2009 but for those in the over 24 month category there has been a slight downward trend.

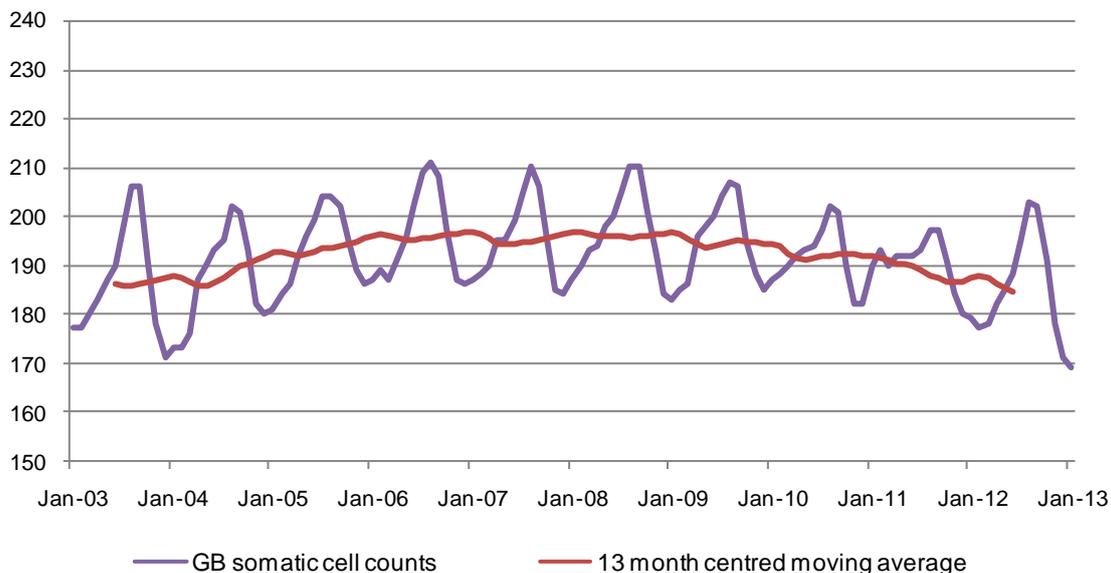
Somatic cell counts in the dairy herd

Rationale

Low counts of somatic cells in milk indicate a healthy, well managed dairy herd. High counts of somatic cells normally indicate a mastitis infection or udder damage often caused by faulty milking machines or improper use of milking equipment. A high cell count can mean reduced productivity.

Somatic cell counts, GB

('000 per ml)



Source: DairyCo

Trends

The trend in the somatic cell count increased from 2003 to 2006 but has decreased since 2009. A “healthy” somatic cell count range is generally accepted to be between 50,000 and 250,000 cells per ml.

2.4.4 Dairy: manure management

The system of manure management, both storage and application, is relevant to the control of environmental risks to air and water including ammonia.

In terms of solid manure systems, the 2013 Farm Practices Survey (FPS) reported that:

- 69% of dairy farms had facilities to store solid manure in heaps on a solid base, unchanged from 2012. Incidence increased by farm size ranging from 61% of small dairy farms to 70% of medium and large dairy farms. Overall just 2% of such stores were covered.
- 65% of dairy farms could store solid manure in temporary heaps in fields, again little changed on 2012.

In terms of slurry based systems, the 2013 FPS reported that:

- 50% of dairy farms had facilities to store slurry in a tank, little changed from 2012. Of these around 10% were covered.
- 52% could store slurry in lagoons, again unchanged on 2012. There is some variation between farm sizes, ranging from 20% of small dairy farms to 62% of large dairy farms.
- 7% had facilities to store slurry in another type of store and of these 14% were covered.

Note: some farms have more than one type of storage system.

For details on manure application see [Section 2.9.2](#)

2.4.5 Dairy: economic position

Table 3: Gross margins from dairy herds grouped by economic performance band, England

(£/head unless otherwise stated)	2010/11			2011/12		
	Low performers (bottom 25%)	High performers (top 25%)	All	Low performers (bottom 25%)	High performers (top 25%)	All
Average herd size (number)	49	239	132	52	234	138
Forage area (hectares per head)	0.7	0.5	0.5	0.8	0.5	0.6
Yield (litre per cow)	6,079	8,214	7,711	5,782	8,383	7,619
Price (pence per litre)	24	26	25	27	29	28
Milk sales	1,441	2,123	1,952	1,540	2,399	2,149
Calf sales & transfers out	85	88	85	105	90	97
Miscellaneous output	12	14	14	0	3	1
Less herd depreciation	-220	-200	-201	-152	-248	-224
Enterprise output	1,319	2,025	1,850	1,493	2,243	2,023
Variable costs						
Concentrates £ per head	524	558	549	430	705	609
<i>pence per litre</i>	9	7	7	7	8	8
Coarse fodder	30	30	29	32	41	36
Vet and medicine costs	70	80	78	36	98	75
Other livestock costs	187	165	164	146	197	171
Forage variable costs	82	80	82	71	93	88
Fert/litre (pence)	1	1	1	1	1	1
Total variable costs	894	913	902	716	1,134	979
Gross margin/cow	425	1,112	948	777	1,109	1,043
Variable costs pence/litre	15	11	12	12	14	13

Source: Farm Business Survey

Table 3 provides a comparison of gross margins for dairy herds between low and high economic performance groups. The data from the Farm Business Survey indicates that the average milk yield for high performing farms was around 35% higher than low performing farms in 2010/11 and 45% higher in 2011/12. Concentrated feed is the greatest input cost. Whilst high performing farms tend to spend more per cow than low performing farms, the cost per litre of milk is similar. Fertiliser costs per litre of milk were similar for low and high performing groups across both years. The top 25% of performers achieved higher gross margins overall influenced by the more favourable price per litre of milk they achieved in both years. The overall gap between the high and low performers has narrowed between the 2 years but longer term trends³¹ suggest that, in terms of gross margin per cow, the gap has widened over time.

³¹ For longer term trends see Section 2.4 of 2nd Edition of Agricultural Statistics and Climate Change at: <http://webarchive.nationalarchives.gov.uk/20130305023126/http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-enviro-climate-climatechange-120203.pdf>

2.4.6 Dairy: summary

The ratio of compound and blended feed production to aggregate milk production is currently at the highest level since 1990 although there have been fluctuations during this period. With respect to milk production, increased milk yields have partially offset reduced cow numbers ([Section 2.3](#)).

Information from the 2011/12 Farm Business Survey indicates that the difference between high and low economic performance groups is largely driven by yield and average milk price achieved ([Section 2.11](#) for average milk prices). In 2011/12 high performing dairy farms tended to have greater input costs (largely concentrated feed). This is a change to previous years when higher performers tended to incur lower costs, perhaps reflecting the volumes used or more competitive purchasing. Further details of economic and GHG performance in the dairy sector can be found in Section 4 of the 2nd Edition of Agricultural Statistics and Climate Change at:

<http://webarchive.nationalarchives.gov.uk/20130221211227/http://www.defra.gov.uk/statistics/foodfarm/enviro/climate/>

Over the last 5 years, the average age of breeding animals has continued to be stable at around 5 years. Calf registrations have increased slightly in the last 2 years to around 0.85 per breeding cow (note due to data availability this is for both dairy and beef cattle). There have been fluctuations in on-farm mortality for registered dairy calves (under 6 months old) but levels are currently similar to those seen in 2010. For dairy cattle aged 6 to 24 months and those over 24 months levels of on-farm mortality have remained relatively stable over the last 3 years. Somatic cell counts have also been stable over recent years, reducing slightly since 2010. Taking all these factors into consideration suggests that there may have been a reduction in the intensity of GHG emissions from the dairy sector.

2.4.7 Dairy: further developments

Current statistics provide a partial picture of the relevant drivers of GHG emissions as, for example, it is not possible to calculate milk production per kilogramme live weight. The following measures have been proposed as potential factors for inclusion in the new agricultural GHG inventory. Not all of the proposed measures can feasibly be populated with robust data in the short term; although some of the data are collected through the Cattle Tracing System there are significant complexities in extracting it from its current format.

- Calving interval (reasons why intervals are longer than expected)
- Age at first calving
- Number of lactations
- Live weight split by beef and dairy
- Herd replacement rate (via lactation number)
- Number of calves available for finishing as beef
- Calving season
- Grazing days
- Percentage of milk from grass based systems
- Reasons for culling

2.4.8 Dairy: notes on data collection methodology and uncertainty

Milk production and feed production

- i) The data on compound and blended feed production shown here are from the survey returns of all of the major GB animal feed companies. Data on raw material use, stocks and production of the various categories of compound animal feed are recorded. The major producers typically cover 90% of total animal feed production surveyed each month. The remaining smaller companies are sampled annually in December for their figures in the preceding 12 months. Sampling errors of the production estimates are small. Links to the survey methodology are given in the [Appendix](#).
- ii) On-farm production of animal feed is not covered here, nor are transfers between farms or exports of compound feed. However, trade in compound feeds in the UK is not significant (unlike trade in raw ingredients used to produce compound feeds).
- iii) Annual milk production is based on data collected by the Rural Payments Agency under milk quota regulations, adjusted to account for on farm usage (farmhouse consumption and fed to stock) and wastage.

Information from the Cattle Tracing System

- iv) The CTS is an administrative dataset and all cattle in GB are included in the dataset. Thus estimates shown here are based on the full cattle population. Links to the methodology are given in the [Appendix](#).

Farm Business Survey

- v) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

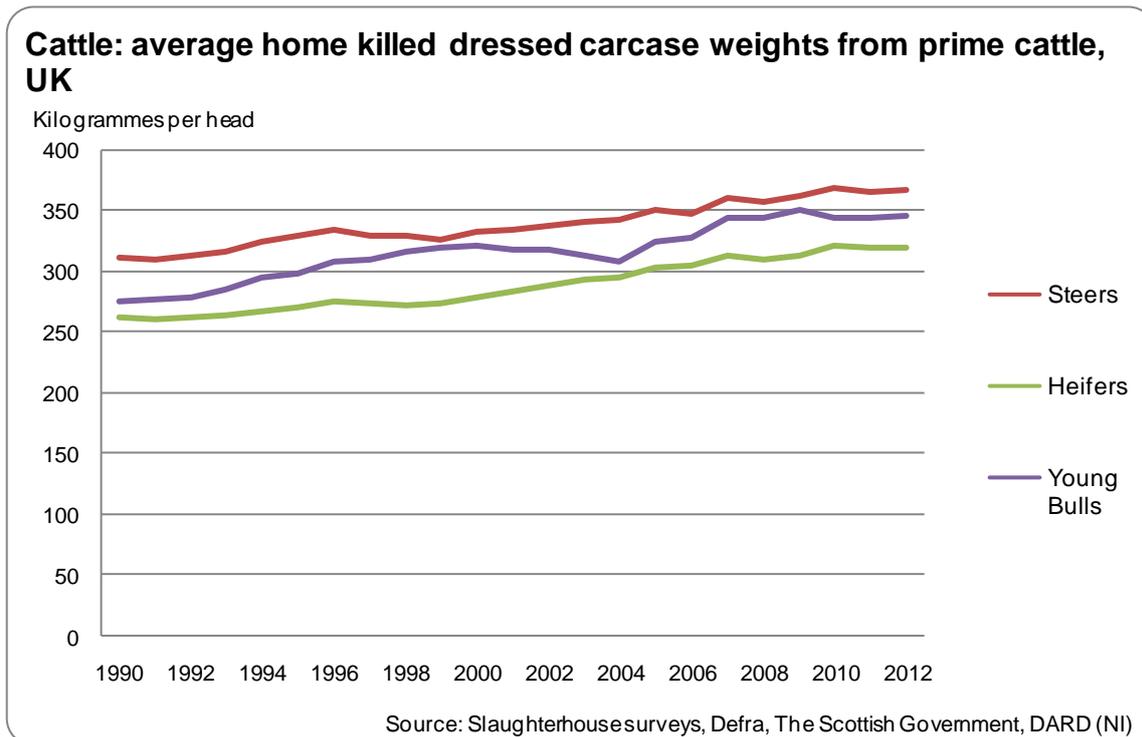
2.5 Beef

2.5.1 Beef: efficiency of output

Weight at slaughter

Rationale

More efficient finishing³² has the potential to reduce emissions and increase productivity. It is desirable for average carcass weights to increase, though not at the expense of increased intensity of emissions, i.e. greenhouse gas (GHG) emissions per kilogramme of meat produced.



Trends

Since 1990 there has been an overall increase in the average carcass weight of prime beef cattle although little change has been seen in more recent years.

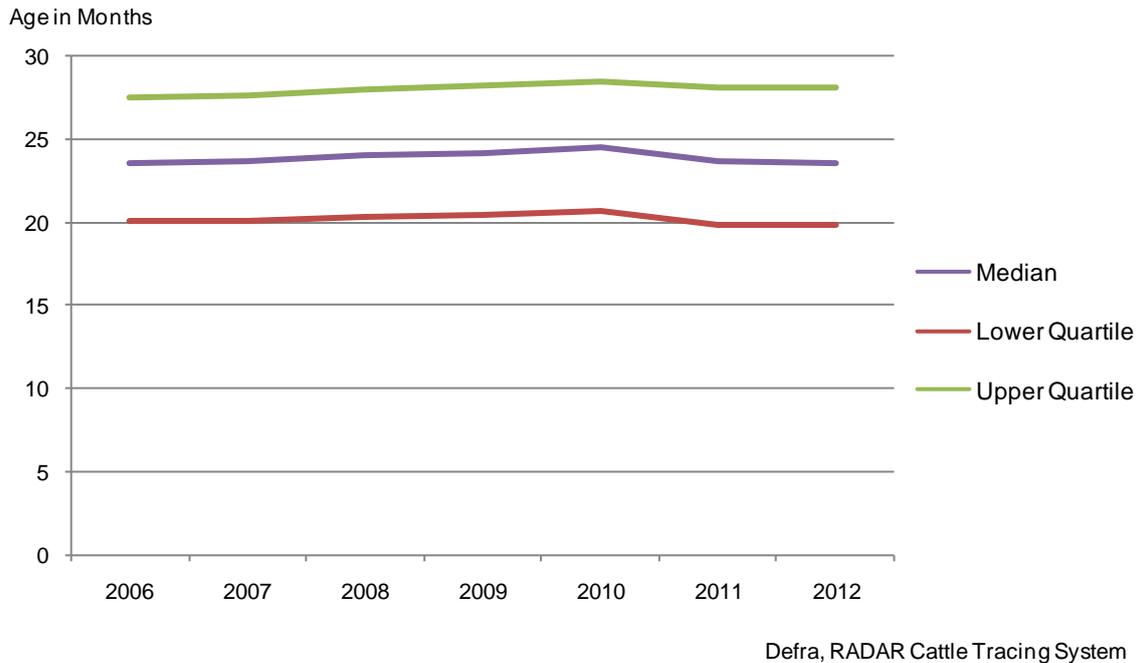
³² Finishing is the feeding process used prior to slaughter for cattle or sheep intended for meat production.

Age at which cattle under 4 years are slaughtered

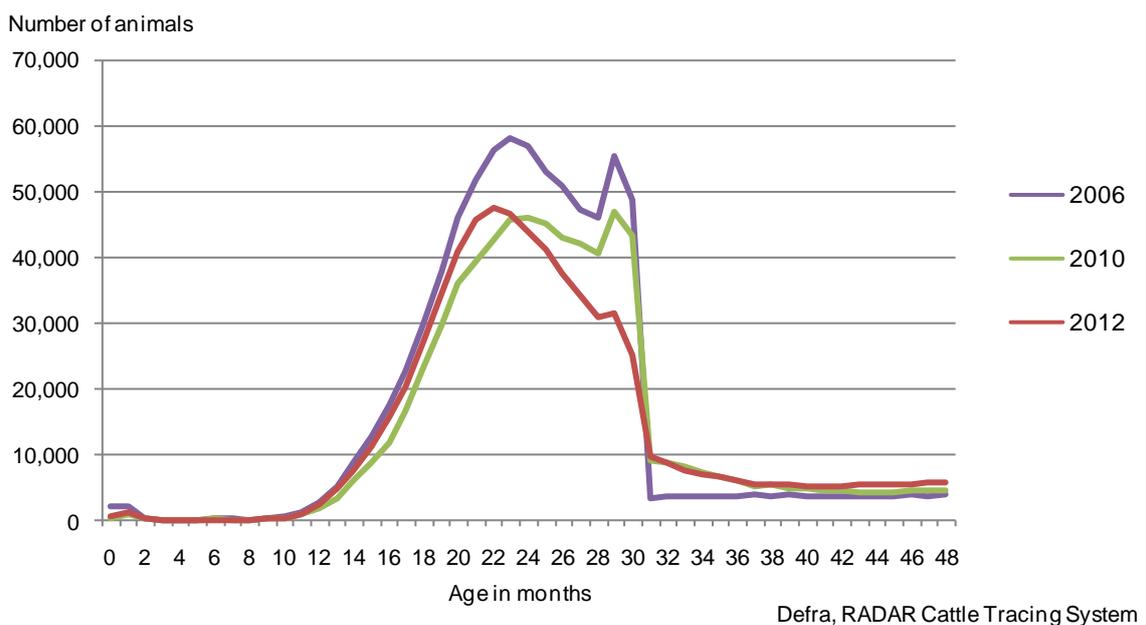
Rationale

Both the average meat produced per animal (see previous page), and the age of cattle at slaughter are factors in determining emissions. Considering these jointly helps to inform understanding of the emissions intensity. Here we consider the median as a measure of age at slaughter. It is also of interest to understand the spread in age; the lower and upper quartiles provide a measure of this. The second chart provides more details of the age at which animals have been slaughtered over the last 6 years. Cattle over 4 years have been excluded as these will primarily be breeding animals.

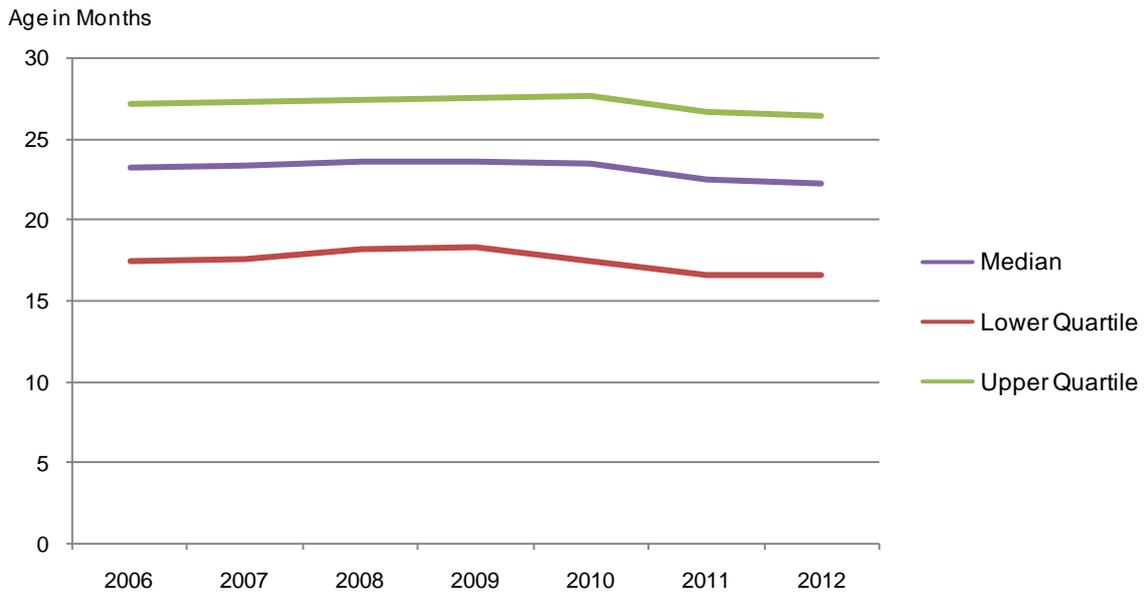
Age at slaughter for female cattle under 4 years, GB



Age at slaughter for female cattle under 4 years in 2006, 2010 & 2012, GB

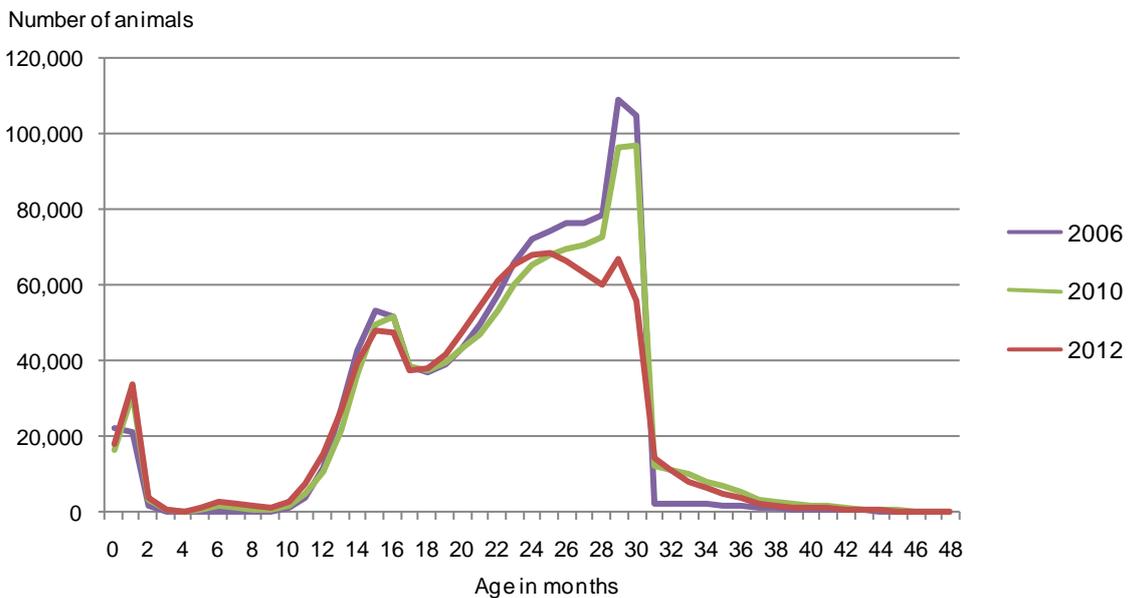


Age at slaughter for male cattle under 4 years, GB



Defra, RADAR Cattle Tracing System

Age at slaughter for male cattle under 4 years in 2006, 2010 & 2012, GB



Defra, RADAR Cattle Tracing System

Trends

The average age at slaughter of both male and female cattle (under 4 years old) has remained virtually unchanged since 2006 although a slight decline was seen in 2011 and 2012, particularly in male cattle. There has been some increase in the number of animals slaughtered beyond 30 months as meat from older animals is now allowed to enter the food chain, but there is still a significant dip around 30 months. The overall increase in average carcass weights, with little change in the age at slaughter suggests the intensity of GHG emissions may have improved marginally since 2006.

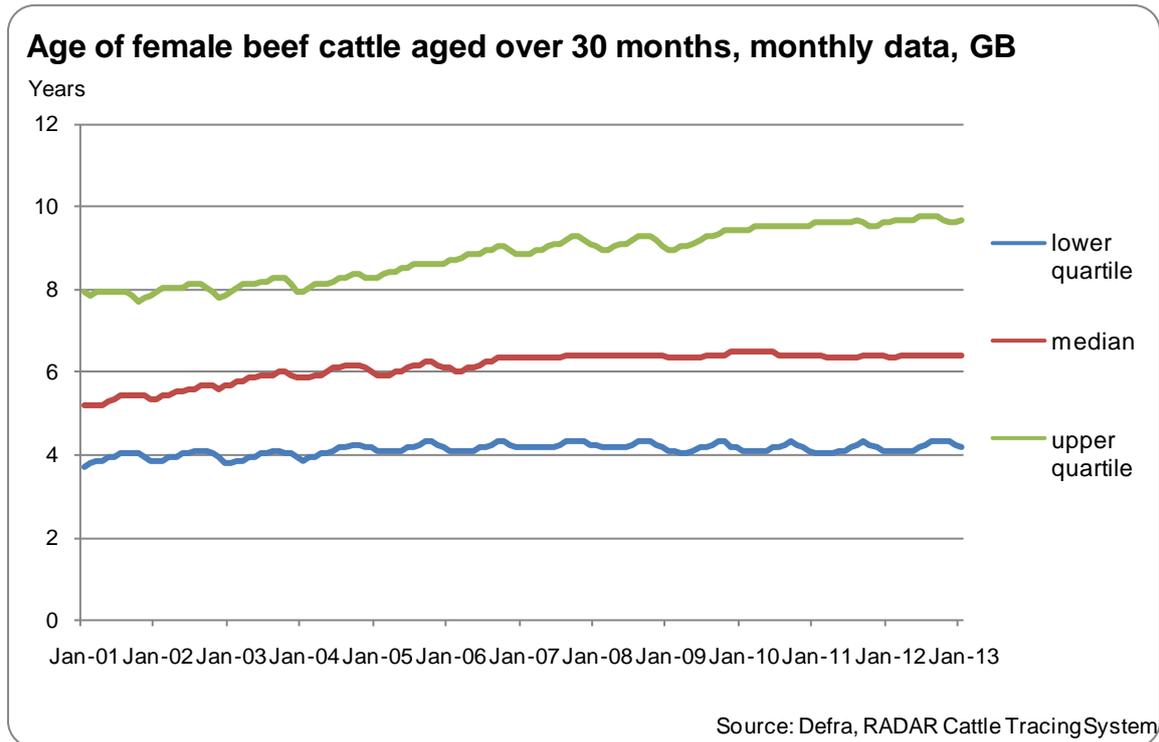
2.5.2 Beef: longevity and fertility

Rationale

Increased fertility rates and longevity of breeding animals will help secure reductions in GHG emissions as all things being equal fewer breeding females would be required.

Age of beef herd (breeding animals)

In the following chart, we consider the median average age and inter quartile range of female cattle aged 30 months and over.



Trends

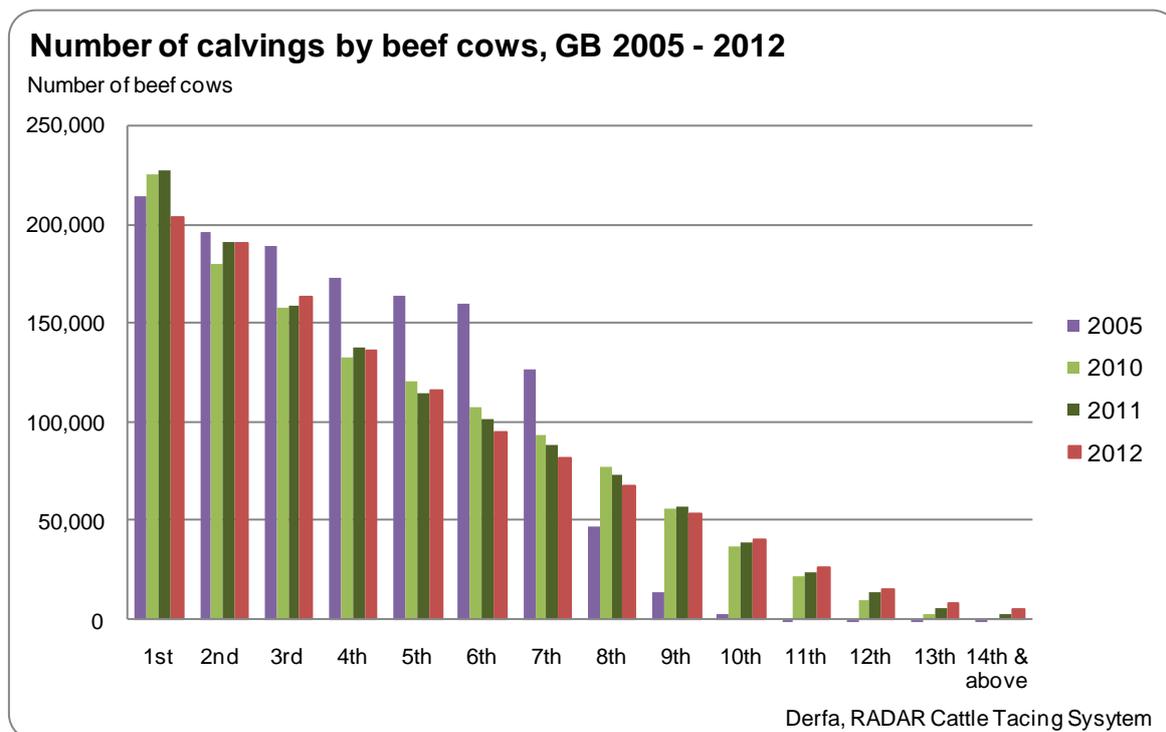
The median age of the beef breeding herd (cows aged over 30 months) has increased since 2001 but has remained relatively stable since 2007. This rise is thought to be due to a recovery following Foot and Mouth (FMD) and changes to restrictions associated with Bovine Spongiform Encephalopathy (BSE) (where Over Thirty Month scheme and Older Cattle Disposal scheme impact on the trends). The data do not suggest any significant increase in age of breeding cattle above levels prior to FMD and BSE restrictions.

The inter quartile range (IQR) is given to assess the spread of the age of cattle. Increased longevity in the beef breeding herd will be demonstrated by an increase in the median or an increase in the IQR, such that the upper quartile increases by more than the lower quartile. The IQR for beef cattle ages has increased since 2007 and the upper quartile has changed more than the lower quartile implying an increase in the overall longevity. For distribution of beef cows by age in months please see (iii) in the [Appendix](#).

Calf registrations per cow (at present data is only available for all dairy and beef animals)

See [Section 2.4 Dairy](#). The overall levels have remained relatively stable with no major upward or downward trend.

Number of calvings



Trends

In 2012, 1.20 million beef cows had calves compared to 1.28 million in 2005. Of these, 17% calved for the first time (the effective replacement rate) in 2012, similar to 2005. The proportion calving for a second time also remained virtually unchanged between the same years at 15% and 16% respectively.

In recent years there has been an increase in the number and proportion of beef cows calving at least 8 times; from around 47 thousand in 2005 to 67 thousand in 2012. This trend suggests increased longevity within the breeding herd.

2.5.3 Beef: animal health

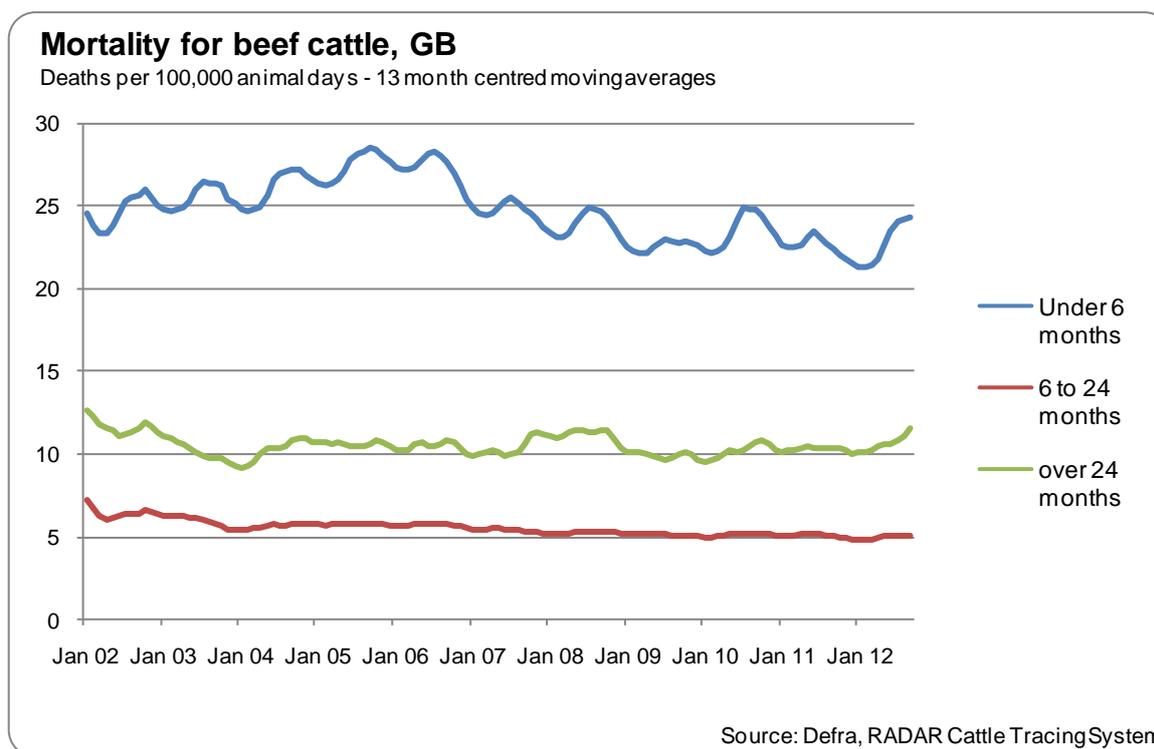
On- farm mortality

Rationale

All other things being equal, reductions in on-farm mortality³³ will lead to fewer animals required for food production. Reduced disease should also lead to greater productivity. For cattle, overall mortality

³³ On-farm mortality rate is defined as the number of deaths per 100,000 days at risk on agricultural premises. It is calculated using the number of cattle deaths divided by the number of cattle days in the period. The number of cattle days in the period represents 1 day for each animal each day. For example, if 5 animals were present on a location for 20 days the sum of the animal days would be 100. Conversely, if 20 animals were present on a

may be a better indicator than specific disease levels (for which we do not have full data in many cases).



Trends

Although there have been fluctuations across the period, there has been an overall reduction in the on-farm mortality of registered beef calves (under 6 months) since 2006. For beef cattle aged 6 months and above there has been little change in on-farm mortality since 2002.

2.5.4 Beef: manure management

The system of manure management, both storage and application, is relevant to the control of environmental risks to air and water including ammonia.

For grazing livestock farms the 2013 Farm Practices Survey (FPS) reported that:

- 49% of lowland farms had facilities to store solid manure in heaps on a solid base similar to the results from the 2011 and 2012 FPS. For those in less favoured areas (LFA) the proportion was 57% in 2013. Although lower than in 2012 the reduction is not statistically significant. In 2013, these stores were covered on 10% of LFA and 6% of lowland farms.
- 62% of lowland farms had facilities to store solid manure in temporary heaps in fields. For LFA farms the proportion was 49%. Both results show little change from the 2012 FPS.

location for 5 days the sum of the animal days would also be 100. This means, for any specified risk to the cattle in an area, that areas with a high density of cattle can be compared directly with areas with a low density of cattle. On-farm mortality was calculated by analysing only premises that were registered as being an agricultural premise. Therefore, this data excludes deaths at slaughter houses.

- 18% of LFA farms had facilities to store slurry in tanks, of these 24% were covered, although a 9% increase from 2012, it is not statistically significant. 7% of lowland grazing livestock farms were able to store slurry in a tank, of these 9% were covered.

For details of manure application see [Section 2.9.2](#)

2.5.5 Beef: economic position

Table 4: Gross margins for finished cattle (£ per head), England

	Finished cattle from calves & stores from the dairy herd			Finished cattle from calves & stores from the suckler herd		
	2009/10	2010/11	2011/12	2009/10	2010/11	2011/12
Average herd size	156	170	147	111	116	99
Finished livestock sales	455	544	527	855	990	1065
Other cattle/ throughput	140	47	161	117	-40	183
Less herd depreciation /calf & store cattle purchases	-222	-203	-160	-598	-598	-704
Enterprise output	373	388	528	375	369	544
Variable costs						
Concentrates	151	190	208	131	166	151
Coarse fodder	6	7	6	6	6	12
Vet and medicine costs	11	11	13	11	10	12
Other livestock costs	47	56	53	54	68	74
Forage variable costs	37	34	37	36	32	39
Total variable costs	251	298	317	238	283	287
Gross margin per cow	122	90	211	137	90	257

Source: Farm Business Survey

Table 4 provides a comparison of beef cattle gross margins from the Farm Business Survey based on standard output typology³⁴. Figures are in £ per head and have not been adjusted to reflect price changes due to inflation.

There have been increases in total variable costs for finished calves and stores from both the dairy herd and the suckler herd. Enterprise output rose significantly though between 2010/11 and 2011/12 which more than offset the increased costs and resulted in gross margins more than doubling for both categories. However, this increase followed substantial reductions in gross margins in the period between 2009/10 and 2010/11 for finished cattle and calves from both the beef and dairy herds.

2.5.6 Beef: summary

Since 1990, average carcass weights have increased. At the same time the age at which animals are being slaughtered has remained at a broadly similar level, although there was a slight reduction in the median age at slaughter between 2010 and 2012, particularly in male cattle.

³⁴ Further details about farm typology can be found at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182207/defra-stats-foodfarm-landuselivestock-june-results-typology.pdf

The median age of the beef herd has changed little since pre Bovine Spongiform Encephalopathy (BSE) and Foot and Mouth Disease (FMD) restrictions, though overall longevity has increased. There has been an overall reduction in the on-farm mortality of registered beef calves (under 6 months) since 2006. For beef cattle aged 6 months and above there has been little change in on-farm mortality since 2002. Calving numbers suggest that more beef cows are productive for longer. Considering all these factors together suggests that, all other things being equal, the intensity of GHG emissions may have reduced.

2.5.7 Beef: further developments

Current statistics provide a partial picture of the relevant drivers of GHG emissions. The following measures have been proposed as potential factors for inclusion in the new agricultural GHG inventory. Not all of the following can feasibly be populated with robust data in the short term; although some of the data are collected through the Cattle Tracing System (CTS) there are significant complexities in extracting it from the current format.

- System including winter forage from maize or grass silage or hay and concentrate level
- Housing period, which can vary considerably from year to year
- More information on combining age and weight at slaughter
- Fat score at slaughter
- Calving interval
- Grassland management including legume use

2.5.8 Beef: notes on data collection methodology and uncertainty

Meat production

- i) Carcase weights given here are from the Defra Slaughter house surveys. These surveys cover all the major slaughter houses, and are subject to small sampling errors. Links to the survey methodology are given in the [Appendix](#).

Information from the Cattle Tracing System

- ii) The CTS is an administrative dataset and all cattle in GB are included in the dataset. Thus estimates shown here are based on the full cattle population. Links to the methodology are given in the [Appendix](#).

Farm Business Survey

- iii) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

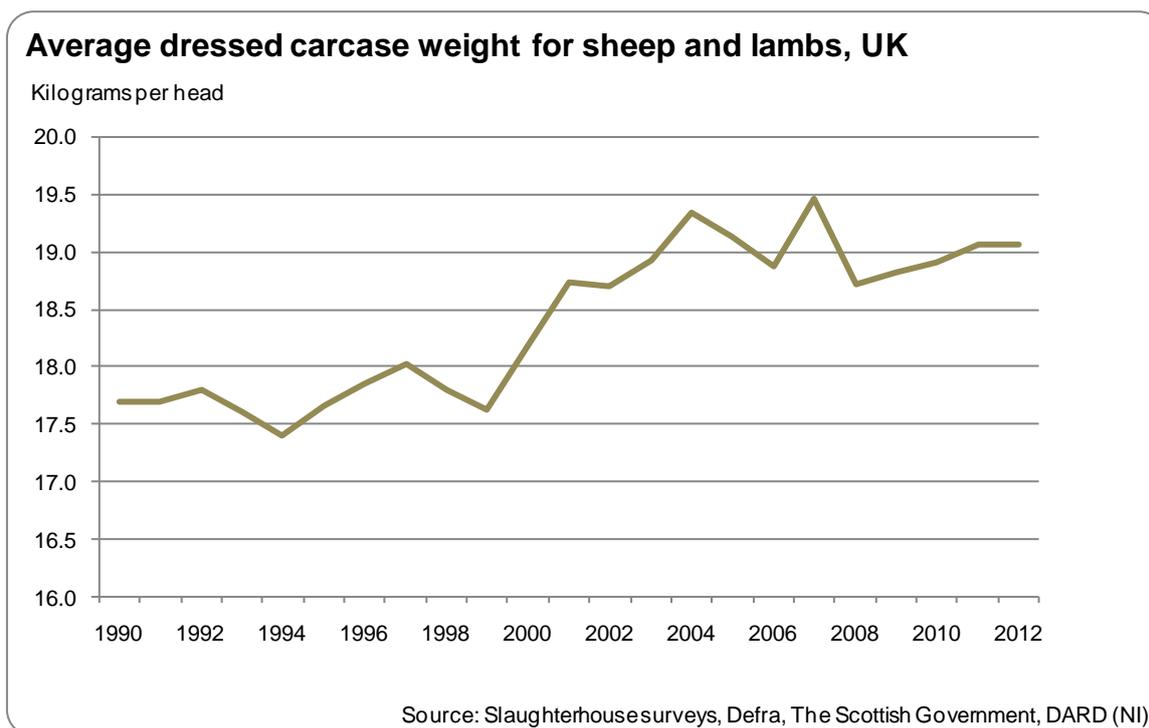
2.6 Sheep

2.6.1 Sheep: efficiency of output

Weight at slaughter

Rationale

Reducing age at slaughter by increasing growth rate through breed improvement, feeding and health management has the potential to reduce intensity of greenhouse gas (GHG) emissions (defined as GHG emitted per kilogramme of meat produced). All other things being equal, an increase in the annual average carcase weights as a consequence of lambs being slaughtered later will not improve the intensity of emissions. A move to later slaughtering would be evident from a change in the monthly slaughtering pattern.

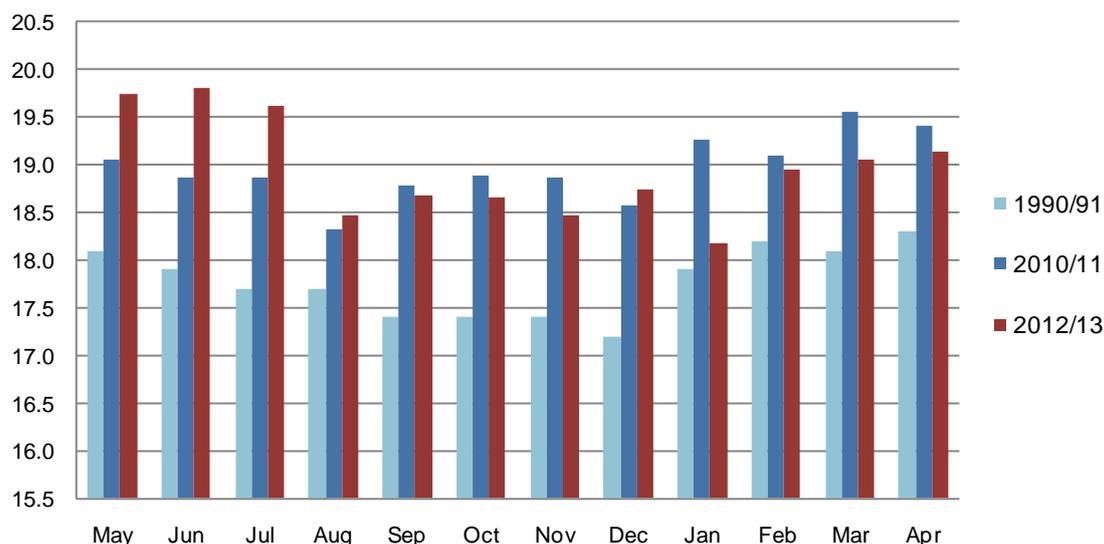


Note: excludes ewes and rams

Monthly distribution of slaughter weights and marketing pattern

Average dressed carcasse weights for clean sheep and lambs, UK

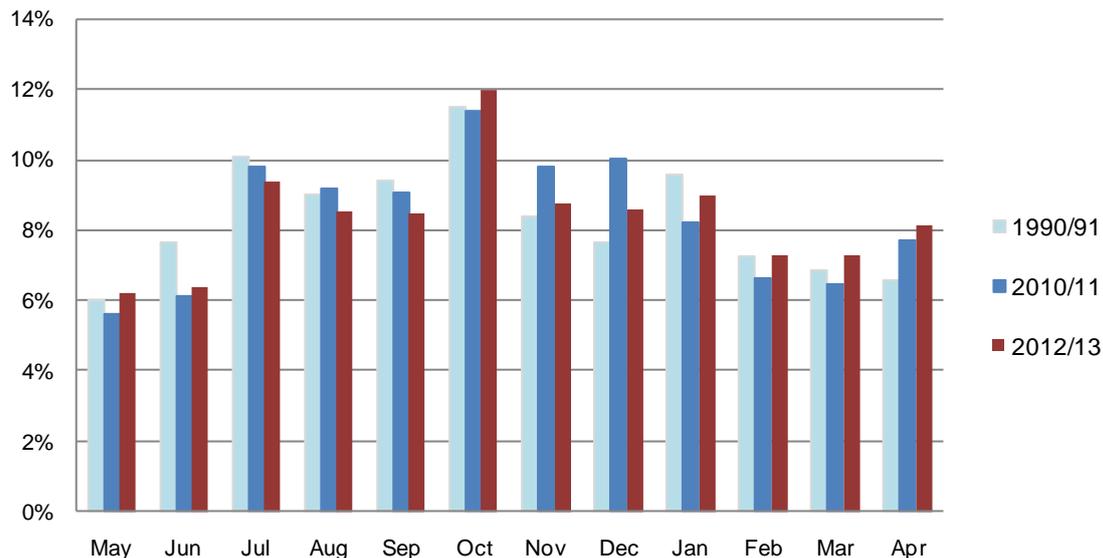
Kilogrammes per head



Source: Slaughterhouses surveys, Defra, The Scottish Government, DARD (NI)

Monthly marketing pattern for clean sheep and lambs, UK

Per cent



Source: Slaughterhouses surveys, Defra, The Scottish Government, DARD (NI)

Trends

Average carcasse weights for sheep and lambs have increased overall since 1990; after remaining relatively stable during the 1990s carcasse weights increased steadily between 2000 and 2004/05. This will, in part, be driven by farmers finishing to greater weights to achieve better prices. The peak in 2007 is probably due to the effects of the Foot and Mouth Disease (FMD) outbreak in that year which resulted in some producers retaining lambs on farm for longer.

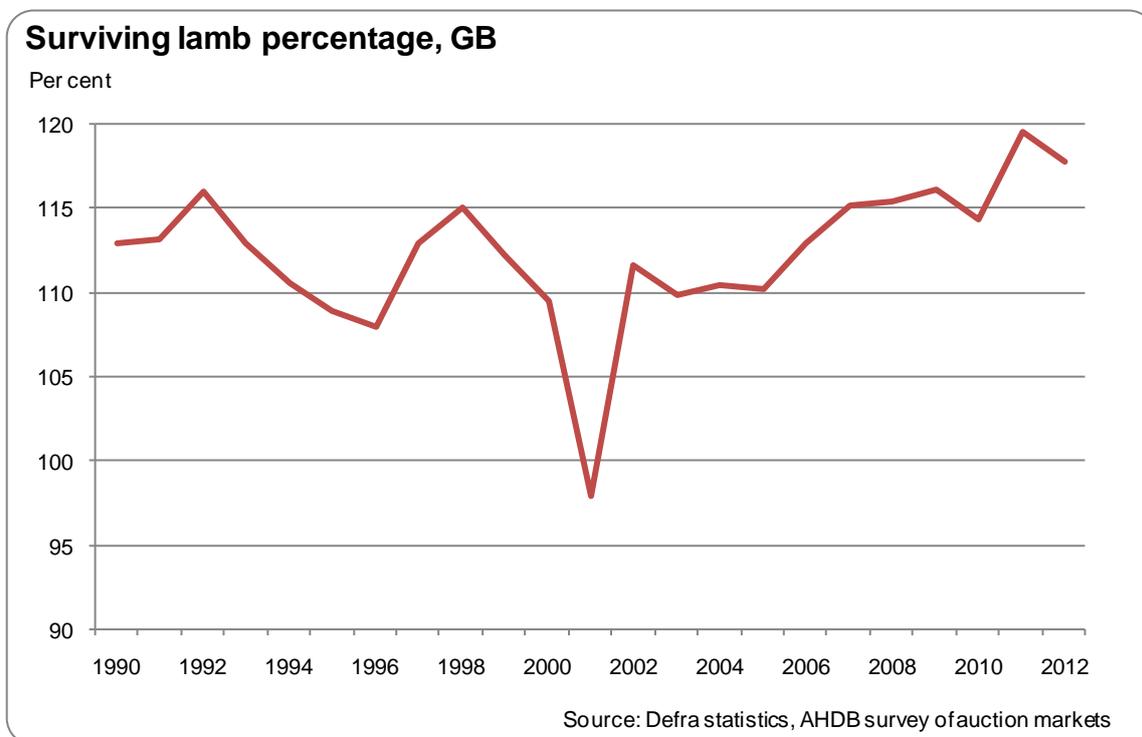
The increase in carcass weights has taken place across the year with no sustained changes to the monthly marketing pattern over time to suggest a move to later finishing. Changes within years tend to be shorter term reactions to weather and prices. For instance, the wet summer of 2012 led to problems finishing lambs and resulted in delayed marketings and lower carcass weights than in 2011.

2.6.2 Sheep: longevity and fertility

Surviving lamb percentage

Rationale

Increased fertility rates and longevity of breeding animals could help reduce greenhouse gas (GHG) emissions intensity because fewer breeding females would be required for the same level of output. By assessing the “surviving lamb percentage” (based on populations and slaughter statistics) it is possible to gain an overall indication of both the productivity of the ewe flock and lamb survival; all other things being equal an increase will represent an improvement in emissions intensity.



Trends

There has been an upward trend in the surviving lamb percentage over the last 10 years. Following the high survival rate in 2011 helped by favourable weather conditions, the surviving lamb percentage fell slightly in 2012. Ewe condition at tupping was reported to be good, feed availability and the winter was generally mild. However, bad weather (particularly on the high ground and in the north of the country) and drought in the south and east of England are thought to have mitigated this to some degree.

Definition of the surviving lamb percentage

The lambing percentage is calculated as $(A + B)/(C+D)*100$, where

A: Number of lambs at June (source June Survey)

B: Number of lambs born after December, but slaughtered before June (i.e. new season lamb slaughter), source: AHDB and Defra slaughter stats

C: Number of breeding ewes at December (source December Survey)

D: Number of ewe lambs put to the ram at December (source December Survey)

Note: the survival of lambs is dependent on weather conditions, and this needs to be considered when interpreting year on year changes.

2.6.3 Sheep: economic context

Table 5: Gross margins for breeding ewes (£/head), England

	Lowland breeding ewes			LFA breeding ewes		
	2009/10	2010/11	2011/12	2009/10	2010/11	2011/12
Average flock size	258	271	265	409	507	450
Forage area (hectares per head)	0.2	0.2	0.2	0.2	0.2	0.2
Finished livestock sales	75	82	92	35	41	43
Store sales	11	7	12	18	13	22
Other lamb throughput	12	14	19	17	21	23
Miscellaneous revenue	1	2	3	0.7	1	2
Less flock depreciation	-9	-10	-12	-10	-10	-10
Enterprise output	90	94	114	61	66	79
Variable costs						
Concentrates	15	17	19	10	11	12
Coarse fodder	1	2	2	3	4	4
Vet and medicine costs	6	6	6	5	5	6
Other livestock costs	10	11	12	6	8	9
Other crop costs	9	8	9	3	4	4
Total variable costs	40	44	48	28	33	35
Gross margin/ewe	50	50	67	33	33	44

Source: Farm Business Survey

Table 5 provides a comparison of gross margins for breeding ewes on lowland and Less Favoured Area (LFA) farms from the Farm Business Survey. Figures are in £ per head and have not been adjusted to reflect price changes due to inflation.

Gross margins per ewe increased in 2011/12 for both lowland and LFA ewes to £67 per ewe and £44 per ewe respectively following better returns for both finished and store animals.

2.6.4 Sheep: summary

Carcase weights for lambs have increased since 1990 and this has occurred across the year, suggesting that there has not been a sustained move to later slaughtering but that more are being finished³⁵ at greater weights. This change can be explained as a result of a combination of productivity gains, restrictions on the movement of the animals during the FMD outbreak and the reduction in lighter lambs in the uplands. There does not appear to be any sustained change to the marketing pattern to suggest lambs being slaughtered later in the marketing year. Overall trends in the last 5 years suggest that ewe flock fertility and lamb survival have improved with 2011 seeing the highest surviving lamb percentage of the period since 1990.

2.6.5 Sheep: further developments

Current statistics provide a partial picture of the relevant drivers of GHG emissions. The following are the most relevant pieces of information which are currently not included. Not all of the following can feasibly be populated with robust data in the short term.

- More information on the age at which lambs are slaughtered. This would be about providing more detail than is currently available.
- Measures of the longevity of breeding flock. This information represents an important gap. It is not clear if this could be populated with data in the short term.

2.6.6 Sheep: notes on data collection methodology and uncertainty

Meat production

- i) Carcase weights given here are from the Defra Slaughter house surveys. These surveys cover all the major slaughter houses and are subject to small sampling errors. Links to the survey methodology are given in the [Appendix](#).

Farm Business Survey

- ii) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

³⁵ Finishing is the feeding process prior to slaughter for cattle and sheep intended for meat production.

2.7 Pigs

2.7.1 Pigs: efficiency of output

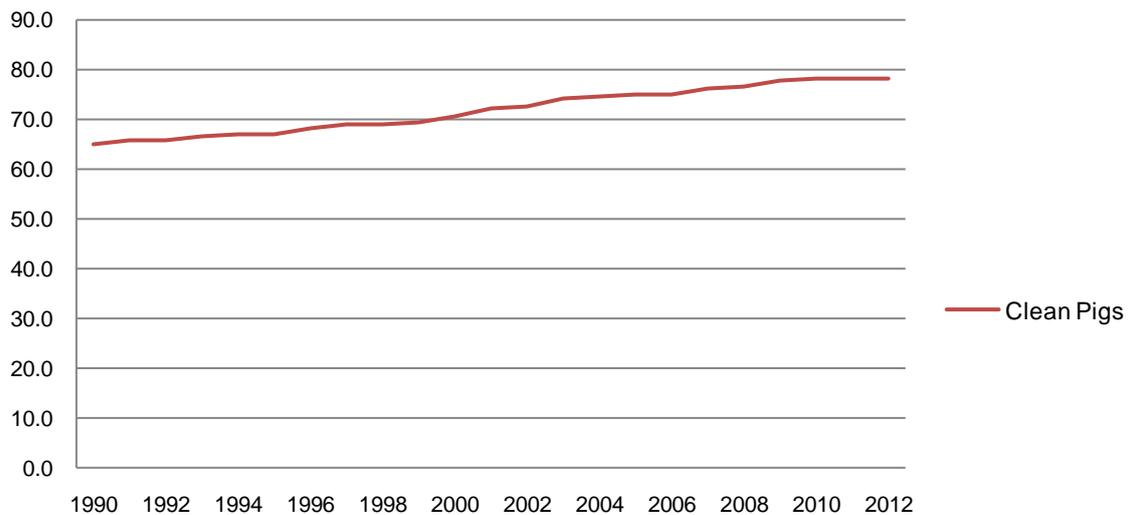
Weight at slaughter and daily live weight gain

Rationale

More efficient finishing has the potential to reduce emissions and increase productivity. It is desirable for average carcass weights to increase though not at the expense of increased intensity of emissions.

Average dressed carcass weights for pigs, UK

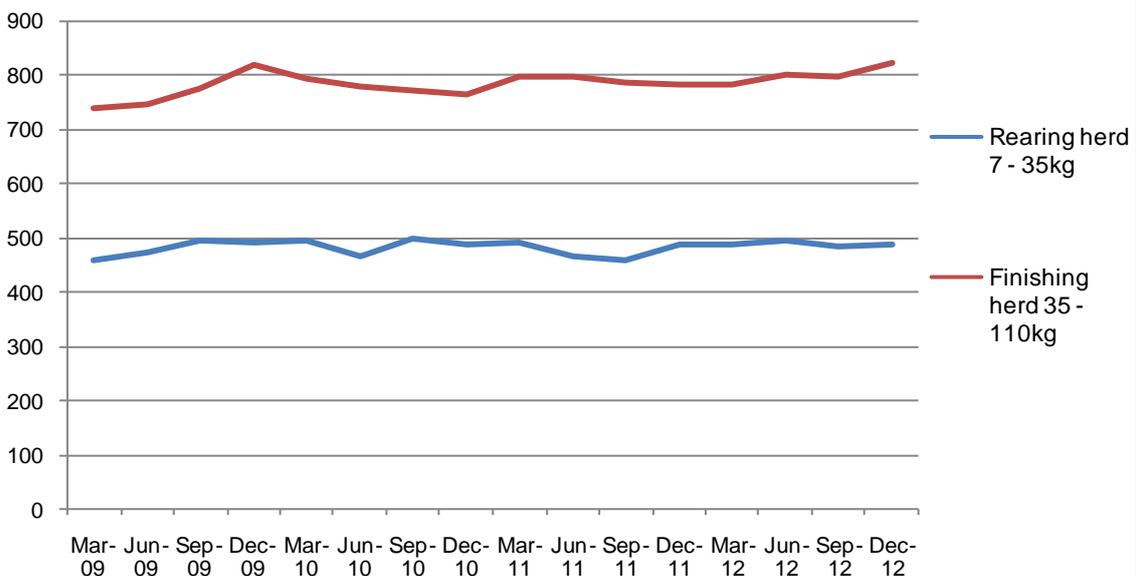
Kilogrammes per head



Source: Slaughterhousesurveys , Defra, The Scottish Government, DARD (NI)

Daily live weight gain rearing and finishing herds, GB

Grammes per day



Source: BPEX and Agrosoft Ltd

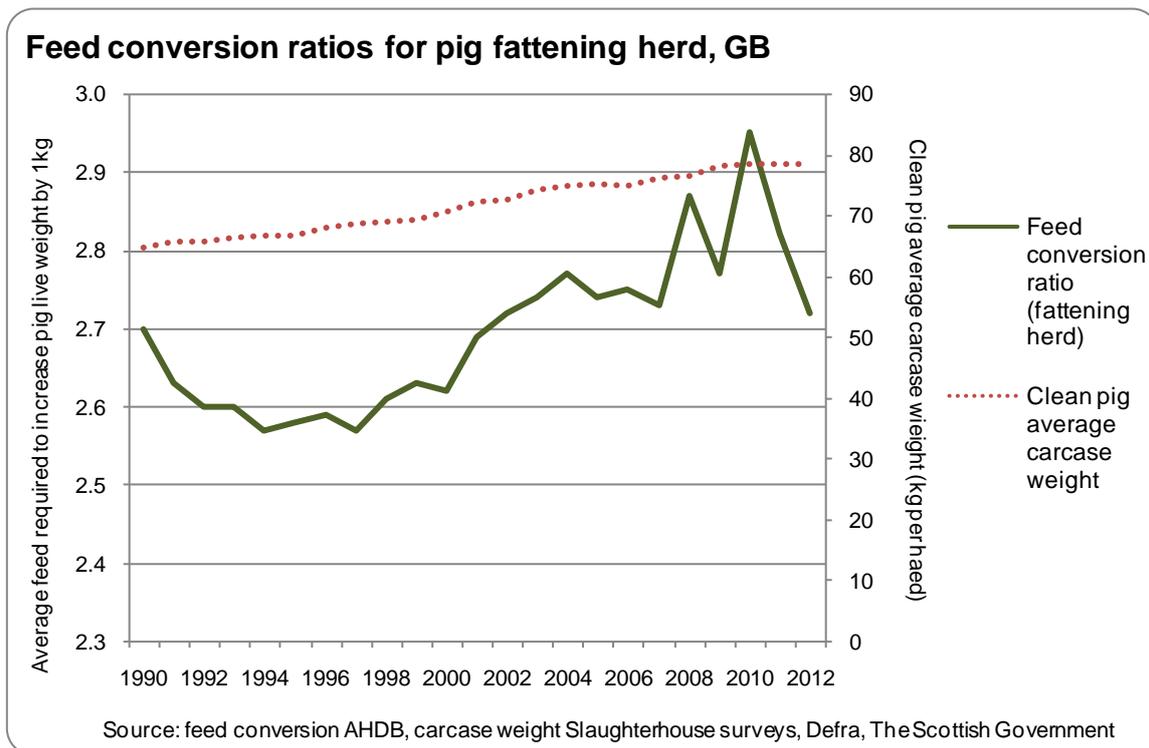
Trends

Average carcass weights have increased consistently since 1990. Increases in daily live weight gain were seen in both the rearing and finishing herd during 2009. Since then levels have remained relatively stable.

Feed conversion ratio of the fattening herd

Rationale

More efficient use of feed has the potential to increase productivity and reduce greenhouse gas (GHG) intensity. The feed conversion ratio (FCR) is a measure of the amount of feed required to increase pig live weight by 1 kilogramme i.e. a lower FCR indicates greater feed efficiency. The FCR is used here as a proxy measure for the intensity of on-farm GHG emissions.



Trends

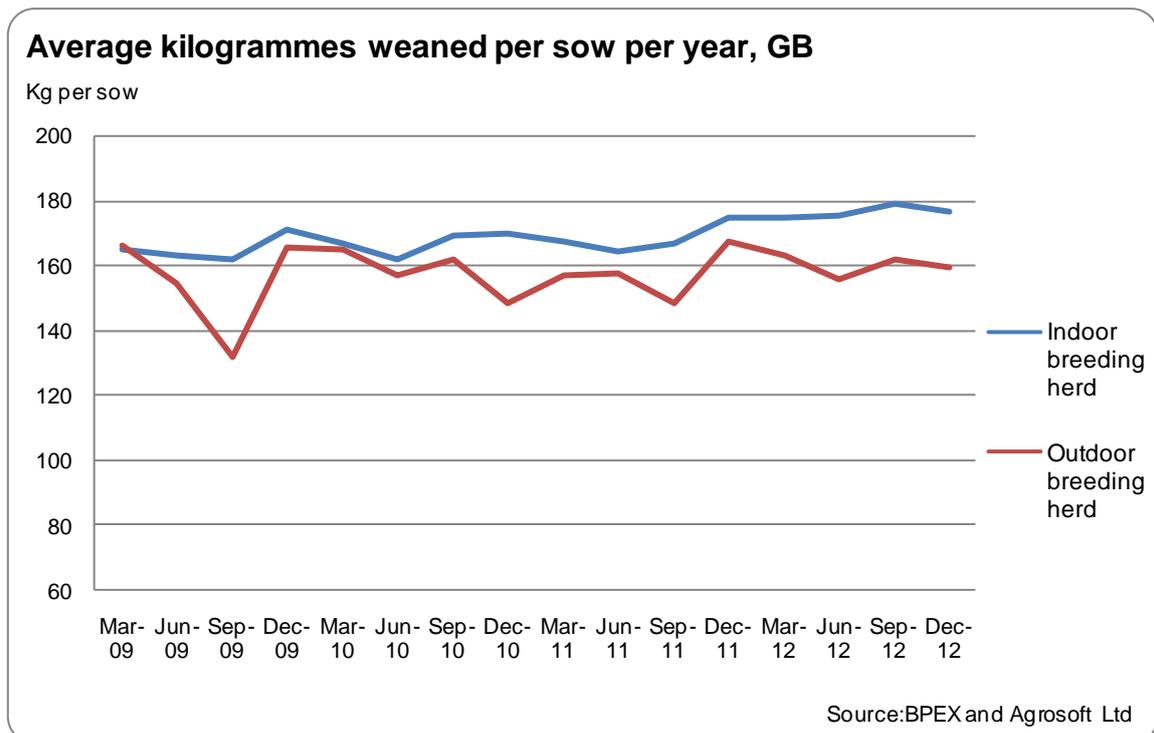
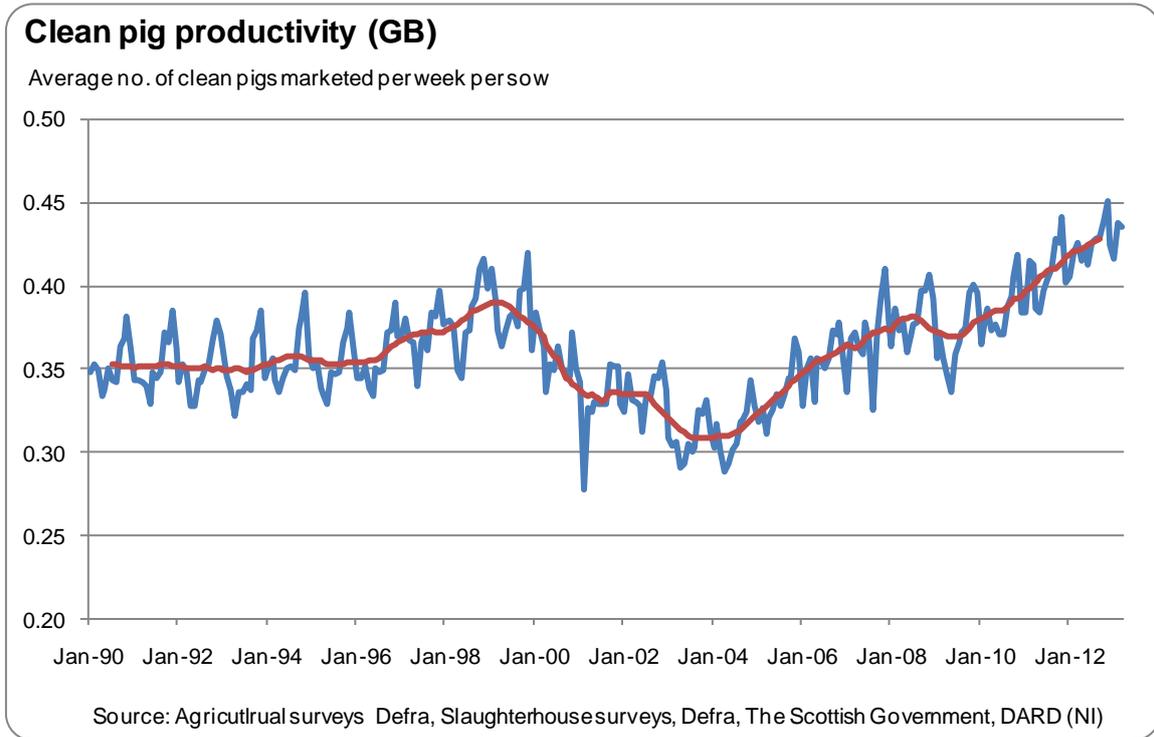
The feed conversion ratio for the pig fattening herd has increased since the mid-1990s indicating more feed has been required per unit increase in pig weight, albeit with some fluctuations. This suggests that the increase in carcass weights seen over the same period was achieved through more feed per kilogramme of meat produced implying a reduction in feed efficiency and increased emissions intensity. Several factors could explain this including achieving and maintaining heavier weights, changes in production systems and disease. Since 2010 there has been a reduction in the FCR (suggesting a possible improvement in feed efficiency and reduction in emissions intensity) and it is now at similar levels to those seen in the early 1990s. It is too early to say if this trend will be maintained.

2.7.2 Pigs: animal health and fertility

Pig productivity and fertility

Rationale

Comparing pig marketings with breeding herd populations allows an assessment of pig survival and productivity whilst considering changes in the weight of weaned piglets per sow allows an assessment of sow fertility; these factors can all have an influence on the GHG intensity of production.



Trends

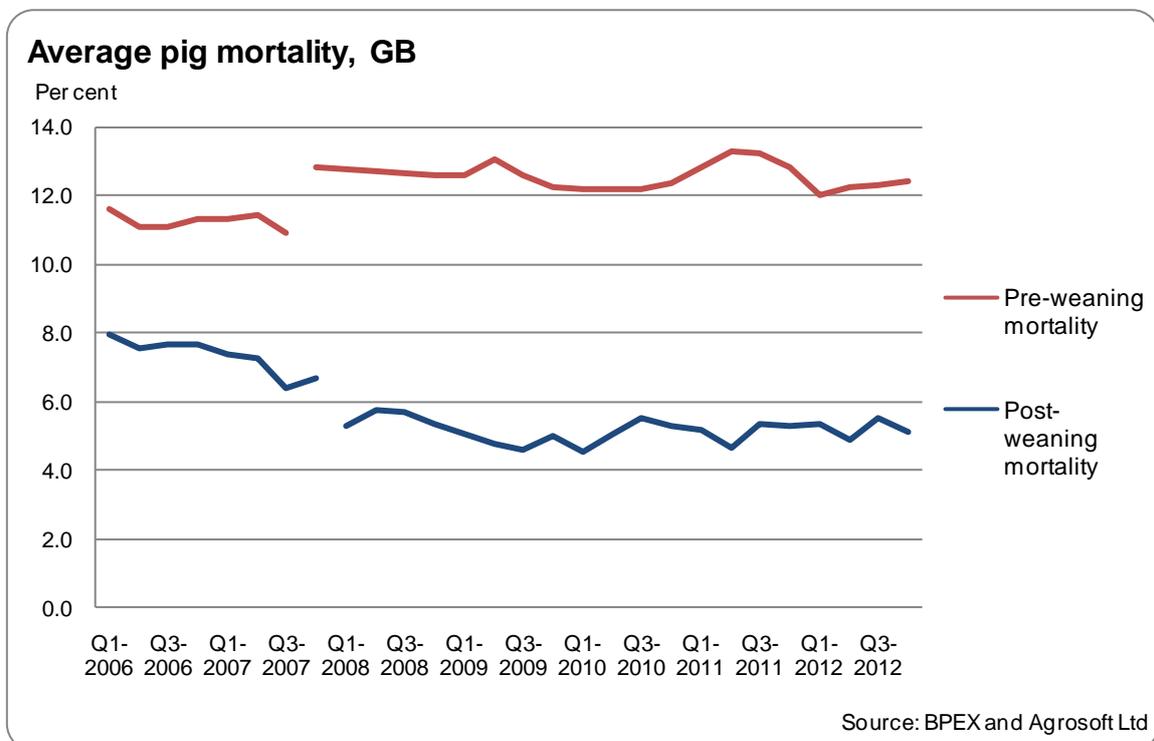
Clean pigs marketed per sow per week dip around 2003/04 but there has been a gradual upward trend since then and current levels exceed the previous high points of the late 1990s. Disease will have influenced this trend, for example swine flu in 2000 and Foot and Mouth Disease (FMD) in 2001 - both of which contributed to a decrease. Additionally, non-notifiable pig wasting diseases were prevalent from the late 1990s, though these are considered to have been brought under better control since 2004.

The increased proportion of sows which are kept outdoors may have offset some of the productivity gains seen in recent years and the second chart above illustrates the variation in kilograms weaned per sow per year in the outdoor breeding herd.

Mortality

Rationale

All things being equal, reductions in mortality will lead to fewer breeding animals required for food production.



Note, the break in the series indicates a change in methodology, including a change in the sample.

Trends

The data suggests that there appears to have been little change in pre weaning mortality over the last 5 years. The step change in the chart is associated with a change in the sample size which increased from Q4 2007 for breeding herd and from Q1 2008 for the rearing and feeding herd. It is possible that there have been some reductions in post-weaning mortality over the period, although changes to the sample at the end of 2007 mean it is difficult to interpret the overall trend. More recently there has been little change.

2.7.3 Pigs: housing and manure/slurry management

The type of manure application method, the housing system used (e.g. the type of manure/slurry management), whether pigs are kept outdoors and systems which relate to length of time to finish can all have an effect on the levels of GHG emissions, and for the latter, emission intensity.

Trends

The results of the FPS 2009 give some details on pig housing and can be found in Section 2.7 of the third edition of Agriculture and Climate Change at:

<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/agricultural-statistics-and-climate-change>

In terms of manure and slurry management the 2013 FPS surveyed 156 holdings with pigs. From this relatively small sample it is difficult to draw a precise conclusion; however, they do provide an approximate indication that:

- 52% (+/-9%) of pig holdings had storage facilities for solid manure on a solid base.
- 22% (+/-7%) could store slurry in a tank; of these a fifth were covered (20% +/-13%).
- 15% (+/- 5%) could store slurry in a lagoon and 4% (+/-3%) store slurry in another type of store. There is insufficient evidence to draw conclusions on the proportions with covers.

For details on manure/slurry application see [Section 2.9.2](#)

2.7.4 Pigs: economic position

Table 6: Gross margins for breeding sows (£/head), England

	2009/10	2010/11	2011/12
Average herd size	143	118	133
Finished livestock sales	2,269	2,279	2,062
Store sales	110	73	139
Miscellaneous revenue	0.5	2	1
Less herd depreciation	11	36	13
Enterprise output	2,368	2,318	2,189
Variable costs			
Concentrates	1,221	1,386	1,402
Vet and medicine costs	69	69	59
Other livestock costs	141	153	138
Heating	3	1	2
Total variable costs	1,434	1,609	1,602
Gross margin/sow	934	709	587

Source: Farm Business Survey

Table 6 provides a comparison of gross margins for breeding sows from the Farm Business Survey. Figures are in £ per head and have not been adjusted to reflect price changes due to inflation

Gross margins per sow have reduced considerably over the last three years from £934 in 2009/10 to £587 in 2011/12. This has been due to increased expenditure on feed (concentrates) and reductions in the returns for finished pigs.

2.7.5 Pigs: summary

Carcase weights have increased consistently since 1990. However, in the long term, data on feed conversion ratios suggests that this increase has been achieved by proportionally more feed which may have increased emissions intensity. The last 2 years have seen an improvement in the FCR which is now at similar levels to those in the early 1990s, although it is too early to say if this trend will be maintained. Sow fertility and post weaning mortality have shown improvements over the last 5 years, both of which may have reduced the intensity of emissions. Pre weaning mortality remains high, and is little changed since 2006, the earliest point for which data are available.

2.7.6 Pigs: further developments

Current statistics provide a partial picture of the relevant drivers of GHG emissions. The following are the most relevant pieces of information which are currently not included. Not all of them can feasibly be populated with robust data in the short term.

- More productivity measures such as: rearing feed conversion ratio; average live weight; feed consumed per sow. This would be about providing more detailed information than is currently provided in this section. Some data are available although currently for relatively short timescales. As more data are collected these will be included.

2.7.7 Pigs: notes on data collection methodology and uncertainty

Meat production

- i) Carcase weights given here are from the Defra Slaughter house surveys. These surveys cover all the major slaughter houses, and are subject to small sampling errors. Links to the survey methodology are given in the [Appendix](#).

Farm Business Survey

- ii) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

BPEX data

- iii) BPEX data are taken from publicly available datasets published on their website. These are not official government statistics. The data are collected by Agrosoft Ltd from customers submitting regular database backup files. Agrosoft Ltd verifies all data before delivery / publication.

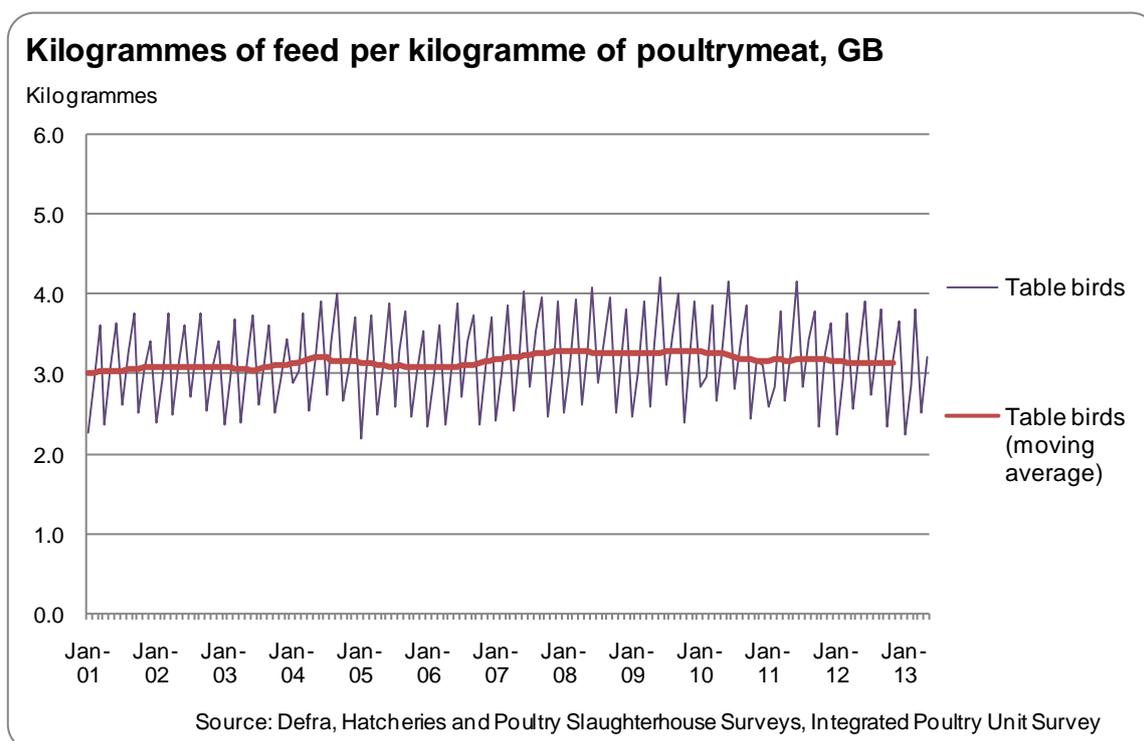
2.8 Poultry

2.8.1 Poultry: efficiency of output

Feed conversion ratio³⁶

Rationale

More efficient use of feed has the potential to increase productivity and reduce greenhouse gas (GHG) intensity. The feed conversion ratio (FCR) is a measure of the amount of feed required (in kilogrammes) to produce 1 kilogramme of poultrymeat (dressed carcass weight). The quantity of poultry feed produced per kilogramme of poultrymeat produced is used here as a proxy measure for the intensity of on-farm GHG emissions.



Trends

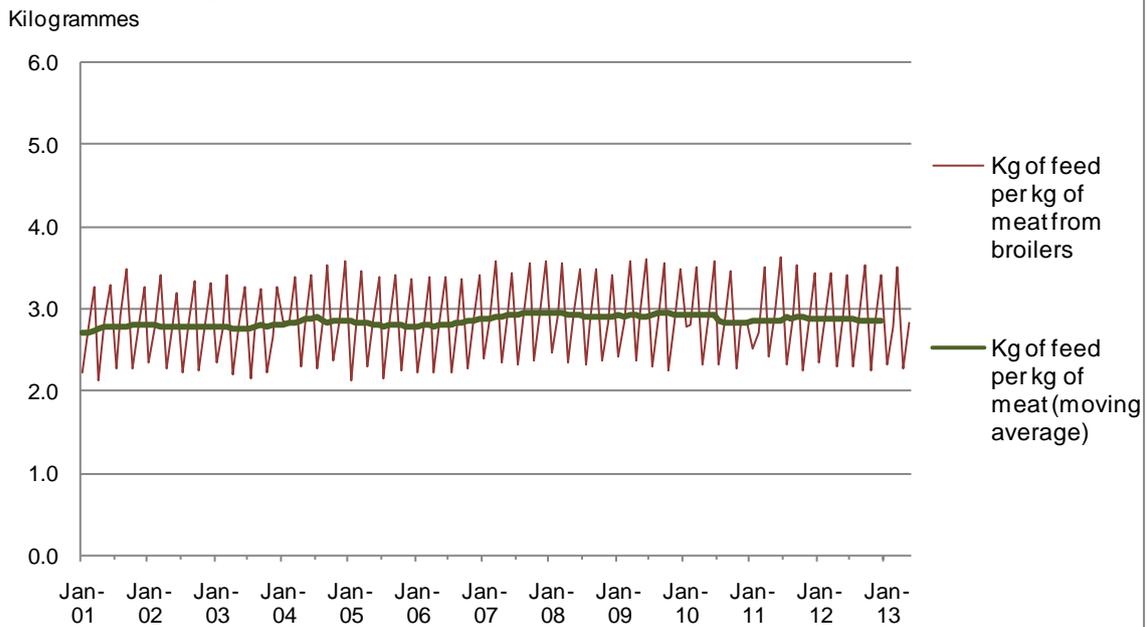
The chart above shows that the overall moving average trend is relatively stable; a slight upward trend since 2007 has been largely reversed between 2010 and 2012, although the change is well within the year on year variation.

Considering all table birds provides an overall measure of feed efficiency. Within this there are differences between production systems and species. The following charts are presented to illustrate this and show FCRs for broilers (chickens bred and raised specifically for meat production) and turkeys. Data are not readily available to determine FCRs for differing production systems.

The average FCR for broilers is consistently lower than for all poultrymeat, but follows a similar trend. Within this, there will be variations between different rearing systems, such as indoor rearing and organic production. In addition, a significant proportion of birds are reared to an older age (and have a higher resulting FCR) as a deliberate marketing choice.

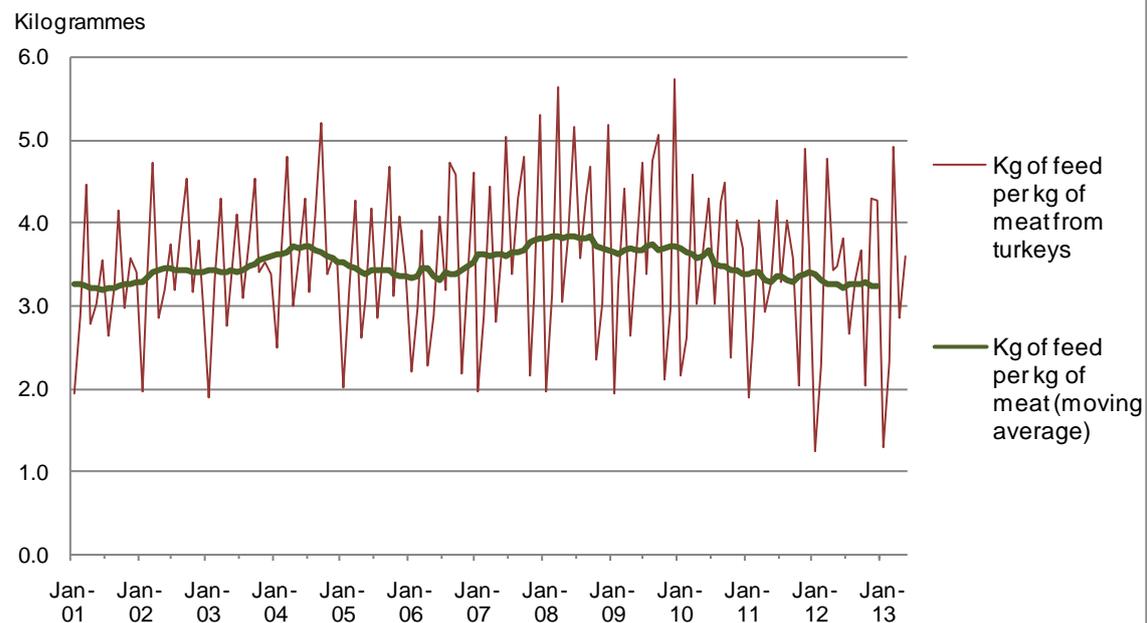
³⁶ For data availability reasons the feed conversion ratio (FCR) shown is kilogrammes of feed per kilogrammes of meat based on carcass weights. The FCR is more usually expressed in relation to live weight. Carcass weight is approximately 75% of the live weight which would give a lower ratio feed per kilogrammes of meat produced.

Broilers: kilogrammes of feed per kilogramme of meat, GB



Source: Defra, Hatcheries and Poultry Slaughterhouse Surveys, Integrated Poultry Unit Survey

Turkeys: kilogrammes of feed per kilogramme of meat, GB



Source: Defra, Hatcheries and Poultry Slaughterhouse Surveys, Integrated Poultry Unit Survey

The average turkey FCR is higher than that for chickens. The trend has fluctuated over the period, but has generally declined over the last 4 years, suggesting increased feed efficiency and a reduction in emissions intensity.

2.8.2 Poultry: housing and manure management

Housing systems and type of manure management, for example use of in-house litter drying and incorporation time of manure, can have an effect on the levels of emissions. Whilst some data were

collected as part of the 2009 Farm Practices Survey the implementation of the EU-wide ban on the keeping of hens in conventional cages at the beginning of 2012 means that this may no longer be reflective of the current situation.

2.8.3 Poultry: summary

Defra has limited information from national level datasets for the poultry sector. From information which is available the underlying trend in feed conversion for 'table birds' increased marginally from 2001 but has shown a slight downward trend in recent years suggesting the GHG intensity of production has reduced. Similar trends can be seen in the FCR of broilers and turkeys.

2.8.4 Poultry: further developments

Limited information is currently provided on the poultry sector. The main factors proposed for the inventory development relate to information on housing type and system. The feasibility of providing robust data in the short term is not clear at present.

2.8.5 Poultry: notes on data collection methodology and uncertainty

Meat production and feed production

- i) Meat production is derived from Defra's survey of poultry slaughterhouses and registered hatcheries in England and Wales and similar surveys run by The Rural & Environment Research and Analysis Directorate for Scotland. Links to the survey methodologies are given in the [Appendix](#).
- ii) Data on feed production are from the survey returns of all of the major GB animal feed companies. The survey records data on raw material use, stocks and production of the various categories of compound animal feed. The major producers typically cover 90% of total animal feed production surveyed each month. The remaining smaller companies are sampled annually in December for their figures in the preceding 12 months. Sampling errors of the production estimates are small. Links to the survey methodology are given in the [Appendix](#)
- iii) Feed data are sourced from Defra's Integrated Poultry Units Survey. This survey covers all of the major GB poultry feed manufacturers of integrated poultry units. The accuracy of the results is very high as they are based on a census carried out across all companies. Links to the survey methodology are given in the [Appendix](#).

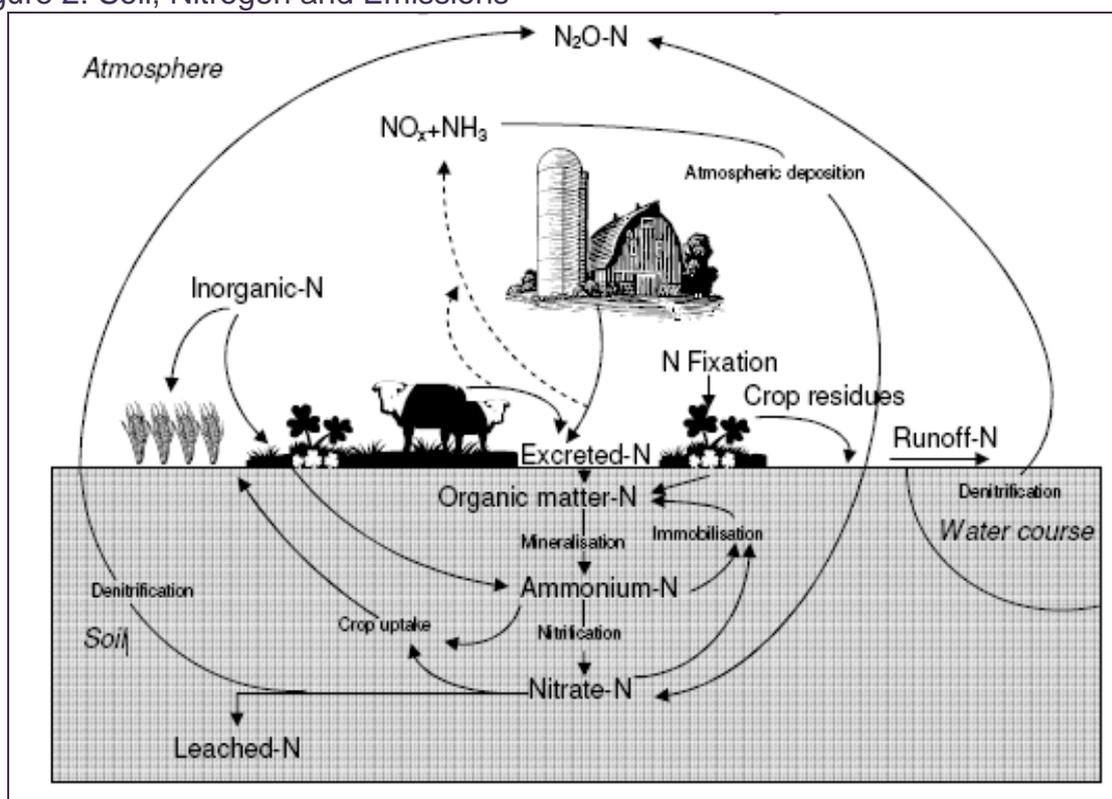
2.9 Land and Nutrient Use

Background information

Inputs of manufactured or livestock derived nitrogen fertilisers are critical to maintain yields of food and fodder crops³⁷, but the yield benefits of nitrogen application come at the expense of polluting losses to air and water and emissions of greenhouse gasses (GHG). Losses can be minimised by reducing the surplus in soils or reducing the risk of this surplus being lost to the environment by implementing best practice management techniques and on-farm efficiency measures. This section covers the outcomes associated with the uptake of these practices through GHG intensity measures. Section 3 presents information about the uptake of specific on-farm management practices and efficiency measures.

GHG emissions from nitrogen fertilisers principally arise directly from the soil as microbes transform fertilisers in the nitrification and denitrification processes (see Figure 2). Some losses can occur within the first few days of application. However, significant losses also occur indirectly after nitrogen has leached from soils into water courses, or after gaseous loss as ammonia followed by deposition to soils. In both cases, there are potentially detrimental impacts on biodiversity and human health.

Figure 2: Soil, Nitrogen and Emissions



A number of factors influence the level of GHG emissions resulting from nitrogen applications. These include land use, the soil nitrogen content before application, the organic carbon content of the soil, the soil moisture content and compaction of the soil (the latter two are associated with reduced soil aeration).

³⁷ <http://www.bis.gov.uk/assets/foresight/docs/food-and-farming/science/11-573-sr31-fertiliser-availability-in-resource-limited-world.pdf>

Background information

Within this publication we focus on GHG intensity, though this could result in pollution swapping (for example, from nitrous oxide to water quality). A reduction in absolute levels of nitrogen would provide multiple environmental benefits.

2.9.1 Land and nutrient use: efficiency of output

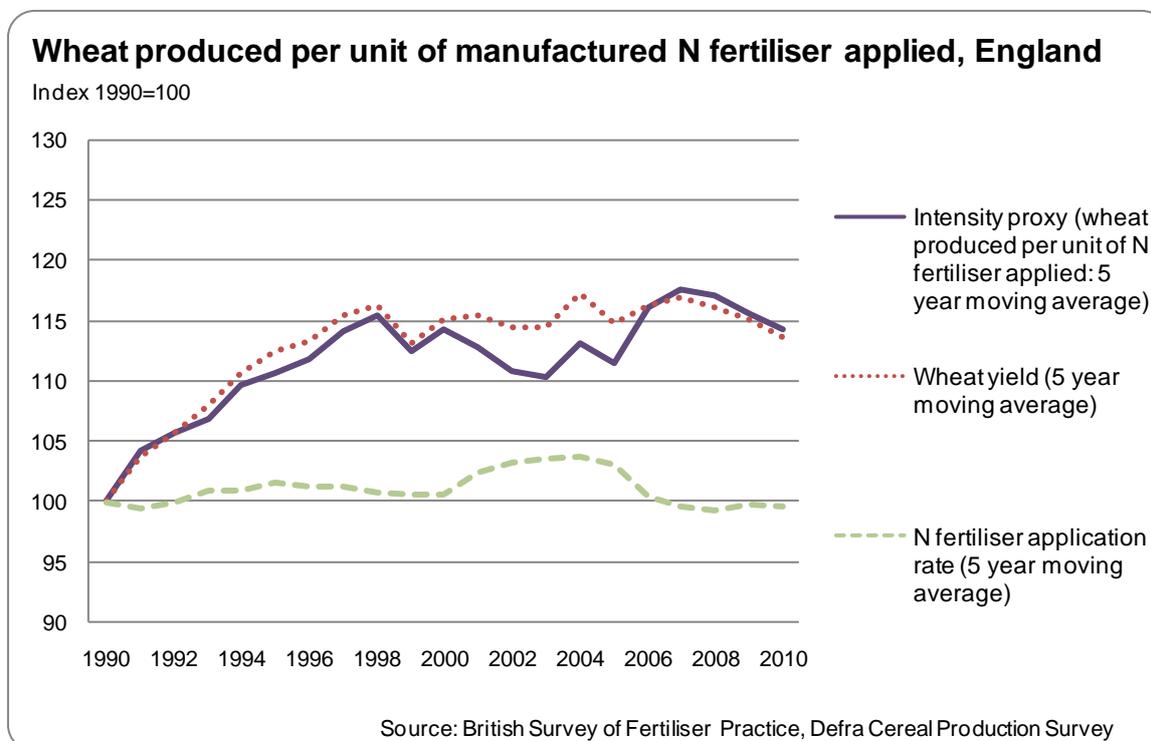
Long term measure of change: Crop production per unit of manufactured N applied³⁸

Rationale

Trends in crop yields provide a headline measure of productivity; more efficient use of nitrogen fertiliser has the potential to increase productivity and reduce the environmental risk. The ratio of the weight of crops produced to the weight of manufactured nitrogen fertiliser applied provides a proxy measure for the intensity of greenhouse gas (GHG) emissions. This section does not cover slurries and manures which are considered in [2.9.2 Land and nutrient use: application of organic nitrogen](#).

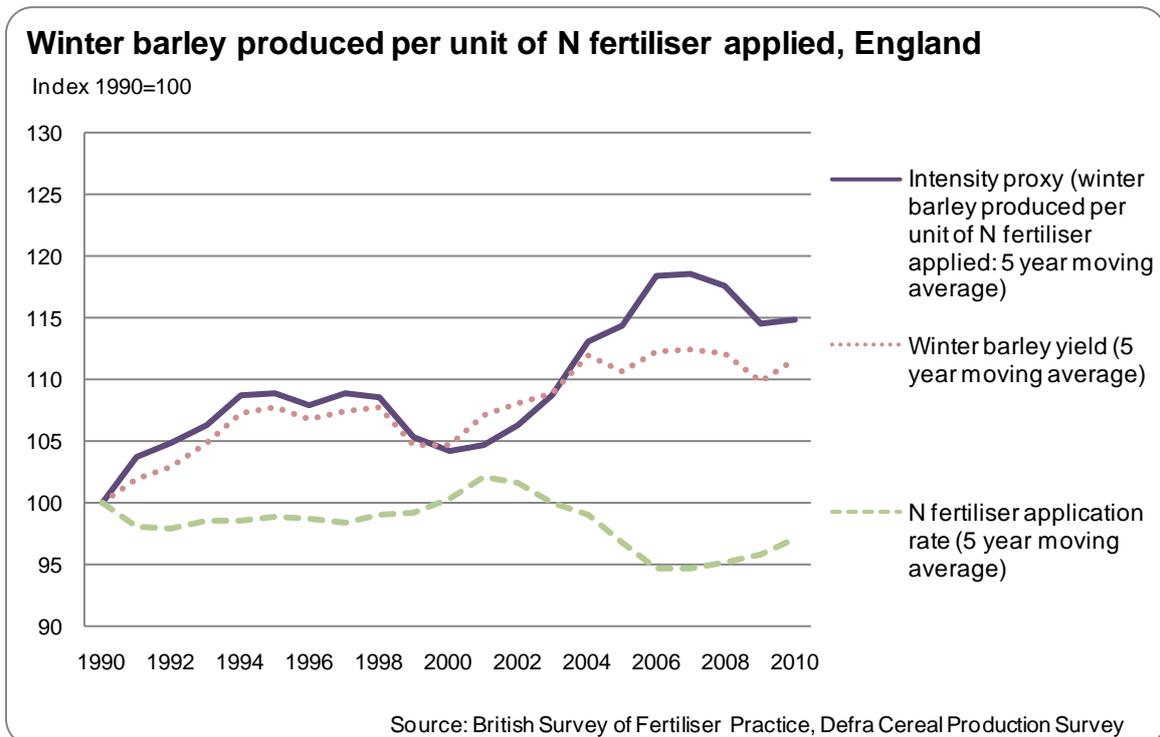
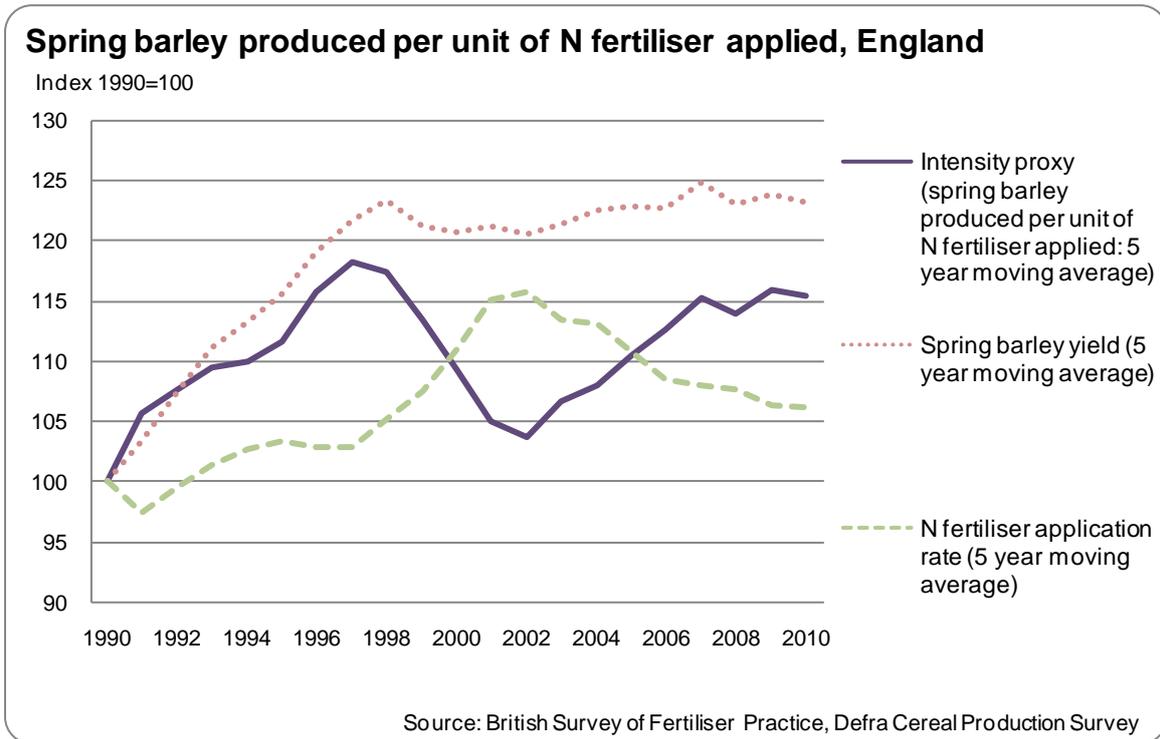
Random factors in crop production (such as the weather) also impact on yields. This measure is, therefore, more suitable for monitoring change over the longer term (5 to 10 years). The measures referred to here are 5 year centred moving average trends which smooth the random year on year variation present in the time series. The latest year for which figures are available using this method is 2010. Any later estimates of the trend are less certain, since for year on year changes, the random component in the data series is more significant than the trend component.

Application rates of nitrogen based fertiliser per hectare provide an indication of short term changes (year on year).



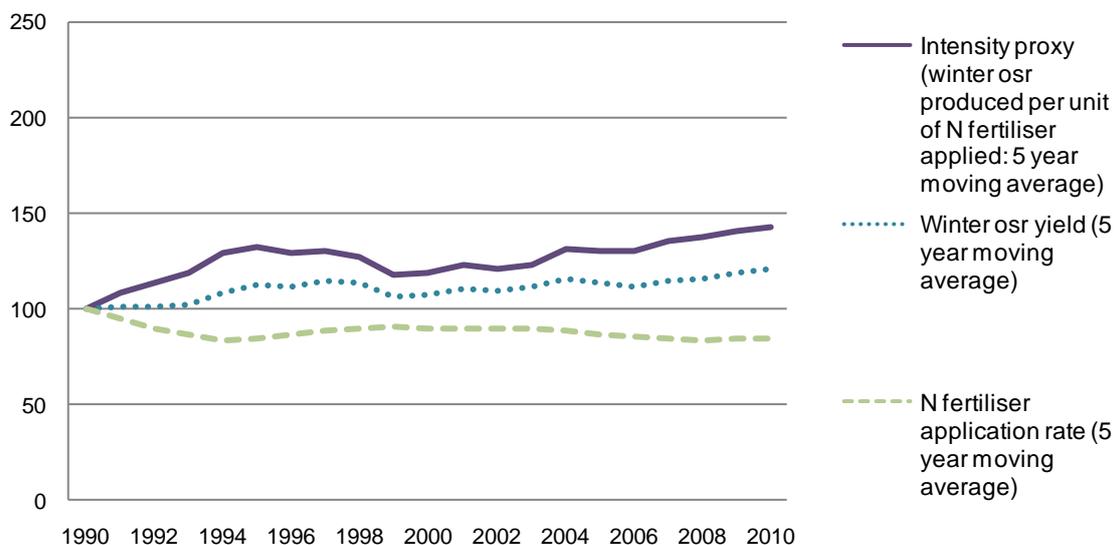
³⁸ This measure does not include organic nitrogen from manure or slurry.

For an illustration of the magnitude of the trend and irregular components of the time series for wheat please see (iv) in the [Appendix](#).



Winter oilseed rape produced per unit of N fertiliser applied, England

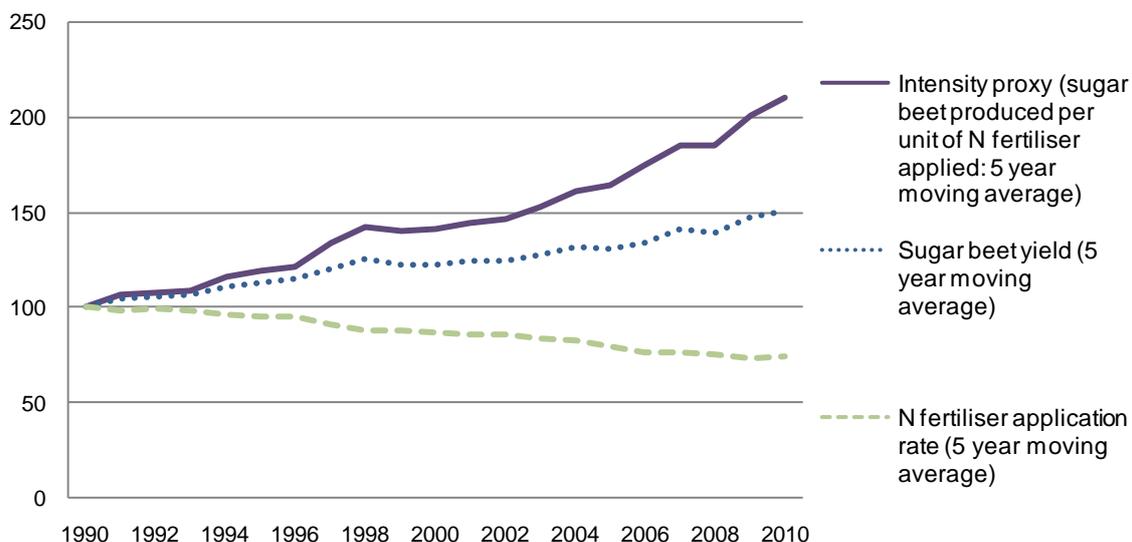
Index 1990=100



Source: British Survey of Fertiliser Practice, Defra Oilseed rape Production Survey

Sugar beet produced per unit of N fertiliser applied, England

Index 1990=100



Source: British Survey of Fertiliser Practice, Defra Agriculture in the UK

Trends

Long term measure of change: since 1990 there has been an increase in the quantity of wheat produced per unit of manufactured nitrogen applied. Much of the increase took place during the 1990s as wheat yields increased whilst application rates remained relatively constant.

The trend in wheat yields has remained relatively stable since 2000 with changes in the intensity measure driven by overall application rates (increasing application rates between 2000 and 2005;

reducing thereafter). This suggests that since 1990, the overall GHG intensity of wheat production has reduced. However, more recently a reduction in the yield trend (particularly due to weather conditions in 2012) has led to a reduction in the intensity measure.

The trends for the intensity measures for winter and spring barley are similar to those for wheat. Over the last 10 years the intensity measure for winter oilseed rape has seen a slight upward trend, whilst that for sugar beet has been consistently upward since 1990. Historically bonuses were offered by British sugar for low amino-nitrogen levels, which may have influenced this trend. More recently, the sugar industry in England has undergone considerable restructuring following reform of the EU sugar regime in 2006. The closure of factories in York and Allscott led to a concentration of production in Eastern England and a more recent “outgoers” scheme (announced in 2010³⁹) aimed to redistribute contract tonnage from low yielding producers (particularly those furthest from factories) to those achieving higher average yields.

Latest position

There is variability in production from year to year due to weather, disease and pest pressure affecting yields. Early indications for 2013 show a degree of uncertainty for final crop areas due to poor drilling conditions in autumn 2012, over winter crop failures, slow crop growth and late spring drilling. There has been an increase in spring sown crops, especially barley, as a replacement for failed winter sown crops and these have generally established well. There is expected to be a significant reduction in the total wheat area of around 19%. Winter barley and winter oilseed rape areas are also expected to be reduced by around 17% and 25% respectively compared to 2012 but in the case of barley this will be offset by a significant increase in spring plantings. Despite greater spring plantings an increase in fallow land is expected this year, mainly due to crop failure. Yields for all crops will be dependent on the weather leading up to harvest but estimates are currently (July 2013) at the lower end of the 5 year average. Low plant populations and bare patches will affect overall yield potential particularly for oilseed rape.

Short term measure of change: manufactured nitrogen application per hectare

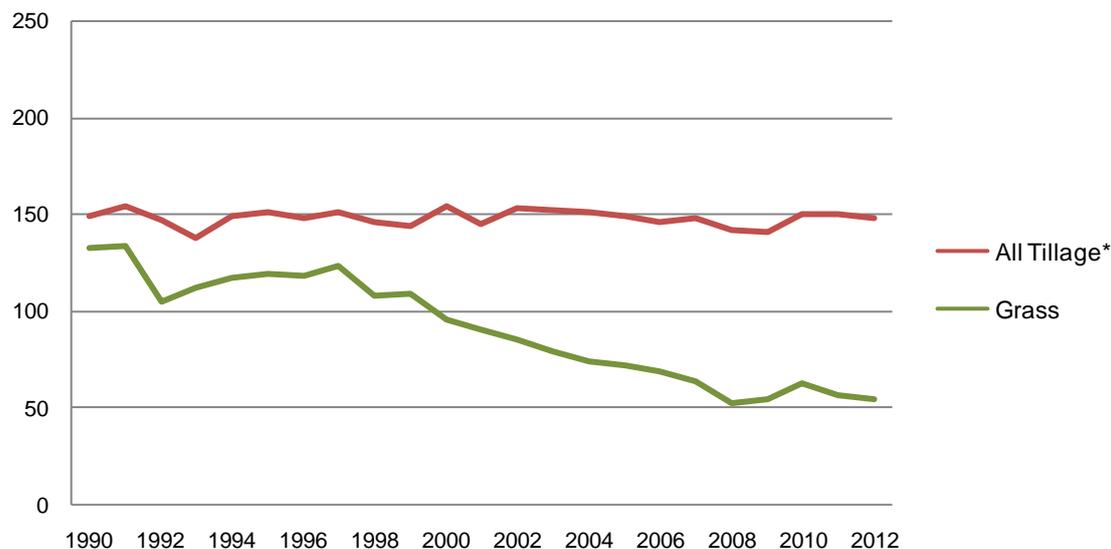
Rationale

Trends in average application rates provide a short term indication of (GHG) intensity (since they are less affected by random factors which impact on yields).

³⁹ http://www.britishsugar.co.uk/Media/2010/new_beet_deal.aspx

Average nitrogen fertiliser application rates, England and Wales

Application rate = kg/ha

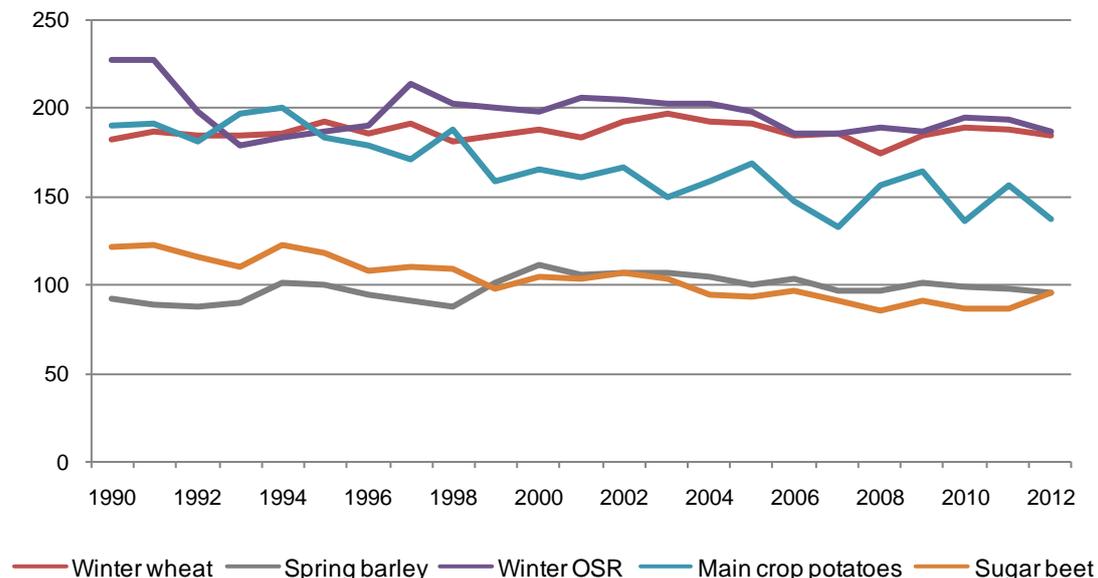


*All tillage includes crops but not bare fallow, set-aside or grassland

Source: British Survey of Fertiliser Practice

Average nitrogen fertiliser application rates, England and Wales

Application rate = kg/ha



Source: British Survey of Fertiliser Practice

Trends

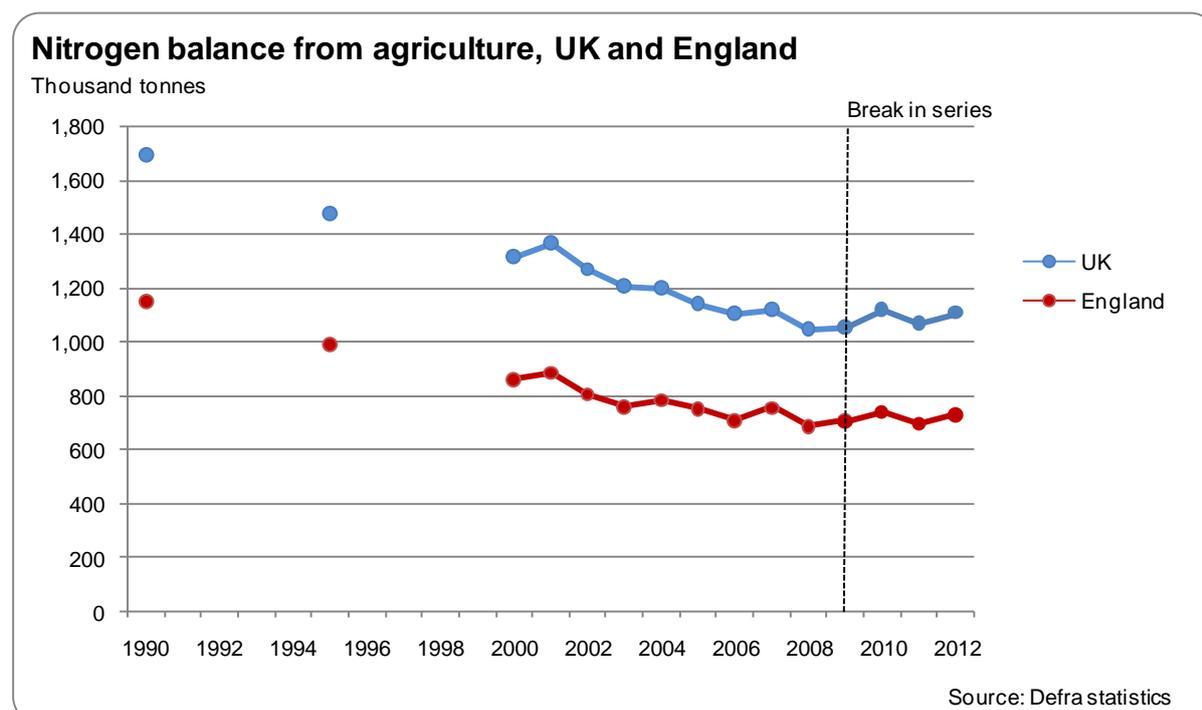
Short term measure of change: the overall application rate for manufactured nitrogen fertilisers has fallen substantially over the last 20 years. Whilst arable application rates have remained relatively stable, grassland application rates have reduced; explaining the majority of the fall in recorded nitrous oxide emissions. As shown in the previous section, cereal yields have increased over this period, leading to more cereals being produced for roughly the same amount of manufactured nitrogen applied.

Soil nitrogen balance

The soil nitrogen balance provides a measure of the total loading of nitrogen on agricultural soils each year.

Rationale

The overall balance of nitrogen⁴⁰ provides a high level indicator of potential environmental pressure allowing comparisons over time and between countries. All other things being equal, more efficient use of manufactured and organic nitrogen fertilisers will be illustrated through a declining nitrogen balance which will in turn lead to a reduced risk of nitrous oxide emissions and other environmental pressures.



Note: from 2010 in England, June Survey data for land and animals are collected only for commercial farms⁴¹ resulting in a break in series.

Trends

The estimates of nitrogen balances show an overall decline over the last 20 years. This will be associated with a lower risk of all forms of nitrogen loss to the environment.

Provisional estimates for 2012⁴² suggest that the nitrogen balance for England was a surplus of 731 thousand tonnes. Although this is an increase of 31 thousand tonnes (4%) compared to 2011, it is 11 thousand tonnes (1%) lower than in 2010 and a reduction of 133 thousand tonnes compared to 2000. The increase between 2011 and 2012 has been driven by reduced offtake from harvested cereals and fodder following the poor weather in 2012. This has more than offset the reduction in inputs from manufactured nitrogen fertilisers.

⁴⁰ The nitrogen balance is the difference between nitrogen inputs (including manufactured and organic fertilisers), and off-takes (via crop/livestock production and fodder for livestock, including grass).

⁴¹ See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182206/defra-stats-foodfarm-landuselivestock-june-junemethodology-20120126.pdf for information on the thresholds applied.

⁴² The latest estimates for UK soil nutrient balances can be found under "Soils" at: <https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/agri-environment-analysis>

2.9.2 Land and nutrient use: application of organic nitrogen

This section has largely focused on the application of manufactured nitrogen. Organic manures are also an important source of nitrogen but data on the volume of manures applied are sparse. Historically, the British Survey of Fertiliser Practice (BSFP) has focussed on the application of manufactured fertilisers although in recent years it has also collected information on the use and movement of organic manures. However, it should be remembered that the underlying sample design is constructed to measure manufactured fertiliser usage and may not represent the population of farmers using organic manures as robustly.

Organic manures applied to agricultural land may be produced on farm by livestock as slurries, farmyard manure (FYM) and poultry manures or imported from other sources such as treated sewage sludges (also called bio-solids) and some industrial ‘wastes’ such as paper waste or brewery effluent. Of the 1,409 farms in the 2012 BSFP around 70% (948) used organic manures on at least one field on the farm. Table 7 shows the percentage of farms using each type of manure in Great Britain between 2006 and 2012.

Table 7: Percentage (%) of farms using each type of manure, GB 2006 to 2012

	None	Cattle FYM	Cattle slurry	Pig FYM	Pig slurry	Layer manure	Broiler/turkey litter	Other FYM	Other
2006	30	59	19	2	1	2	2	3	3
2007	33	56	20	1	1	2	2	2	3
2008	31	55	18	3	1	2	3	5	4
2009	32	53	17	2	1	2	2	3	4
2010	33	53	17	2	1	2	2	4	4
2011	32	53	17	2	1	2	2	5	5
2012	36	48	19	2	1	2	2	4	5

Source: British Survey of Fertiliser Practice

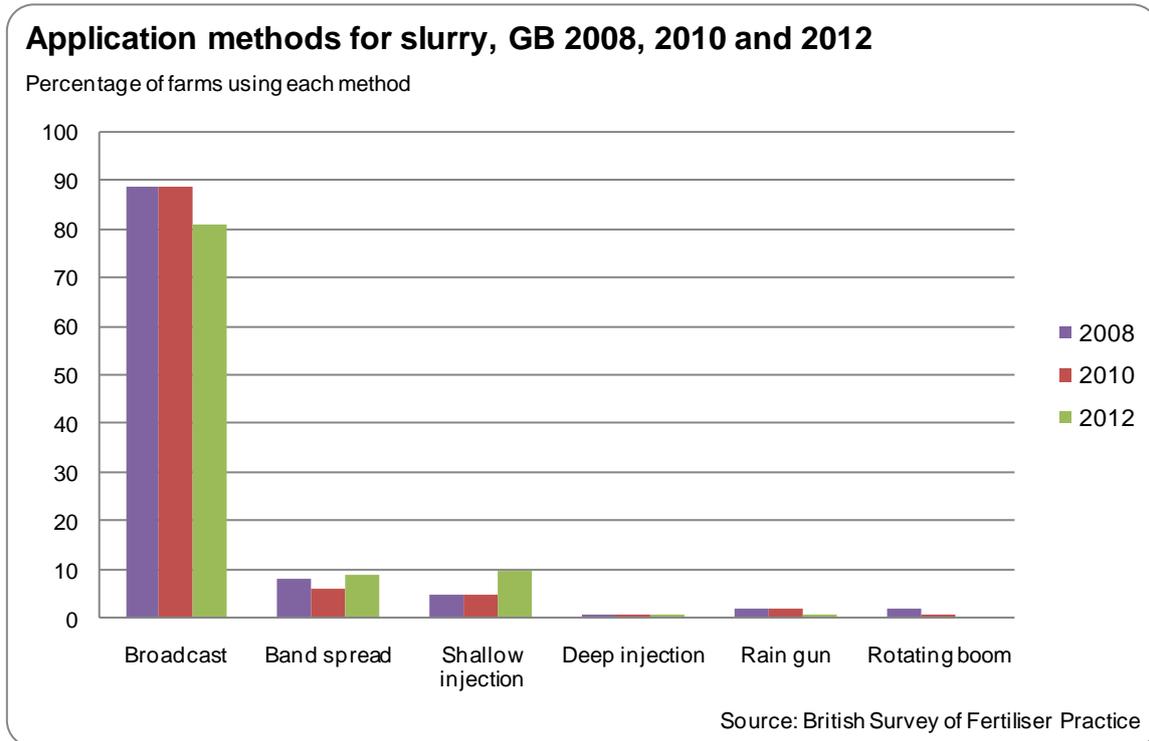
Cattle manure from beef and dairy farms is by far the largest volume of manure type generated in Great Britain. The percentage of farms using cattle FYM has declined by 11% since 2006, whereas the use of cattle slurry has remained more consistent over the period and was used on 19% of farms in 2012. Not all of the manure generated by a farm is necessarily retained for use by that farm and excess manure/slurry can be exported for use elsewhere. The BSFP indicates that about 2% of farmers export manure.

Methods of slurry application can have a bearing on GHG emissions; slurries can have high direct GHG emissions since the majority of the nitrogen content is in available forms. This high available nitrogen content can also make them prone to indirect emissions from ammonia losses. Certain methods of application, such as injection or use of a trailing shoe can help mitigate these losses. Both slurry injection and band spreading application techniques are also good mitigation methods for ammonia (which is associated with secondary GHG emissions).

Application methods for slurry

The following chart compares the percentage of farms using each type of slurry application method in Great Britain in 2008, 2010 and 2012. The data serve as a guide only. They do not account for the area of each farm receiving slurry (or any variation in the rate at which slurry may have been applied

using different application methods). Notwithstanding these considerations, it is clear that broadcast application is by far the most widespread method adopted.



Application of slurries to land in the autumn and winter months can be less effective (as there is little or no crop uptake) and may be associated with leaching losses. These indirect emissions from slurry can potentially be high unless careful storage and application management is in place. Table 8 shows the timing of applications of different organic manure types for 2012 (as a proportion of fields receiving applications of each manure). The crops have been classified as either “winter sown”, “spring sown” or “grass”. This segmentation highlights the prevalence of applications in August and September for winter sown crops (prior to drilling), whereas spring sown and grass fields are predominantly treated between November and April.

Table 8: Percentage (%) of fields receiving each organic manure type by sowing season and timing, GB 2012

	Cattle FYM	Cattle slurry	Pig FYM	Pig slurry	Layer manure	Broiler/turkey litter	Other FYM	Other farm manure	Bio-solids	Other non-farm
Winter sown										
August	3	0	11	5	23	20	3	0	30	20
September	8	1	26	3	31	33	7	0	33	34
October	2	0	0	2	4	4	0	0	6	5
Winter (Nov-Jan)	0	0	0	0	0	0	0	0	0	0
Spring (Feb-Apr)	0	0	0	40	7	4	0	0	0	0
Summer (May - Jul)	1	0	0	0	1	0	0	0	1	0
Spring sown										
August	0	0	0	0	0	1	0	0	0	0
September	0	0	17	0	0	0	0	0	0	0
October	1	0	3	0	0	0	0	0	1	0
Winter (Nov-Jan)	2	1	3	0	0	0	1	0	9	6
Spring (Feb-Apr)	13	4	35	7	11	31	9	0	9	11
Summer (May - Jul)	1	1	1	3	3	0	0	0	2	2
Grass										
August	5	2	0	0	1	0	26	10	1	0
September	5	2	0	0	0	0	3	2	0	0
October	5	3	0	0	3	0	6	10	0	0
Winter (Nov-Jan)	10	13	0	0	0	0	10	1	1	4
Spring (Feb-Apr)	32	48	3	29	16	6	31	41	1	10
Summer (May - Jul)	11	24	0	10	1	0	4	37	8	6

Source: British Survey of Fertiliser Practice

Organic manures are valuable sources of the major plant nutrients, including nitrogen, and their use can lead to a reduction in applications of manufactured fertiliser. The BSFP does not ask farmers directly whether they make adjustments to fertiliser inputs as a result of using manure. However, an indication of possible adjustments has been derived by comparing fields that received manure with those that did not (Table 9⁴³). Organic fields, which use no mineral fertilisers, have been excluded from these comparisons since they would distort the influence of manures on mineral application rates. The trend for reduced manufactured nitrogen rates on fields also receiving manure is evident across all major tillage crops throughout the period, with the exception of potatoes in 2010.

⁴³ For tillage crops, the overall fertiliser rate means that some fields are included which have received no fertilisers. For the "with manure" data, it may indicate that the manure was judged to supply all the fertiliser which was required.

Table 9: Overall application rates (kg/ha) of manufactured fertiliser to tillage crops with and without applications of organic manure, GB 2008 - 2012

		2008	2009	2010	2011	2012
Winter wheat	with manure	161	180	187	179	170
	without manure	183	192	197	198	190
Spring barley	with manure	88	89	91	97	95
	without manure	101	107	108	107	105
Winter barley	with manure	122	138	138	137	140
	without manure	137	142	146	144	145
Potatoes (maincrop)	with manure	154	155	139	146	133
	without manure	156	185	138	178	136
Sugar beet	with manure	80	88	87	81	89
	without manure	89	101	96	99	99
Winter oilseed rape	with manure	159	176	175	174	166
	without manure	197	191	204	203	191

Source: British Survey of Fertiliser Practice

2.9.3 Land and nutrient use: impact of farm performance

Table 10 below provides a comparison of winter wheat gross margins per hectare for 2010/11 and 2011/12 for low and high economically performing farms.

Table 10: Gross margins per hectare of winter wheat, England

	2010/11			2011/12		
	Low (bottom 25%)	High (top 25%)	All	Low (bottom 25%)	High (top 25%)	All
Average crop area (ha)	14	167	68	15	160	66
Average yield (tonnes/ha)	7	9	8	7	9	8
Average price/tonne (£)	154	157	158	163	162	163
Crops sales	1,008	1,317	1,262	1,032	1,371	1,303
Straw	85	42	53	66	47	57
Total crops output	1,093	1,359	1,315	1,097	1,419	1,359
Variable costs						
Seed	59	52	54	65	58	60
Fertiliser	146	159	158	189	183	183
Crop protection	136	160	156	151	159	157
Other crop costs	33	29	31	32	37	37
Total variable costs	375	399	399	437	437	436
Gross Margin	718	960	916	660	982	923

Source: Farm Business Survey

High economically performing farms have, on average, at least ten times the area of wheat than low performing farms and achieve greater yields driving the better levels of achieved output. In 2010/11, input costs per hectare were lower on low performing farms; mainly due to lower expenditure on crop

protection and fertilisers. Increases in seed, fertiliser and crop protection costs narrowed this gap in 2011/12 with low and high performing farms having similar levels of variable costs.

2.9.4 Land and nutrient use: soil carbon

Soil carbon

The extent to which soil carbon sequestration can offset agricultural emissions in the UK is uncertain at present but the best available science indicates that potential in the UK is limited. It is known that soils can accumulate carbon as a result of some land use changes, for example through conversion of arable land to permanent grassland, or under appropriate management conditions, for example through increasing applications of organic materials (e.g. compost or other organic materials diverted from landfill and not previously spread to land) to arable soils. Such changes are generally small, temporary and sensitive to management practice.

Short term increases in soil carbon stocks have been estimated in EU funded programmes over time periods of 3-5 years using high tech measurements of carbon dioxide (CO₂) above the soil surface. There are large uncertainties associated with the methods employed in such studies, and overall the estimated rates of soil carbon increase were not significantly different from zero i.e. the results could have been due to chance alone because of the high variability of the measurements. Longer term studies measuring soil carbon concentrations over multi-decadal time periods seem to indicate that after any change in management, soil carbon will change to reach a new equilibrium concentration. This means that soils cannot indefinitely continue to store carbon, but rather tend to accumulate carbon rapidly at first before stabilising in the long term. Such changes occur over the order of 20 to 100 years, and are rapidly reversed if management reverts to the original practice. This is particularly true of grassland to arable conversions, so grass leys in crop rotations appear to have limited potential to sequester carbon on a permanent basis.

In comparison to many EU soils (particularly those of southern Europe), the UK tends to have fairly high soil carbon concentrations and whilst there are uncertainties surrounding the data on trends of soil carbon in the UK (with countryside survey data indicating no significant changes whilst the National Soils Inventory indicates losses of soil carbon) there is little evidence to support the conclusion that soil carbon sequestration can significantly offset UK emissions. There is some evidence to suggest that UK arable soils may be losing soil carbon, both through the National Soils Inventory data and in observational studies. Other evidence suggests that arable soils may now be reaching or are at a new lower equilibrium level following previous losses due to drainage and historic land use change.

There may be some scope to identify management practices to increase soil carbon concentrations in arable systems under UK conditions, or at least reduce further losses. In many parts of the world, minimal or zero tillage systems seem to result in increases in soil carbon concentrations, but under typical UK soils and climatic conditions results have been far less promising. Research on minimum tillage in the UK (and other parts of the world) indicates a redistribution of soil carbon with depth rather than large absolute increases in soil carbon sequestration. Unfortunately, for the soil types predominant in the UK, compaction may be an issue under reduced tillage systems with consequent increases in nitrous oxide emissions. Given the relative strength of nitrous oxide as a greenhouse gas these enhanced emissions are likely to exceed any benefit of soil carbon sequestration.

Defra is continuing research in this area, with a project to better quantifying the emissions and removals of CO₂ resulting from land management.

2.9.5 Land and nutrient use: summary

The GHG intensity of cereal production has reduced significantly over the last 20 years through improved yields for similar amounts of nitrogen based fertiliser. Cattle manure is the predominant source of organic nitrogen across farms in Great Britain although the percentage of farms using cattle FYM has declined by 11% since 2006. The proportion of farms using cattle slurry has remained little changed over the same period. The 2012 BSFP indicated that broadcast application remained the most common method adopted for both pig and cattle slurries. This suggests that there could be scope to reduce emission intensity and indirect emissions if other methods of application were adopted.

2.9.6 Land and nutrient use: further developments

The following are all areas considered to be relevant to understanding emissions related to land and nutrients.

- **More information on the nutrient use for other crops including fodder crops, hay (and hay silage), maize (maize silage).** Detailed information is not readily available and it is unlikely that further information will be available in the short term.
- **More information on the impact of lime use.** Application of lime can adjust the pH of soils and when applied to agriculture land can help neutralise soil acidity. Whilst production of lime is associated with CO₂ emissions application can in some conditions be responsible for uptake of CO₂. Information on application rates of lime is collected by the BSFP although the implications of this may not be available in the short term.
- **Consider location and weather on the impact of emissions.** In general, higher emissions are associated with warm wet soils which contain a source of organic carbon. Heavy or compacted soils with poorer drainage characteristics are also likely to have higher emissions. There is a gradient in the UK of higher emissions in the west of the country and lower emissions in the east due to patterns of rainfall and dominant soil textures⁴⁴.

In terms of land use, grasslands are associated with higher emissions (as a percentage of nitrogen applied) than arable or horticultural land uses because they tend to be associated with imperfectly drained soils which are unsuited to arable cropping. Furthermore, the presence of livestock often results in compaction through trampling and hotspots of nitrogen deposition from faeces and urine. Potatoes, brassicas and sugar beet are associated with higher emissions (again as a percentage of nitrogen input) than cereals or oil seeds, potentially due to their relatively large residue inputs to soils. Cereal crops tend to have the lowest emissions, since modern varieties are adept at making use of the nitrogen applied⁴⁵. Tillage may also reduce GHG emissions from cereal crops as it tends to aerate the soil.

Data relevant to location, weather and land use will be explored through the inventory development project.

- **Separate nitrogen balances for arable and livestock.** Having separate nitrogen balances for different sectors would give a more complete picture of factors related to emissions for each sector. At present it is not possible to separate out the nitrogen balance between 'arable' and 'livestock' sectors, and this is not likely to be developed over the short term.

⁴⁴ Defra project AC0101 - An improved inventory of greenhouse gases from agriculture.

⁴⁵ Skiba and Smith (2000) "The control of nitrous oxide emissions from agricultural and natural soils

- **The following provides some further issues relating to the application of manufactured and organic nitrogen.**

Nitrogen source is an important determinant of the emissions resulting from application. Research indicates that the direct emissions from various sources of manufactured fertilisers are not significantly different from each other⁴⁶; however, urea fertilisers do have significantly higher ammonia emissions than nitrate based fertilisers. Therefore indirect emissions from urea are significantly higher, with associated implications for human health. Ammonium nitrate fertilisers can be associated with large leaching losses, but only if applied at inappropriate times of year. Beyond the farm gate, emissions from industrial Urea production are considerably lower than for ammonium nitrate, although the fertiliser industry continues to improve energy efficiency through installation of abatement technologies.

Applications of fresh farm yard manure (FYM) to land may be associated with higher direct emissions than manufactured fertilisers, although storage of FYM tends to reduce direct emissions to levels less than or comparable with manufactured fertilisers. However, indirect emissions during manure storage can be significant.

Applications of slurries can have high direct GHG emissions since the majority of the nitrogen content is in available forms. The high available N content of slurries also makes them prone to indirect emissions from ammonia losses, although this can be controlled by appropriate application technologies, such as the use of a trailing shoe, injector or band spreader. Slurries may also have considerable indirect losses during storage, again principally through ammonia emissions. If slurries are applied to land in the autumn and winter months they may also be associated with significant leaching losses. As such indirect emissions from slurry can potentially be high unless careful storage and application management is in place.

- **Uptake of inhibitors.** Inhibitor chemicals to reduce both direct and indirect emissions from fertiliser use have long been available to the farming industry, but uptake remains low because historically they have been perceived as costly options. Inhibitors exist to reduce ammonia emissions from urea based fertilisers and therefore indirect GHG emissions, whilst nitrification inhibitors can reduce direct emissions of GHG from fertilisers. New protected fertiliser products which include inhibitor chemicals have come on the market in the EU over the past few years, and there may be potential to significantly reduce emissions if these prove successful in field trials currently being carried out under Defra project AC0213 (more details are given at (vi) in the Appendix).

It is not clear at present what reliable information is available on the uptake of inhibitors.

⁴⁶ Although the Defra NT26 project indicated that urea may have very slightly smaller direct emissions than ammonium nitrate, the overall variability in emissions makes it hard to draw definitive conclusions

British Survey of Fertiliser Practice

- i) The reliability of estimates of manufactured nitrogen from the BSFP are quantified in the annual report. This states that in 2012: for winter wheat the GB overall application rate was 184kg/ha and standard error was 2.3kg/ha; for sugar beet the GB overall application rate was 95kg/ha and standard error 3.6kg/ha; for main crop potatoes the overall application rate was 135kg/ha and the standard error was 8kg/ha. A link to the report including more on the methodology and sampling errors is given in the [Appendix](#).

Cereal Production

- ii) The reliability of the estimates of cereal yields are quantified in the Cereal and Oilseed Rape Production annual time series dataset. For wheat in 2012, the yield estimate for England was 6.7 tonnes per ha, and the 95% confidence interval was +/-0.1. Information on other crops are given in the time series dataset, a link to this can be found in the [Appendix](#).

Soil Nitrogen Balance

- iii) The soil nitrogen balances are compiled using a system which draws on many data sources combined with a set of coefficients. The level of uncertainty around the components of soil surface balances has been explored, although an overall level of uncertainty for the overall balances has not been derived. Much of the activity data has quantified low levels of uncertainty, though some of the factors are expected to have a large degree of uncertainty. Links to the methodology reports are given in the [Appendix](#).

Farm Business Survey

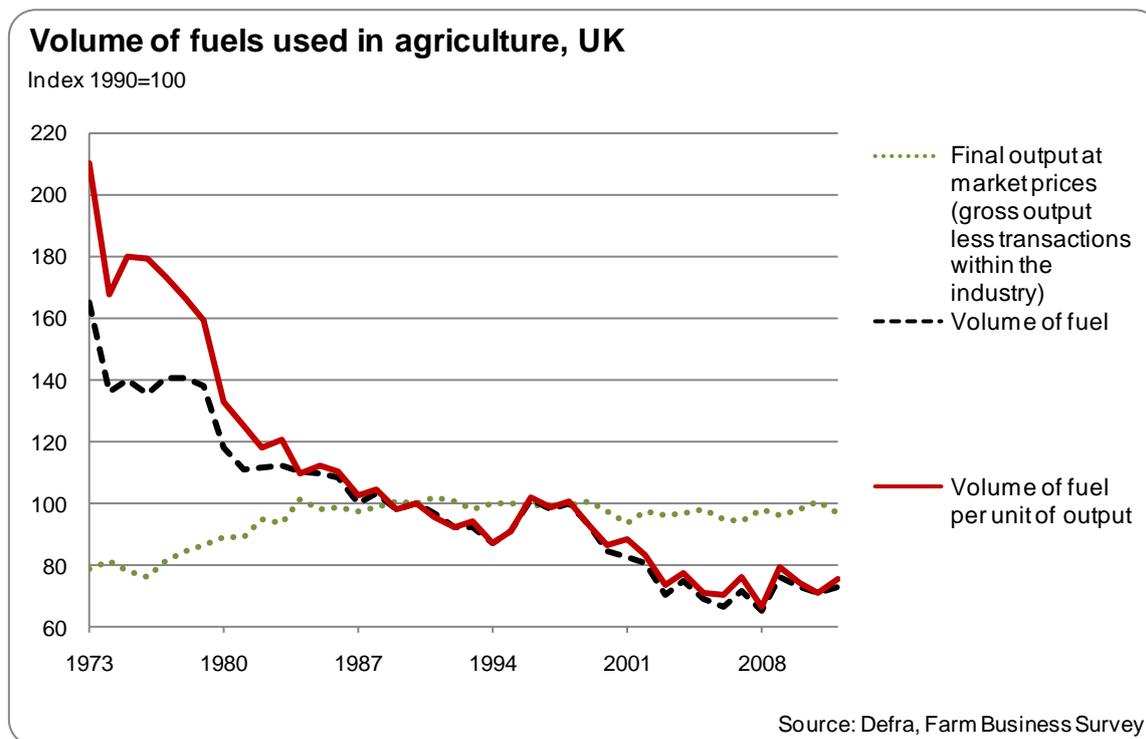
- iv) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

2.10 Fuel use

2.10.1 Fuel use in agriculture

Rationale

Modern agriculture is reliant on mechanisation. The fuel needed to power this is the main source of carbon dioxide from agriculture (although carbon dioxide only accounts for only 8% of the GHG emissions from agriculture).



Trends

Since 1990 there has been an overall decrease in the volume of motor and machinery fuel⁴⁷ used, with some year on year variation. Additionally, total agricultural output is similar to 1990 levels, thus the volume of fuel per unit of output has fallen since 1990.

2.10.2 Fuel use: further developments

The information presented here is used within the agricultural accounts, and is derived from fuel values, and price information. This means that the headline measures over the long term are reliable. However it would be of value to have more detailed information on the actual volume of fuel, as well as information on the type of fuel (red diesel, LPG, natural gas, fuel oil, petrol, (and possibly coal on old horticultural units). It is not clear at present whether this information is available.

⁴⁷ Volume indices are calculated by taking a weighted average of volume relatives (volume relatives are the volume in year n / volume in year n-1) using the monetary values of components of the aggregated index as weights.

2.10.3 Fuel use: notes on data collection methodology and uncertainty

Farm Business Survey

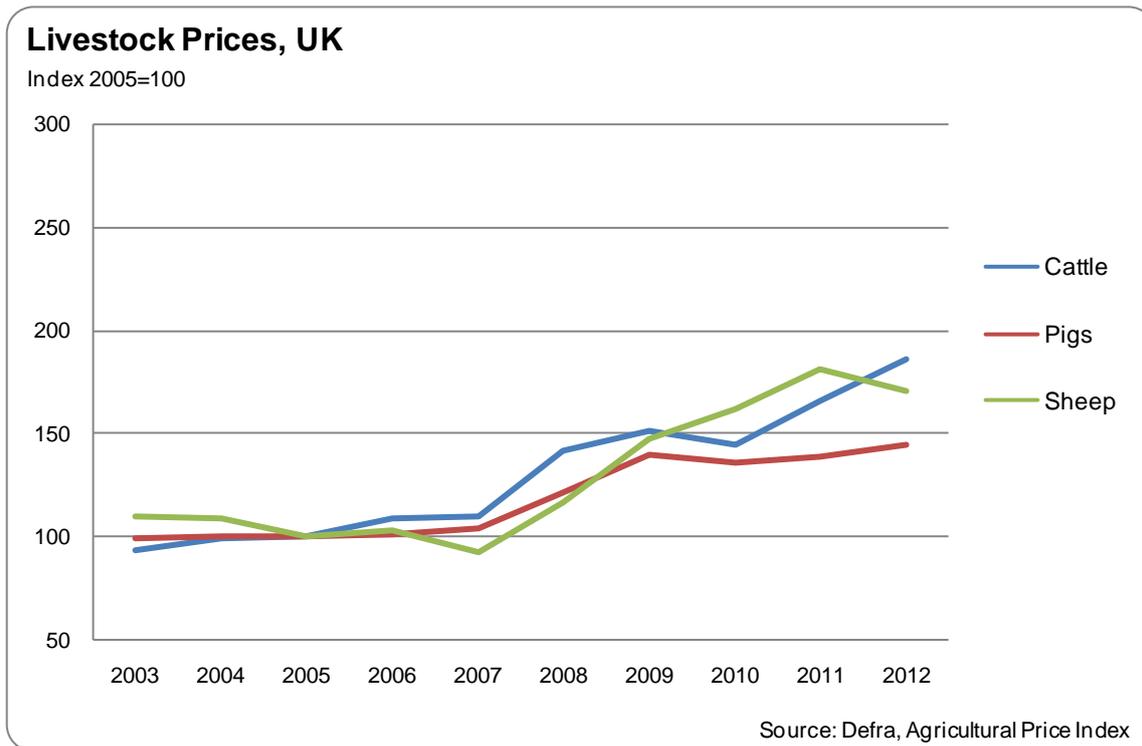
- i) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

2.11 Contextual factors: prices of inputs and outputs

Output prices

Rationale

Prices of both inputs and outputs can influence management and business decisions taken by farmers which can in turn have an impact on greenhouse gas (GHG) emissions from the agricultural sector. For example, market prices may influence the use of mineral fertilisers and the age at which livestock are slaughtered.



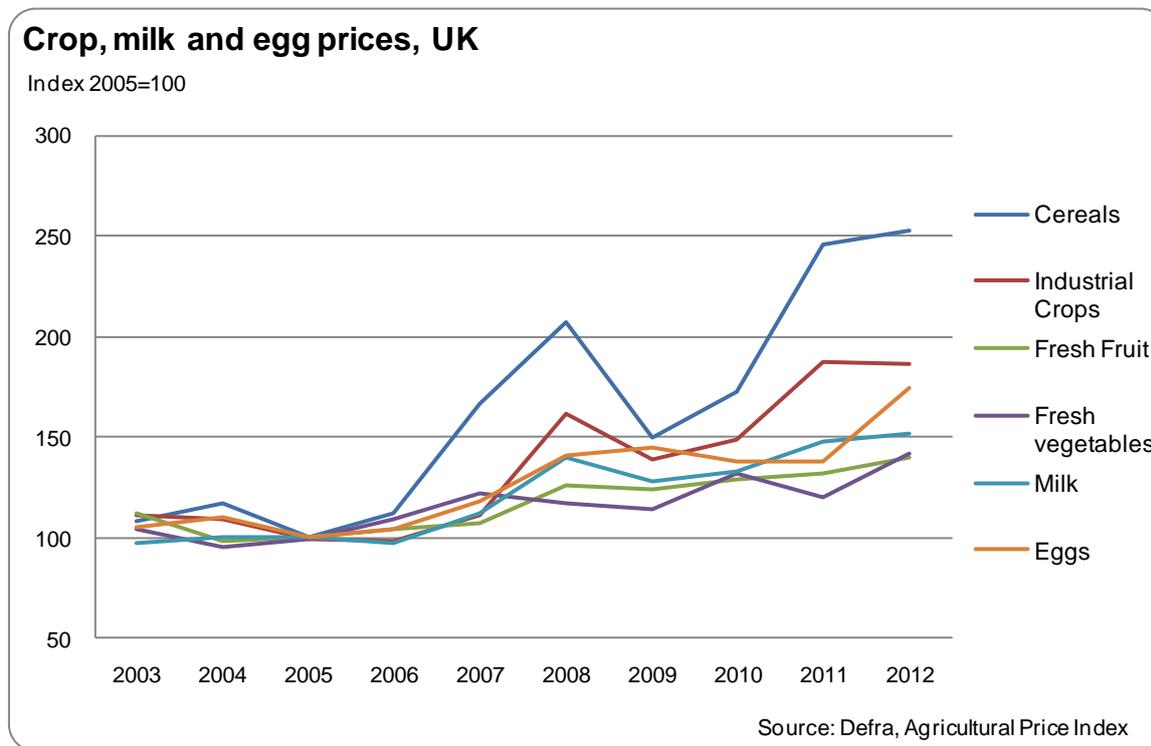
Trends

Livestock prices are influenced by exchange rates, the UK (and global) supply and demand situation and other factors such as disease outbreaks. After remaining relatively stable between 2003 and 2007 cattle, sheep and pig prices all rose sharply in 2008 and 2009.

Cattle price increases in 2008 and 2009 were driven by lower supplies of prime cattle and strong domestic demand combined with increased export demand (due to the exchange rate). In 2010 cattle prices were lower than the previous year as a result of increased supplies. More recently, an increase in demand and lack of supply led to increased prices, which have continued through 2011 and 2012.

Sheep prices increased in 2008, supported by tight domestic supplies and a strong export market. In 2011, strong competition for British lamb continued to result in considerably higher prices which reached record levels. This was driven by reduced global supplies stemming from a shortage of New Zealand lamb. During 2012 there was a drop in lamb prices influenced by the bad weather, limiting finishing and tightening supplies. By the end of the year sheep prices were around a quarter lower than in December 2011, the result of increased volumes of cheaper imported sheep meat, primarily from New Zealand.

Pig prices have improved in recent years, largely in response to higher production costs but also as a result of increased demand both at home and on the continent. However despite record highs, for some producers, profit margins remain stretched.



Trends

Fluctuations in cereal prices have generally been a result of the global supply and demand situation and currency movements. From 2006, cereal prices rose steeply peaking in 2008, this year also saw a peak in prices of industrial crops, fresh fruit, milk and eggs; only fresh vegetables were unaffected. 2009 brought a reduction in prices across all categories except eggs although 2010 and 2011 saw increases in cereal and industrial crop prices. For cereals the increase was driven by international grain prices coupled with lower than expected yields in the United States as a result of adverse weather conditions. Dry weather in Argentina and flooding across Eastern Australia at the end of 2010 also led to further increases in market prices. Prices in 2012 remained high, influenced by high maize prices driven by successive poor US harvests and the 2012 drought being the most severe. There was also reduced wheat availability from Russia and the EU from the 2012 harvest. The UK was a net wheat importer for the 2012/13 season as a result of the poor domestic harvest; cereal prices were 38% higher in December 2012 than a year earlier.

Increased prices for fresh vegetables in 2010 were the result of a number of factors: wet weather reduced imports from Spain while UK weather conditions affected domestic supplies. More recently the poor weather conditions in 2012 reduced fresh vegetable production resulting in large price increases.

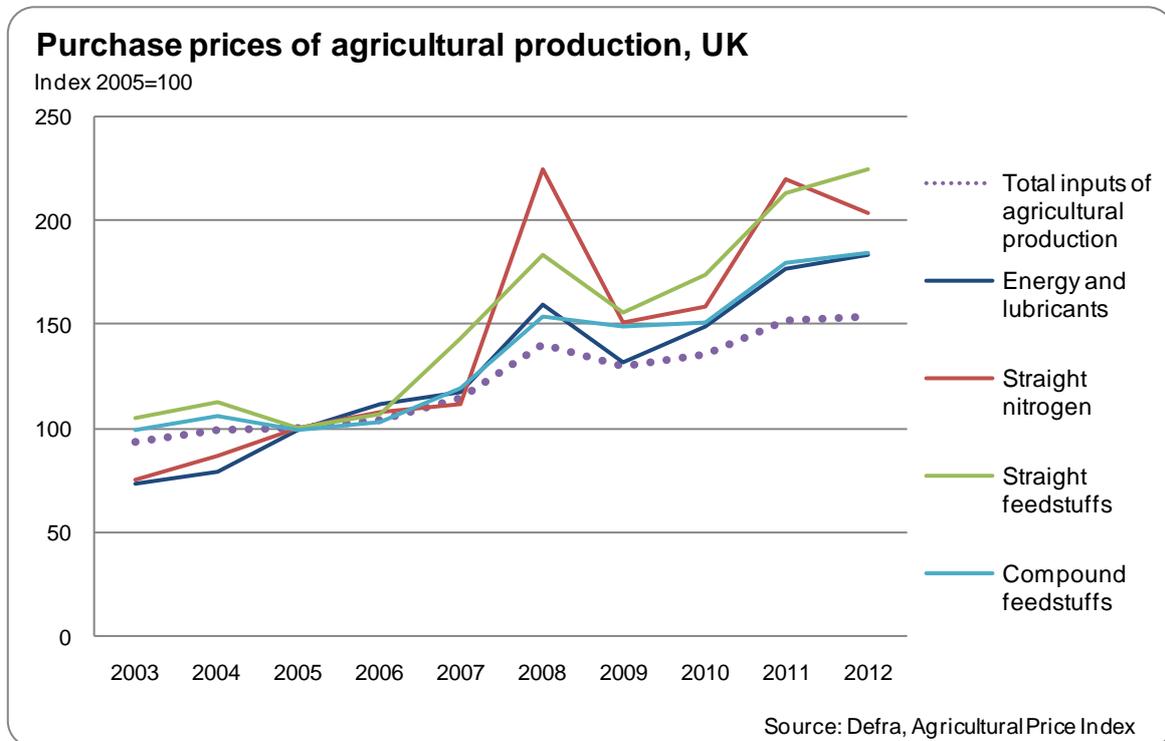
Input prices

Trends

The cattle, pigs, poultry and sheep sectors all purchase compound feed. Purchaser prices (the price paid by producers for agricultural inputs) for compound (and straight) feedingstuffs are influenced by changes in cereal and oilseed prices, although farmers can mitigate some of the price increase seen

here by substituting for different forms of animal feed. Recent increases in animal feed are linked to poor harvests, particularly in Australia and the USA, and the increasing interest in biofuels, primarily abroad and to a more limited extent in the UK, has added some pressure to the demand side of the market.

Prices of straight nitrogen peaked sharply in 2008 resulting in slightly lower levels of usage of nitrogen fertilisers, as illustrated in [Section 2.9](#).

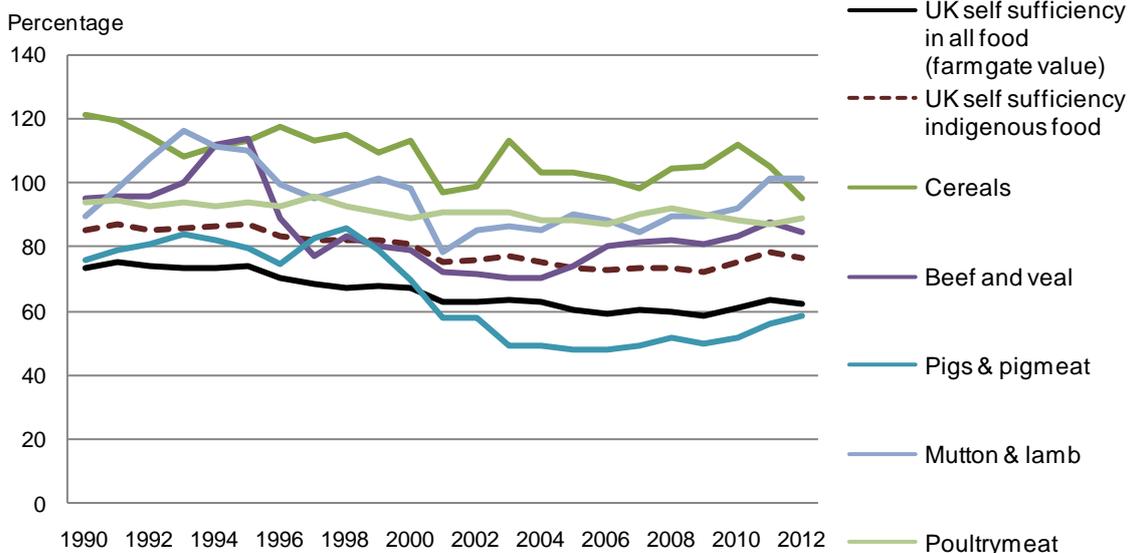


2.12 Contextual factors: trends in UK's ability to meet domestic demand and contribute to the international market

Rationale

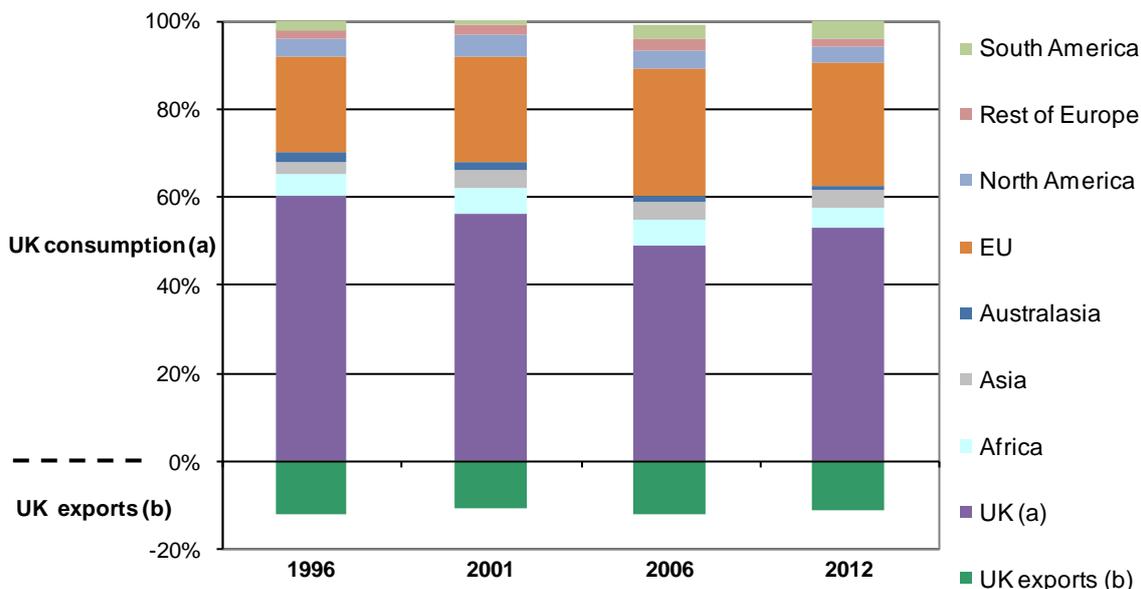
All things being equal greenhouse gas (GHG) emissions associated with UK production would fall if UK production was displaced by produce from international competitors. Measures of UK production as a percentage of UK consumption are shown here to provide an indication of displacement and hence any 'carbon leakage'. These measures only provide an overview and do not capture the GHG emissions associated with food production. However, they do provide a useful high level summary.

UK production to supply ratio ("self sufficiency") in food and key commodities



Note, measures of production to new supply ratio for commodities shown are volume based, whilst headline measure of production to supply ratio in all food is a value at the farm-gate measure. Source: Defra, Agriculture in the UK

Origin of food consumed in the UK: 1996, 2001, 2006, 2012



Based on the farm-gate value of raw food

(a) Consumption of UK origin consists of UK domestic production minus UK exports

(b) UK exports are given as a percentage of total UK consumption.

Source: Defra, Agriculture in the UK

Trends

UK consumption of agricultural products and carbon leakage: whilst production has fallen overall in the UK since 1990, which may result in lower total emissions, in the main domestic production (in particular meat) has been replaced with imports. Therefore, any reduction of emissions in the UK will have been at the expense of increases overseas. There is insufficient evidence to say with any certainty that this displacement will have been of a significantly different level of GHG intensity (that is, GHGs produced per tonne of grain, litre of milk or kilogramme of meat produced).

UK domestic demand and production of agricultural products

The impact of changes in domestic demand for agricultural products on price is limited as UK farmers are price takers within the wider international market

The theory of supply and demand would suggest that a fall in domestic demand might be expected to translate into a fall in price for agricultural products in the UK. However, the influences on food prices are subject to international factors (e.g. UK pig prices follow wider EU prices over time), and coupled with the fact that domestic demand is small relative to global demand, changes in UK demand would not be expected to have a significant impact on prices in an international market.

With any reduced demand domestically exports of agricultural products should rise

We would therefore expect change in domestic demand to impact on trade flows, rather than on prices. For example, given a rising global demand, but a falling domestic demand, UK producers would find international markets more attractive relative to domestic markets, even with the additional costs of exporting. Hence, exports should rise. Similarly, those countries currently exporting to the UK would, if prices started to fall as a consequence of falling demand, assess whether to continue exporting the same quantities to the UK or perhaps instead redirect exports to markets with a better price. This change in trade flows would 're-balance' supply and demand until the UK price was equal to international prices; UK imports would fall while exports would rise.

We can expect greater volatility for individual items than is seen at the all outputs level, and there will be some parts of the market where local supply/demand will have more of a bearing, but overall overseas trade flows will soon adjust to dampen down the impact of any price differential that emerges between the UK and the wider EU and international market as a consequence of changes to UK demand.

This adjustment through trade flows can be illustrated by looking at trends in UK production and consumption of pigmeat since the late 1990s. UK pigmeat production reduced by 37% between 1998 and 2010 while at the same time UK consumption rose by 5%. This imbalance between rising UK demand, and falling domestic production was not reflected in higher prices, rather UK prices over the period continued to follow the trends seen across the EU. But, UK imports rose by 64% and exports fell by 58% thus demonstrating how trade flows adjust to dampen down any differences in price that emerge.

Section 3: Farmer attitudes and uptake of on-farm mitigation measures

Background information

The following section provides key summary statistics on farmer attitudes and views - what farmers think about greenhouse gases (GHGs) and their uptake of a range of mitigation measures. The farming industry, in England, and the UK more generally, is comprised of a large number of relatively small businesses. The characteristics of the many businesses and individual farmers are critical to the uptake of climate change mitigation measures where there is a need for farmers to understand the issues and be willing and able to implement measures. Understanding what practices are adopted, and why, can help highlight the barriers and motivations to action on GHGs.

Many farmers, but not the majority, recognise the importance of GHG emissions but most remain unconvinced about the business benefits of reducing emissions. There is a limit to farmers' understanding of GHGs, most notably the constituents of GHGs and a lack of recognition of the sources of GHGs.

Ensuring a greater understanding of GHG emissions, whilst not a pre-requisite for changing practices and reduced emissions, is likely to be an important driver for change for some farmers. A greater understanding may also lead to the adoption of more measures and cost-effective solutions for reducing agricultural GHGs that fit with the farm business.

While research suggests that most practices to reduce GHG emissions could save farmers money (and many farmers are likely to be influenced to change their practices because it makes good business sense) there are several key barriers to uptake which are non-financial, or not directly financial. These include a lack of willingness to undertake (e.g. limited trust in what is being asked and the outcomes that will result) and a lack of ability to undertake (e.g. a lack of understanding, skills, time or capital). Whilst most farm businesses should be able to implement key actions, not all measures are suitable for all farm businesses.

The industry-led Greenhouse Gas Action Plan (now linked with Tried & Tested within the Campaign for the Farmed Environment) is intended to convey coherent messages covering good farming practices which include resource use efficiency and nutrient management as well as farmland biodiversity and resource protection.

This Chapter presents data on uptake of a range of on-farm practices. This includes nutrient management, anaerobic digestion, fertiliser spreaders, manure and slurry storage, farm health planning, grassland management, cattle and sheep feeding regimes and breeding practices. The data are largely sourced from Defra's Farm Practices Survey (FPS) and the British Survey of Fertiliser Practice (BSFP).

3.1 Farmer understanding, awareness and uptake of actions towards reducing GHGs

Awareness of greenhouse gas emissions

Measuring awareness of the importance of GHGs for the farm business and sources of emissions can provide an indication of the ease to which mitigation measures will be adopted and help to highlight motivations and barriers. However, whilst important, improving understanding and attitudes towards GHGs are not a pre-requisite for the adoption of mitigation practices; business sustainability and financial implications are important drivers for change.

The 2010 Defra funded ADAS study into the feasibility of GHG mitigation methods (AC0222) used a telephone survey to ask farmers to identify (unprompted) the sources of GHG emissions on their farm. The responses showed high levels of awareness for livestock as a source (89% of dairy farms and 81% of grazing livestock farms) but lower levels of awareness for manure and slurry direct from livestock or spread on the farm (53% of dairy farms and 29% of grazing livestock farms). Less than half of arable farmers suggested 'bagged nitrogen' as a source.

The 2013 postal Farm Practices Survey (FPS) asked a series of questions about the different GHGs emitted from various farm practices. The responses showed that for some practices there was a high level of understanding e.g. methane from livestock and slurry storage, carbon dioxide from heating / vehicle fuel and nitrous oxide from manufactured nitrogen fertiliser. However, even for these practices there were a sizeable minority of between 12% and 26% that answered 'don't know'. This lack of knowledge increased with the complexity of the issue i.e. for questions asking about cultivation and anaerobic digestion the 'don't know' responses ranged between 40% and 47%.

Do farmers think reducing greenhouse gas emissions is important and understand the causes?

Whilst awareness of the potential sources of GHG emissions will have some bearing on the uptake of mitigation measures, other factors (particularly economic benefit or regulatory requirement) will also be important drivers. The 2013 FPS sought to further examine these issues and provide robust evidence. Also included was an assessment of the farm and farmer characteristics. Attitudes and behaviours relate to the characteristics of both the farm (e.g. enterprise type and size) and also the farmers (analysed here through a segmentation approach⁴⁸). The segmentation (Table 11) provides an opportunity to assess the way that variations in attitudes and motivations of the farmer influence farm business decision-making.

Table 11: Proportions of farms in the FPS by segmentation code

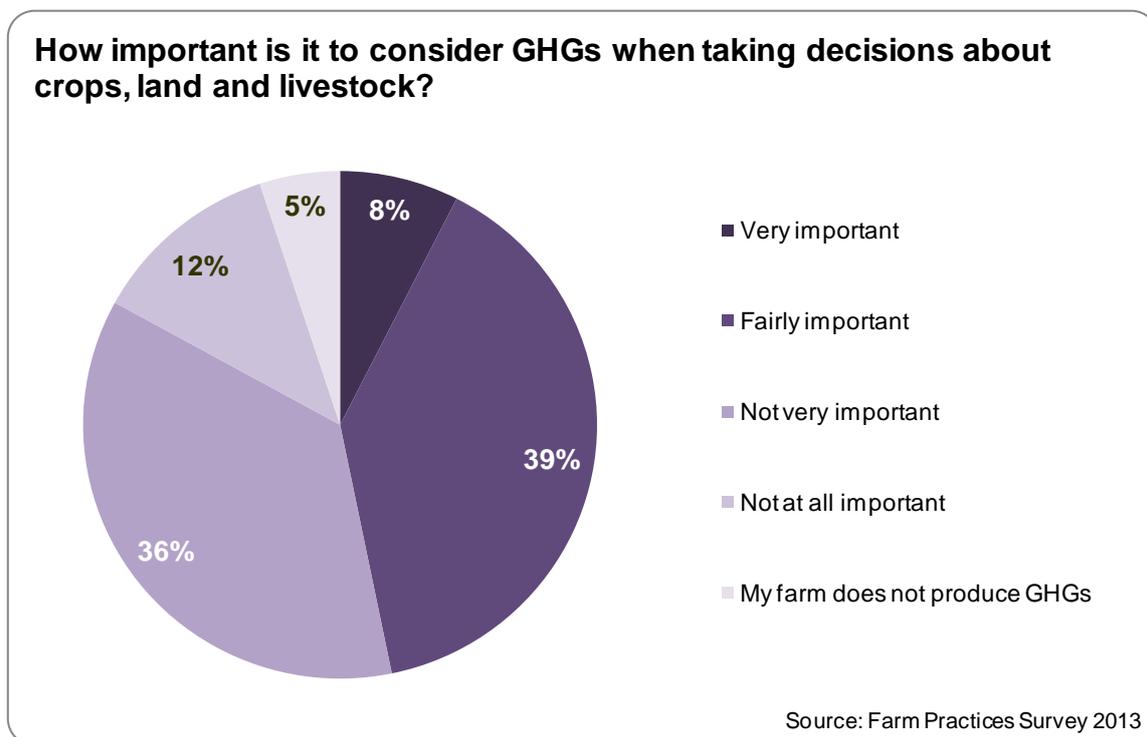
Farm segmentation group	2011 (%)	2012 (%)	2013 (%)
1 Custodian	13	14	10
2 Lifestyle choice	5	4	5
3 Pragmatist	44	43	45
4 Modern family business	33	36	36
5 Challenged enterprise	6	4	3
All farmer types	100	100	100

Based on 3031 responses in 2011, 1159 in 2012 and 1790 in 2013 Source: Farm Practices Survey

⁴⁸ 'Understanding behaviours in a farming context', T Pike, November 2008.

Do farmers think reducing greenhouse gas emissions is important and understand the causes?

The survey demonstrated that there was an even split between farmers in the level of importance given to considering GHGs when making farm business decisions; 47% thinking it was important and 48% not important. There was a relatively small number still considering that their farm did not produce GHGs (5%). These tended to be small farms. Cereals, other cropping and specialist pig and poultry farms tended to place greater importance on GHGs than grazing livestock farms. These findings are very similar to those found in the 2010 ADAS study (AC0222). Attitudes are also influenced by the type of farmer and those segments tending to focus on business planning (Modern Family Business), or costs (Challenged Enterprises), placed greater emphasis on considering GHGs and those with less interest in the financial aspects (Lifestyle Choice) placed less emphasis (only 30% rated as important).



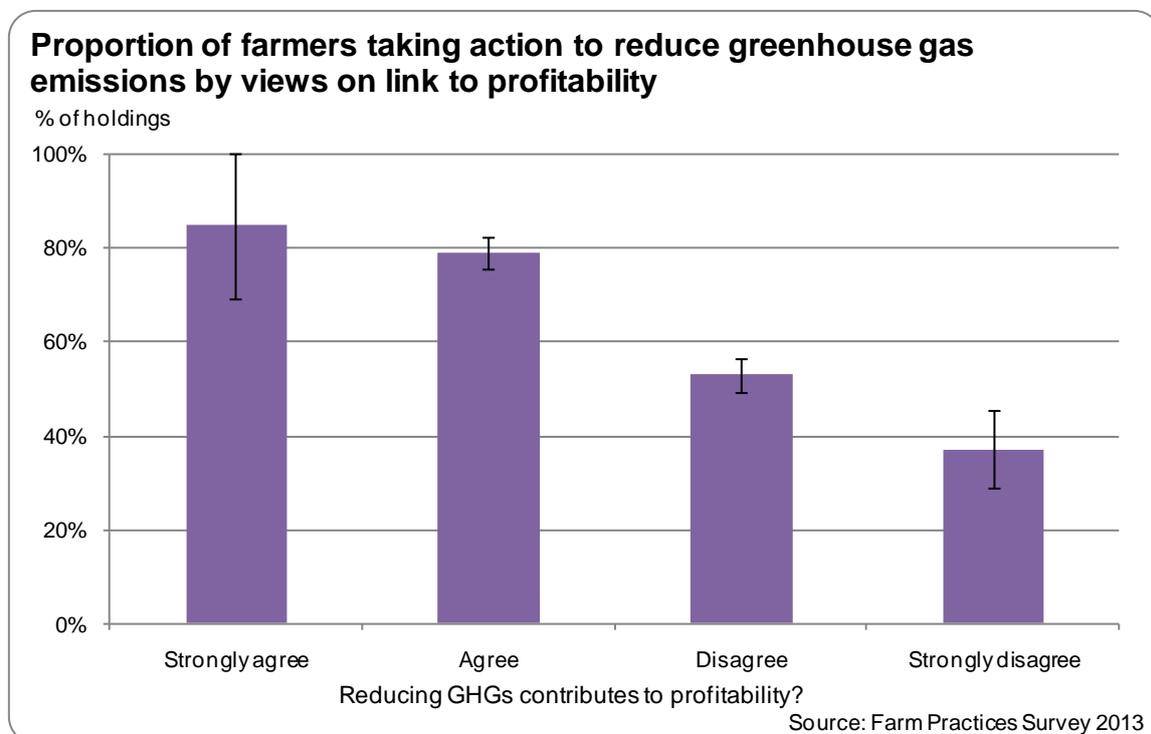
The majority of farmers thought that reducing emissions would not improve farm profitability (62%). Pig and poultry farmers were less convinced about the link to profitability, perhaps due to overall pressure on costs, and dairy farmers were more likely to recognise the link to profitability (they exhibit a lower importance score as there may be an inability to adequately address within their current system).

There was a degree of correlation between the importance given to considering GHGs when decision taking and the link to profitability. However, nearly a quarter (23%) of those saying that it was very important to consider GHGs, did not agree that reducing GHGs would increase profitability.

What farmers say they do to reduce greenhouse gas emissions

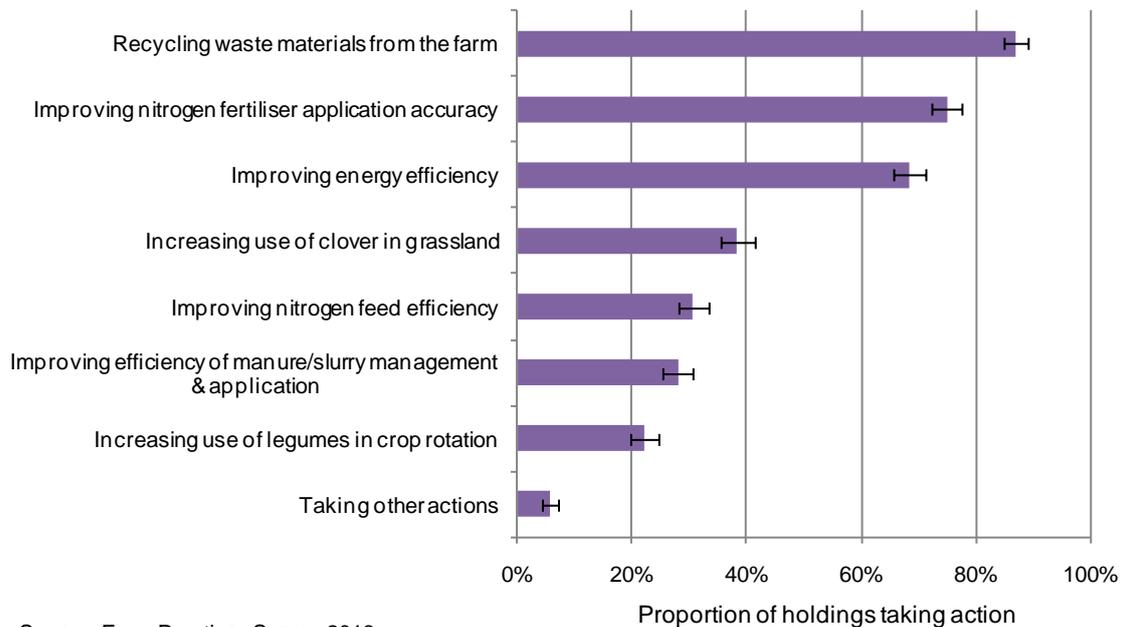
The 2013 FPS indicated that 62% of farmers were taking actions to reduce emissions. Larger farms were more likely to be taking action than smaller farms. LFA and lowland grazing livestock farms were less likely (45% and 51% respectively) to be taking action than other farm types.

Action was most likely for those farmer segments that focus on planning and costs (Modern Family Businesses and Challenged Enterprises, 70% and 62% respectively). Unsurprisingly, those who think that reducing emissions is important are more likely to undertake an action to reduce, e.g. 82% of those who thought it was very important, took action. However, the importance of barriers is illustrated by 15% of those strongly agreeing that reducing GHGs increases profitability still not taking any actions and 37% of those strongly disagreeing that reducing GHGs would increase profitability still took an action. This highlights the range of barriers both in terms of understanding but also in terms of capacity of the business to adapt and motivators which can be both economic and non-economic e.g. regulatory.



The most common actions to reduce GHG emissions (cited by more than half of those undertaking actions in 2013) were recycling, improving nitrogen fertiliser application and improving energy efficiency. These are actions that all farmers can take irrespective of their enterprises. Those actions most suited to livestock enterprises had a lower level of uptake.

Actions being taken by farmers to reduce greenhouse gas emissions

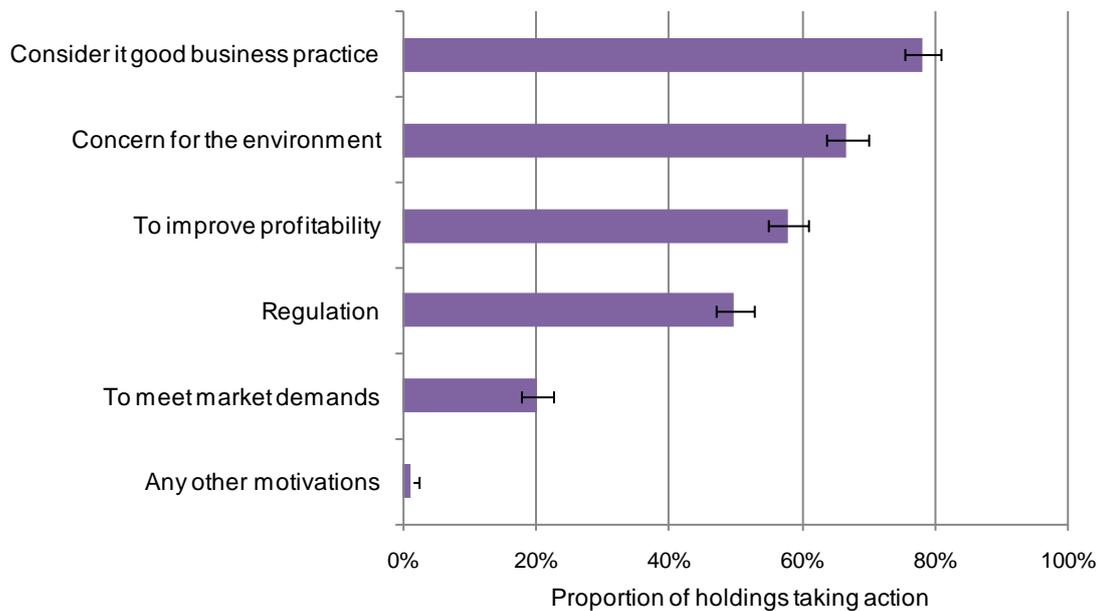


In general, larger farms were more likely to take action but critically there were some key differences between different enterprises which reflected the nature of the business. For example, LFA grazing farms had less focus on energy efficiency (as more extensive, outdoor systems) and less opportunity for planting legumes as part of rotation. Grazing livestock and mixed farm types had the highest uptake of clover in grassland (as fits the nature of management) but these enterprises were less likely to take action when compared to dairy farms in relation to manure / slurry management, nitrogen application and feed efficiency. This lack of a focus on actions that may reduce costs indicates that there are still opportunities for improved practice. For example, over 90% of cereals and other cropping farm types are taking actions to improve nitrogen fertiliser application compared to 74% of dairy farms. Figures for grazing livestock farms are lower (62% of lowland farms and just 47% of LFA farms). However, it is recognised that not all enterprises apply nitrogen fertiliser e.g. organic farms and some grazing livestock farms. Only around a third of grazing livestock farms are improving slurry / manure management and less than a third improving nitrogen feed efficiency compared to over 52% and 61% for dairy enterprises, respectively.

What are the main motivations for undertaking the actions to reduce greenhouse gas emissions?

Most farmers (78%) consider it to be good practice to undertake the actions and there is also a strong positive motivator towards the environment (67%). However, perhaps reflecting past messaging (which focussed on environmental issues rather than efficiency), just 58% undertake the actions to improve profitability and 20% to fit with market demands. Half of farmers (50%) recognise the regulatory reasons for the actions e.g. around nutrient management. Larger farms place more importance on profitability and meeting market demands.

Main motivations for taking action to reduce greenhouse gas emissions

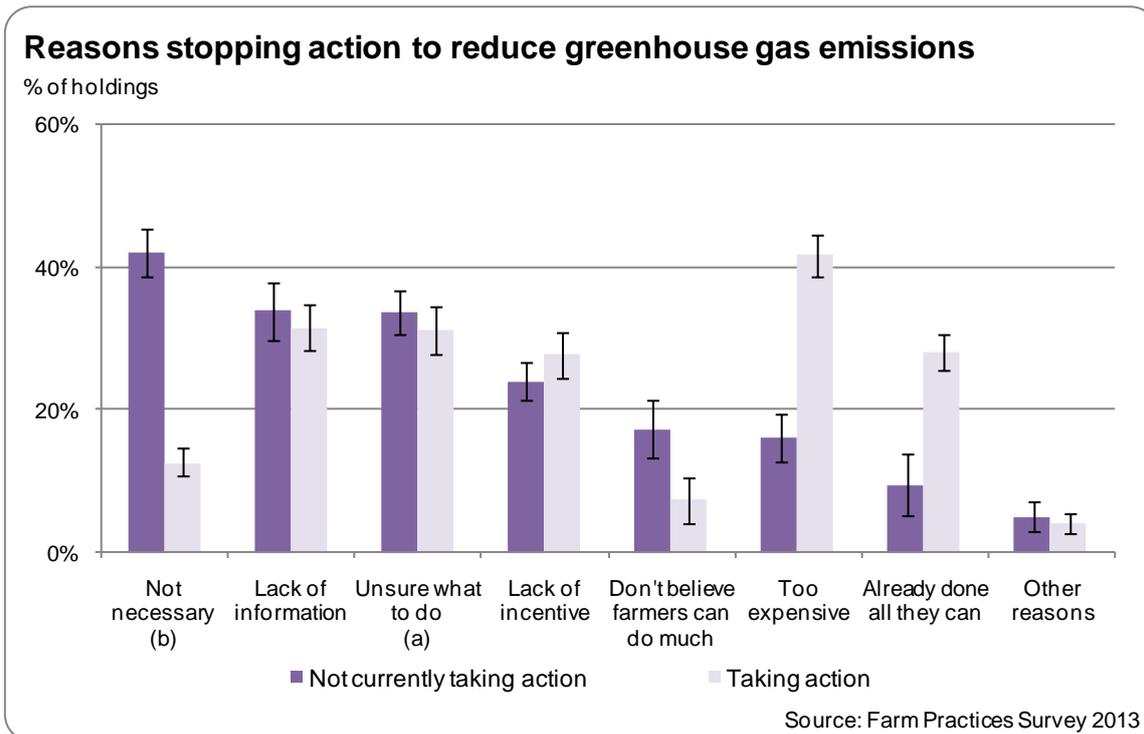


Source: Farm Practices Survey 2013

What farmers say are the barriers to reducing emissions

For those farmers that are not undertaking any actions to reduce GHG emissions, informational barriers are important i.e. the lack of information (34%) and lack of clarity on what to do (34%) were key reasons for not taking action. This could be described as 'personal capacity for action'. However there is also a wider issue around understanding or willingness to take action with 42% not believing any action is necessary, 17% believing there is not much they can do and 10% believing they have done enough. Actual financial barriers are relatively small in comparison, with 24% saying not enough incentive and 16% too expensive. Larger farms were more likely to highlight financial barriers (41% lack of incentive) whilst smaller farms suggested they did not produce enough emissions (50% thought action was not necessary for this reason). The recognition that action was necessary varied by farm type with only 20% of dairy farms thinking they did not need to take action compared to 60% of LFA grazing livestock farms.

For those already undertaking actions, financial barriers are stronger (28% saying not enough incentive and 42% too expensive) but information barriers are still important i.e. the lack of information (32%) and lack of clarity on what to do (31%) were key reasons for not taking action. However, a recognition of the need to take action was reflected in only 13% believing that action is not necessary and 7% believing that there is not much they can do. Over a quarter (28%) of those taking action believe that they have already done enough. Again, larger farms were most likely to highlight financial barriers (51% too expensive), whilst for smaller farms there was no over-riding barrier. The recognition of the need for action varied by farm type with only 5% of dairy farms thinking they did not need to take action compared to 22% of lowland grazing farms. Farmer segments may also play a part as Challenged Enterprises (who may be under financial pressure) were most likely to identify cost as an issue (65% say too expensive), Custodians (who generally recognise the importance of the environment) feeling they have done enough already (36%) and Lifestyle Choice farmers (who may be less committed to, or knowledgeable about, the farm business) most likely not to understand what they need to do (47%).



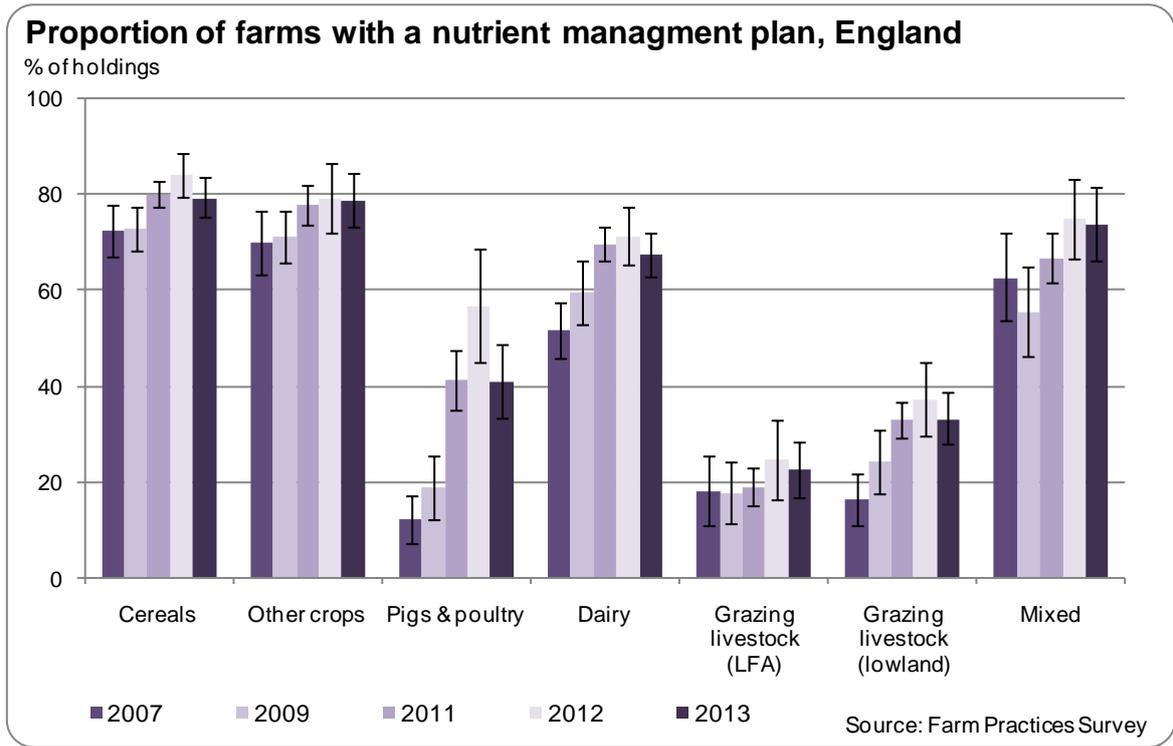
(a) Not necessary as don't think my farm produces many emissions.
 (b) Unsure what to do due to too many conflicting views.

3.2 Uptake of on-farm mitigation measures

Nutrient management plans

Good nutrient management planning can bring a number of important benefits: minimising GHG emissions, reducing the incidence of diffuse water pollution, and helping farmers save money through optimising productivity.

The proportion of farms with a nutrient management plan has increased from 46% in 2006 to 57% in 2013. This could be due to a mixture of regulation and increasing environmental awareness. There was a slight reduction between 2012 and 2013, but this was not statistically significant (see Appendix v). In 2013, those farms with nutrient management plans accounted for 73% of the farmed area. As shown in the following chart, the increasing trend is evident for individual farm types. Uptake is greatest on cereal and cropping farms and lowest on grazing livestock farms, particularly those in the LFA. Over three-quarters (81%) of larger farms have plans but only around half (54%) of smaller farms. Modern Family Businesses (those farmers with an attention to detail and planning) and Challenged Enterprises (those businesses with a focus on costs) were more likely to have a nutrient management plan (72% and 67% respectively) than Lifestyle Choice farmers (41%). This latter group are often smaller farms and tend to do things for enjoyment rather than the paperwork and saving money (i.e. better nutrient practice) is less important.



Note: the ranges shown on the chart are 95% confidence intervals.

A quarter of those with plans developed them without professional advice (25%); these were more likely to be grazing livestock farms than other farm types. Around half (48%) had some professional advice and for a further quarter (27%) a contractor or an advisor created the plan.

For those farmers without a plan the most common motivator to create one was reassurance of a return for the work they had put in (49%). Having more money to pay an adviser (30%) and more time (26%) were also common motivators. However, for around a quarter of farmers without a plan (24%) there remains no motivation to create one.

A variety of formal and informal methods can be used for nutrient management planning. Of the four tools listed within the survey, 'PLANET' has been the most commonly used since 2009. Further analysis by farm type (Table 12) shows that 'PLANET' is a popular choice across most farm types but there are some sectoral differences. Grazing livestock farms were more likely than other farm types to use a method other than the four listed.

Tools used to create nutrient management plans, England

% of holdings with management plans

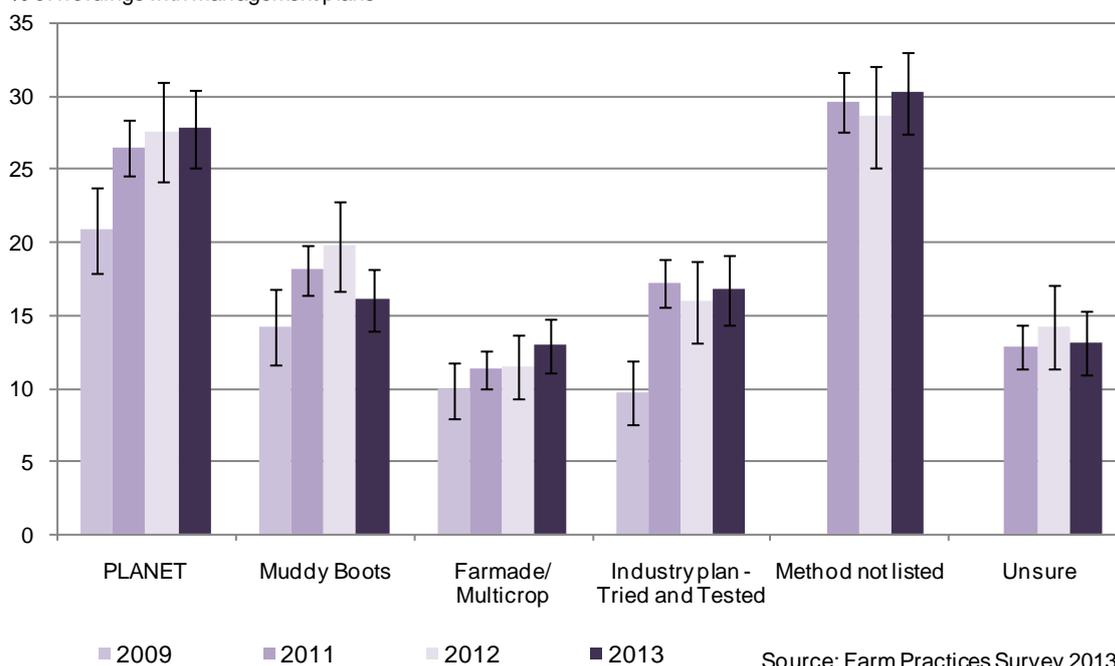


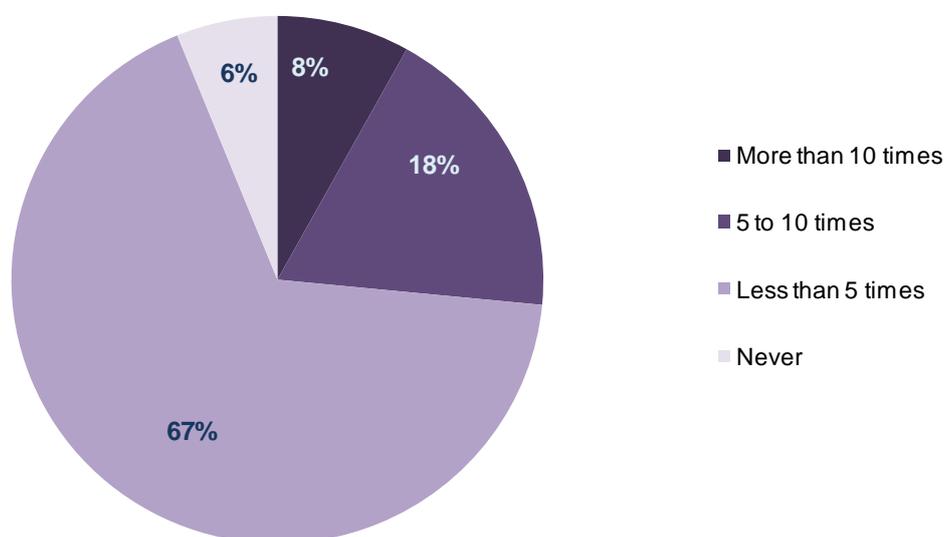
Table 12: Tools used to create nutrient management plans

% of holdings with nutrient management plans

Farm type	PLANET	Muddy Boots	Farmade/Multicrop	Industry plan - Tried & Tested	Method not listed	Unsure
Cereals	31	20	20	15	22	12
Other crops	24	18	21	17	30	10
Pigs & poultry	43	12	13	6	29	14
Dairy	37	13	5	18	31	12
Grazing livestock LFA	7	11	3	17	56	21
Grazing livestock lowland	19	7	3	19	46	16
Mixed	27	19	9	20	26	14
All farms	28	16	13	17	30	13

Source: Farm Practices Survey 2013

Frequency with which the nutrient management plan is referred to in a year, England



Source: Farm Practices Survey 2013

Compiling a nutrient management plan is only the first part of improved practice. Almost all (94%) of those with a plan refer to it at least once a year and 27% refer to it at least 5 times a year. The frequency of referral tends to be lower for grazing livestock farms than for other farm types. There has been a significant increase in the proportion of farmers updating their plan annually from 65% in 2009 to 79% in 2013.

The varying levels of use are also reflected in the way that farmers judge the financial benefits of having a plan. Less than half (43%) of those with a plan saw financial benefits, 36% saw no benefit and 21% did not know. There is some variation in farmer segments relating to the different business approaches. Modern Family Businesses would expect to see a financial benefit and were more likely to respond positively (48% saw a financial benefit). Challenged Enterprises would hope to see some benefit but do not (54% saw no financial benefit).

Manure management plans

In 2013, 71% of applicable⁴⁹ farms had a manure management plan, almost unchanged from 70% in 2009. The greatest uptake is on dairy farms (87% of applicable farms) and lowest on LFA grazing livestock farms (51%). Modern Family Businesses (those farmers with attention to detail and planning) have a higher uptake (83% of applicable farms) and Lifestyle Choice farmers have a lower level of manure planning (58%). This latter group are often smaller holdings and tend to do things for enjoyment rather than the paperwork; saving money is less important. Table 13 shows the source of nutrient recommendations for manure management plans; these show little variation between 2009 and 2013.

⁴⁹ Farms were asked "Do you have a manure management plan" and could respond "Yes", "No" or "Not applicable". Farms that do not produce and/or spread manures or slurries will not require a manure management plan.

Table 13: Source of nutrient recommendations for manure management plans

	% of holdings of with manure management plans			
	2009	2011	2012	2013
Defra recommendations / manual (RB209 ⁵⁰), CoGap ⁵¹	92	87	90	87
Other	12	15	13	16

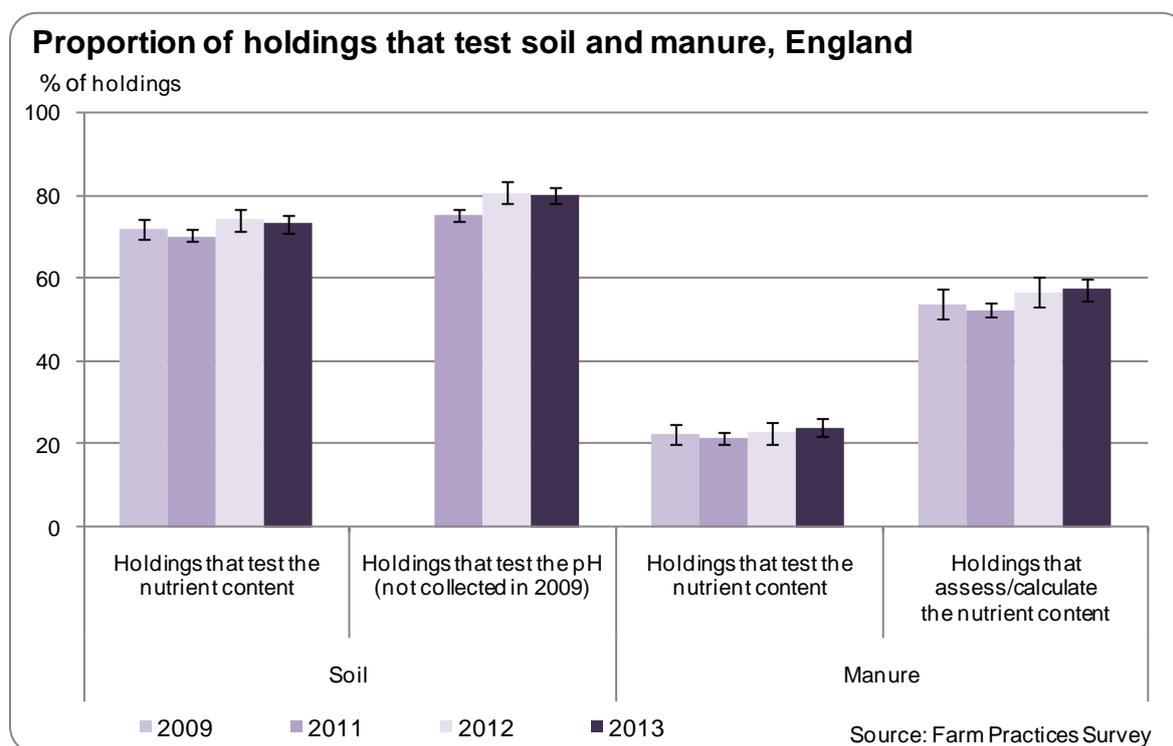
Source: Farm Practices Survey

For details by farm type in 2013 please see (v) in the [Appendix](#).

Nutrient testing of soil and manure

There has been little change in the proportions of farms undertaking some form of nutrient testing of soil or manure between 2009 and 2013. However, there has been an increase in the proportion of holdings that regularly test the pH of their soil, from 75% in 2011 to 80% in 2013. Grazing livestock farms were much less likely than other farm types to test their soils or manure. For each of the tests, a similar pattern emerges where those farms that focus on the management inputs (Modern Family Businesses) have the greatest uptake and those that have less of a business focussed approach (Lifestyle Choice) have the lowest uptake.

Details of the proportion of farms testing soil and manure by farm type can be found in section (v) of the [Appendix](#).



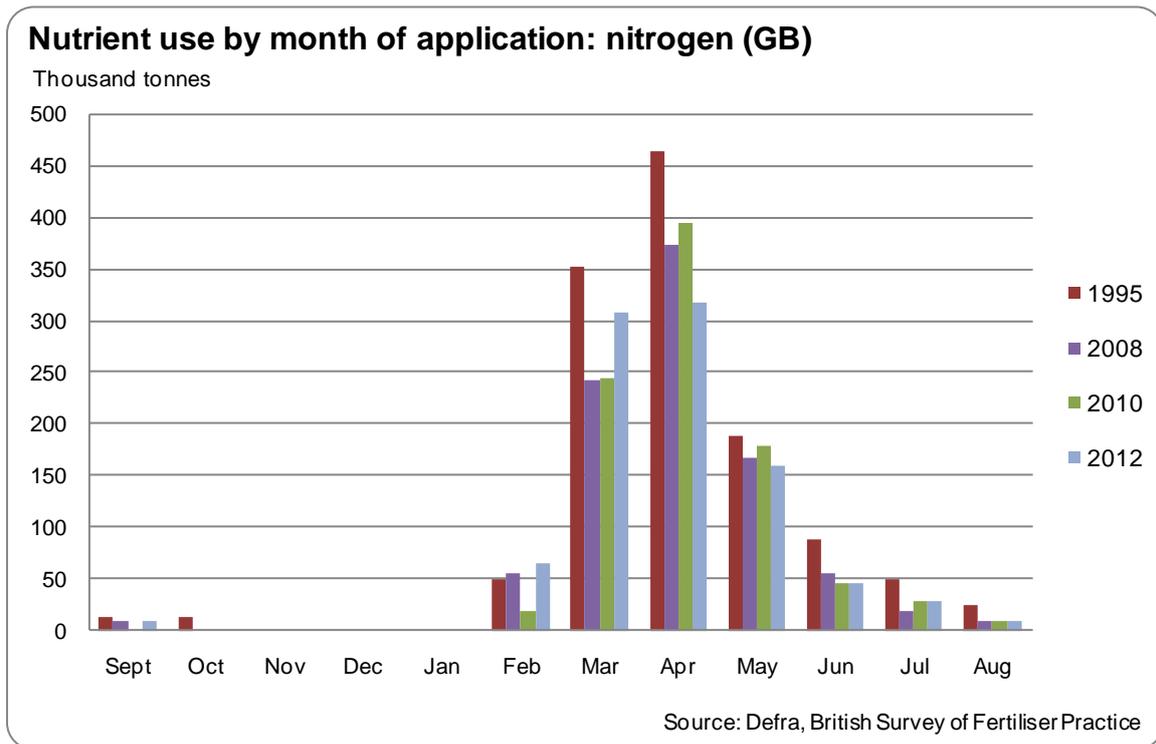
⁵⁰ <https://www.gov.uk/government/publications/fertiliser-manual-rb209>

⁵¹ <https://www.gov.uk/government/publications/protecting-our-water-soil-and-air>

Timing of fertiliser applications (source: British Survey of Fertiliser Practice)

The timing of fertiliser applications can have a bearing on the amount of nitrous oxide released. Avoiding spreading manufactured fertiliser when there is little or no crop uptake (for example between September and February) or when conditions are particularly wet can help to minimise the risks.

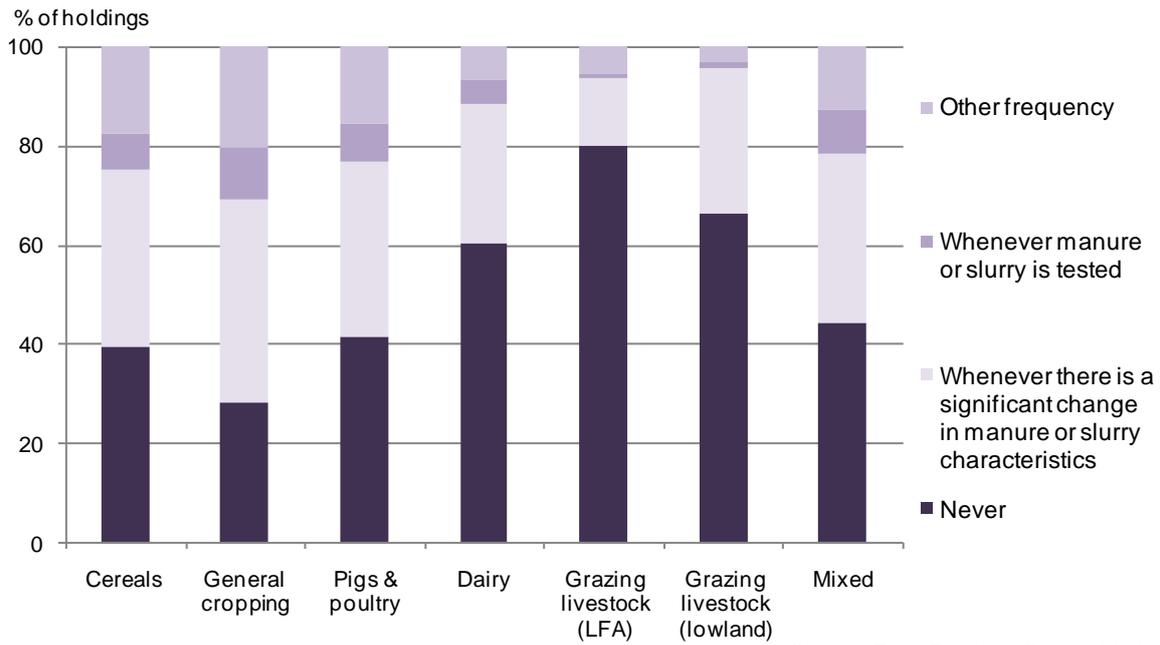
The following chart shows results from the British Survey of Fertiliser Practice which indicate that the majority of nitrogen is applied in March and April, a trend which has remained relatively consistent over time.



Calibrating fertiliser, manure and slurry spreaders

Calibrating fertiliser, manure and slurry spreaders can help to improve input efficiency and reduce GHG emissions. The FPS asked questions about manure (solid manure or slurry) spreader calibration for the first time in 2013. Responses showed that on over half of holdings (58%) where the farmer spreads manure or slurry, the manure or slurry spreader is never calibrated. 29% of farms calibrate their spreader whenever there is a significant change in manure or slurry characteristics, 4% whenever manure or slurry is tested and the remaining 9% calibrate their spreader at some other frequency. General cropping farms are most likely to calibrate their manure spreader while grazing livestock farms are the least likely.

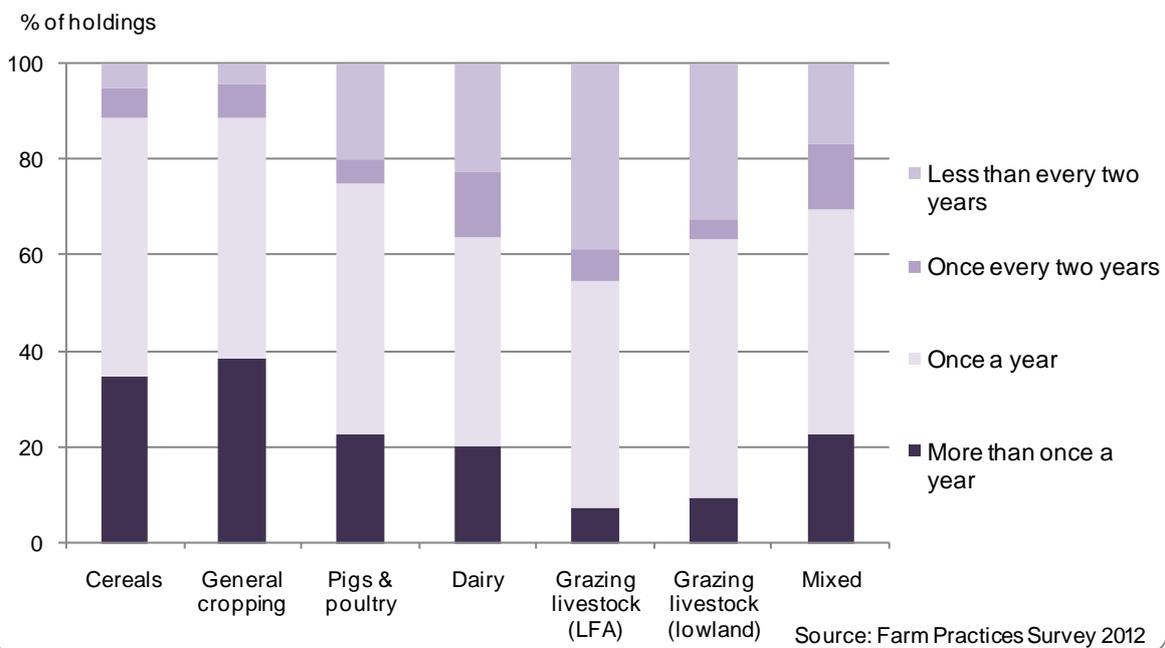
Frequency with which manure spreaders are calibrated, England



Note: Excludes farms where manure/slurry is spread only by a contractor.

Information on spreaders of manufactured nitrogen based fertilisers was not collected in 2013. The 2012 FPS indicated that roughly half of those farmers who spread manufactured nitrogen based fertiliser to crops or grassland gave their spreaders a general check more than once a year and a further 44% undertook a general check once a year. These proportions were similar to those in 2011.

Frequency with which the spread patterns of fertiliser spreaders are checked and calibrated, England



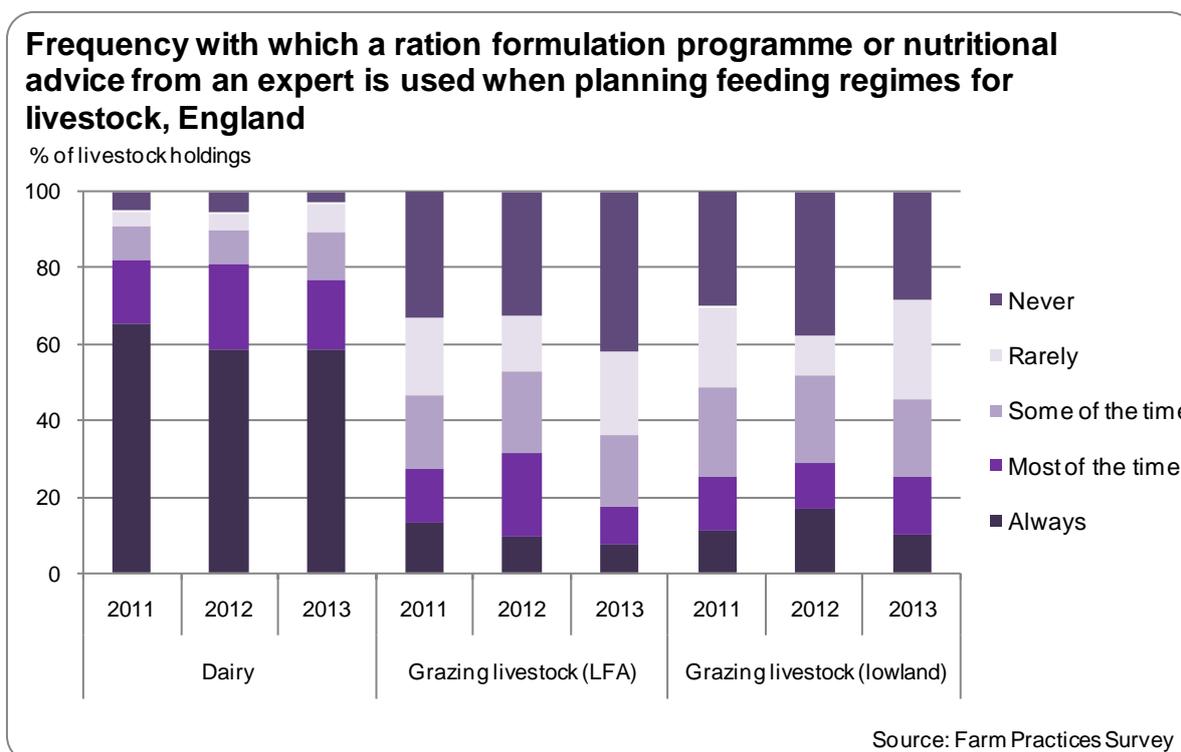
The FPS suggests that the majority of farmers check and calibrate the spread pattern of their fertiliser spreader at least once a year. The proportions are higher for cereals and general cropping farms than for livestock farms. The BSFP asks whether spread pattern checks are undertaken using catch trays.

This source suggests that, in Great Britain, around a quarter of those spreading manufactured fertilisers never check the spread pattern of their spreader using catch trays.

The 2012 FPS also showed that 55% of farmers checked and corrected the rate for the fertiliser type more than once a year and a further 34% c once a year. This was little changed from 2011.

Livestock: feeding regimes

Livestock feeding regimes can play an important role in productivity and efficiency, factors which can impact on GHG emissions. The proportion of livestock farmers using a ration formulation programme or nutritional advice from an expert when planning feeding regimes (at least some of the time) is significantly higher for dairy farms (90% in 2013) than for grazing livestock farms (36% for LFA and 45% for lowland in 2013).

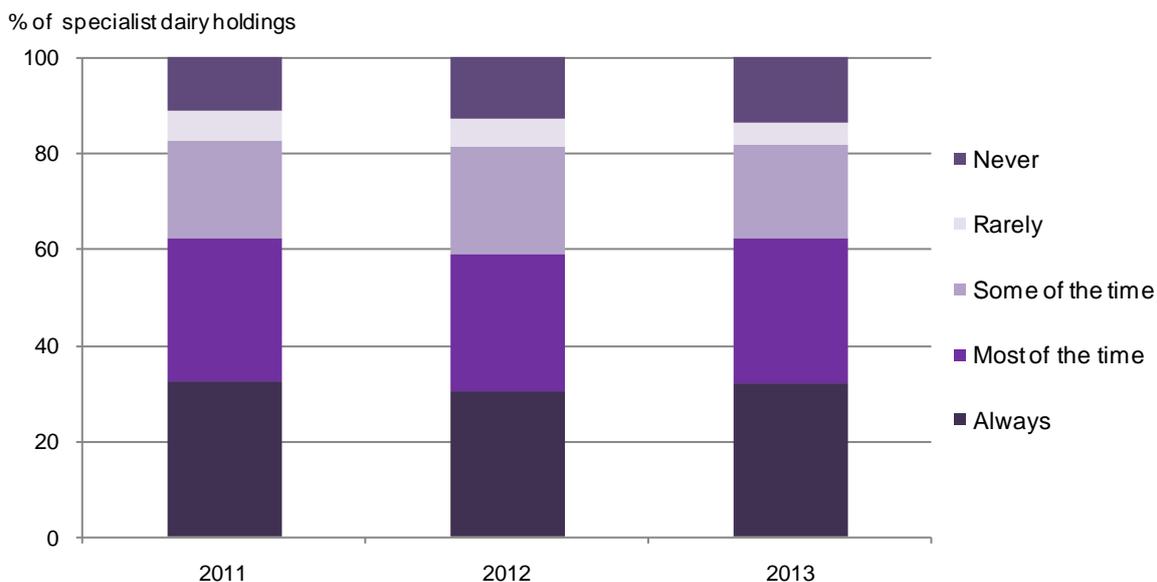


Livestock: breeding regimes

Breeding practices are another area which can contribute to herd and flock productivity and efficiency which in turn can reduce GHG emissions. The FPS shows that between 2011 and 2013 there has been little change in the frequency with which farmers use bulls with a high Profitable Lifetime Index (PLI)⁵² when breeding dairy cows. Around a quarter of farms with dairy cattle (23%) always use bulls with a high PLI, this rises to about 32% of farms where dairy is the main activity (see following chart). Farm size is also a factor in uptake, 79% of “large” farms always use bulls with a high PLI at least some of the time compared to 29% of “small” farms.

⁵² A PLI is a scoring system to identify cattle with the best ‘genetic merit’ used when choosing bulls to breed with dairy cattle. The PLI uses a combination of attributes including life expectancy, health, fertility and milk production.

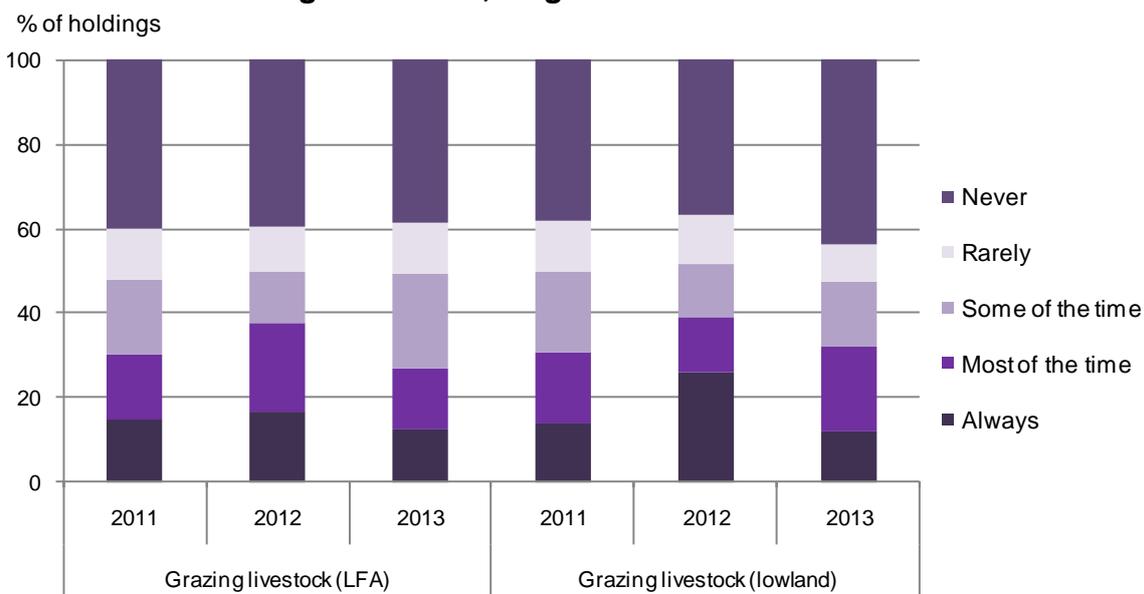
Frequency with which farmers use bulls with a high Profitable Lifetime Index when breeding dairy cows, England



Source: Farm Practices Survey

In 2013, 16% of farms breeding beef cattle and 10% of those breeding lambs always used bulls/rams with a high Estimated Breeding Values (EBV)⁵³. These holdings accounted for 24% of beef cattle and 11% of lambs at June 2012. Focusing on only upland and lowland grazing livestock farms the percentages using bulls or rams with a high EBV are fairly similar, with around half doing this at least some of the time.

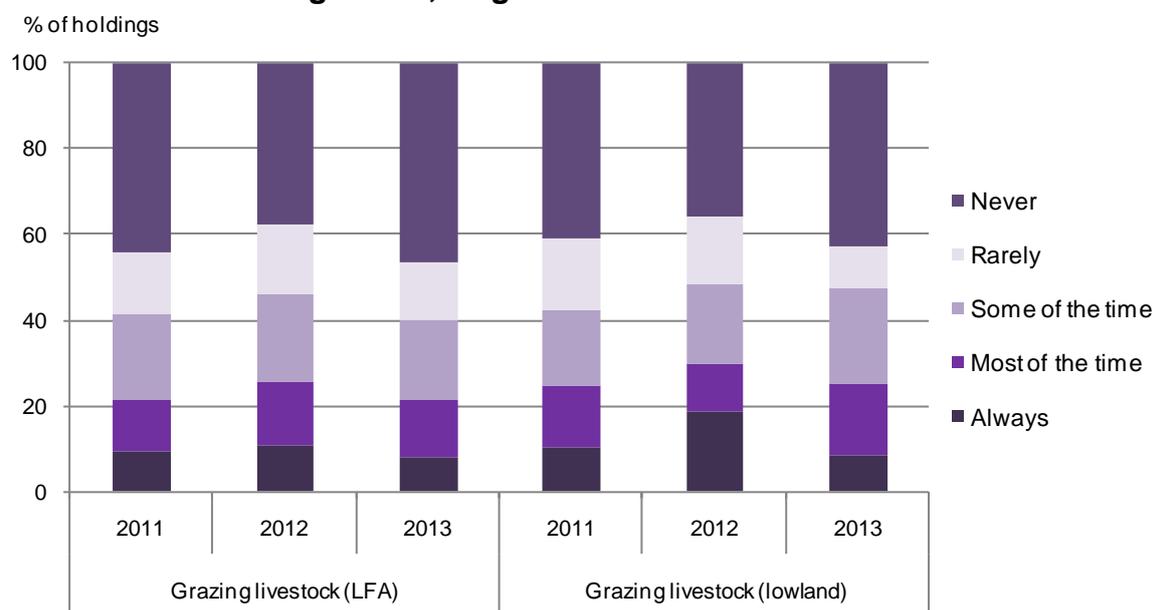
Frequency with which farmers use bulls with a high Estimated Breeding Value when breeding beef cattle, England



Source: Farm Practices Survey

⁵³ Estimated Breeding Values (EBV) estimate the genetic worth of animals using desirable traits such as meat production.

Frequency with which farmers use rams with a high Estimated Breeding Value when breeding lambs, England



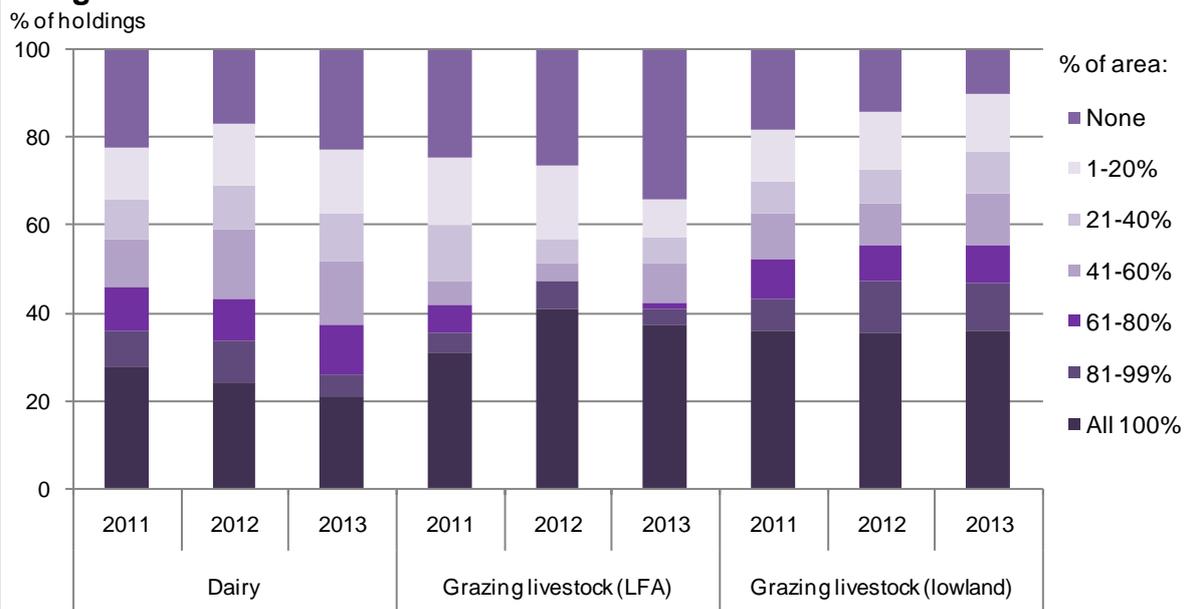
Source: Farm Practices Survey

Grassland

Sowing a clover mix on temporary grassland has a variety of benefits. For example, clover's nitrogen fixing properties (although not suitable for all soil types) can reduce the amount of nitrogen applied and improve grassland yields. The following chart shows that most livestock farmers across each of the three farm types shown plant some proportion of their temporary grassland with a clover mix. Overall, in 2013, 79% of livestock farms indicated that a proportion of their temporary grassland had been sown with a clover mix, little changed from 2011 and 2012.

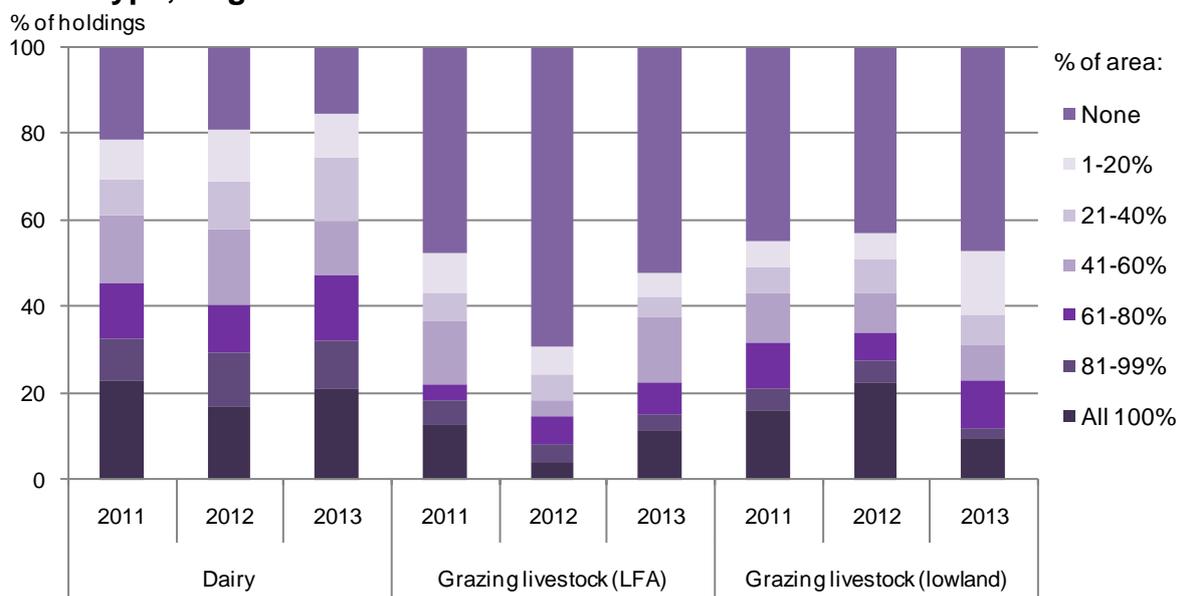
High sugar grasses can help to improve the efficiency of animal production (e.g. improved milk yields and faster live weight gain) and at the same time reduce GHG emissions. In 2013, 63% of livestock farms had sown high sugar grasses on temporary grassland, again showing little change from the two previous years. Dairy farms are more likely to have sown high sugar grasses than grazing livestock farms.

Proportion of temporary grassland planted with a clover mix by farm type, England



Source: Farm Practices Survey

Proportion of temporary grassland planted with high sugar grasses by farm type, England

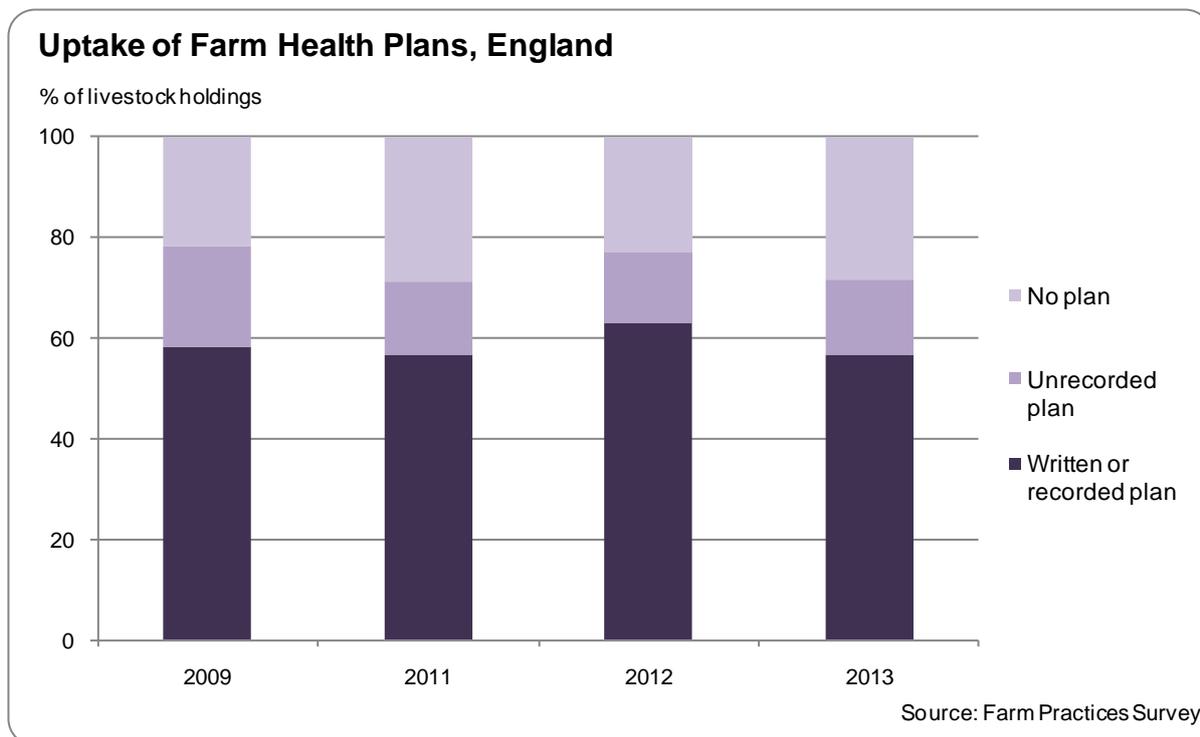


Source: Farm Practices Survey

Farm health planning

Farm health planning can benefit livestock farmers by helping to prevent disease and improve performance. This can help to reduce GHG emissions over the course of an animal's lifetime by, for example, reaching finishing weights earlier and achieving higher feed conversion rates. In 2013, 72% of livestock farms had a farm health plan. Although uptake is lower than in 2012 (77%), the reduction is not statistically significant. The majority of farms had written or recorded plans (57%) and an additional 15% had unrecorded plans. Dairy farms have the greatest uptake of farm health plans

(98% in 2013). Almost all of these (97%) were written or recorded. In 2013, the majority of farm health plans (63%) were created with the assistance of a vet or advisor, similar findings to the 2009 to 2012 surveys.



In 2013, of those livestock farms with a farm health plan, 36% used it “routinely” to inform disease management decisions whilst a further 43% used it “when possible”. Routine use was significantly greater on specialist pig and poultry farms (71%) and dairy farms (45%) than on other farm types.

Of those livestock farms without a farm health plan, 11% planned to complete one with some assistance over the next 12 months. These were more likely to be dairy farms than other farm types.

Covering of manure / slurry stores and slurry separation

Covering manure and slurry stores primarily prevents the loss of ammonia to the air. However, increased use of covers could lead to improved nitrogen use efficiency and a reduction in manufactured nitrogen fertiliser inputs. Of those farms with facilities to store manure or slurry, no more than a fifth of stores were covered (Table 14). When taking into account the variability in the results, the proportion of covered stores has changed very little between 2010 and 2013.

Separating the suspended solids from slurry allows the two manure streams to be handled separately. The solid fraction can be stored on a concrete pad or in a field heap, while the liquid fraction can be stored and transported/pumped to fields for land application. Separation can reduce storage space and improve the efficiency with which nitrogen is applied to land which has the potential to reduce emissions. Results from the 2013 FPS show that, of those livestock holdings with slurry storage facilities, 7% had a separator; similar findings to 2011 and 2012. A further 3% were planning to get one in the future.

Table 14: Proportion of livestock holdings that have covered storage facilities for manure and /or slurry

Type of store	2010		2011		2012		2013	
	% of holdings	95% CI						
Solid manure stored in heaps on a solid base	7	± 1	6	± 1	7	± 3	7	± 2
Solid manure stored in temporary heaps in fields	#	#	1	± 0	0	± 0	0	± 0
Slurry in a tank	19	± 3	15	± 3	12	± 6	14	± 4
Slurry in a lagoon	2	± 1	1	± 1	0	± 0	1	± 1
Slurry in another type of store	14	± 3	12	± 6	19	± 20	9	± 6

Source: Farm Practices Survey

Indicates that data has been suppressed to prevent disclosure of information about individual holdings.

On-farm anaerobic digestion

Anaerobic digestion is the process in which plant and animal waste material is converted into useful products by micro-organisms in the absence of air. The process allows a close management of animal slurries and manures and reduces the loss in nutrients. The methane released can be used to provide heat and power. The remaining material is rich in nutrients and can be used as a fertiliser.

Survey data suggests a significant increase in awareness of anaerobic digestion between 2008 (57% of farmers) and 2011 (71% of farmers). However, there are significant start-up and running costs and the number of farmers processing waste by anaerobic digestion has remained relatively small; the proportion processing slurries, crops or other feedstocks has remained relatively constant since 2008 at around 1%, whilst the number planning to do so in the future has declined slightly from 7% in 2008 to 3% in 2012.

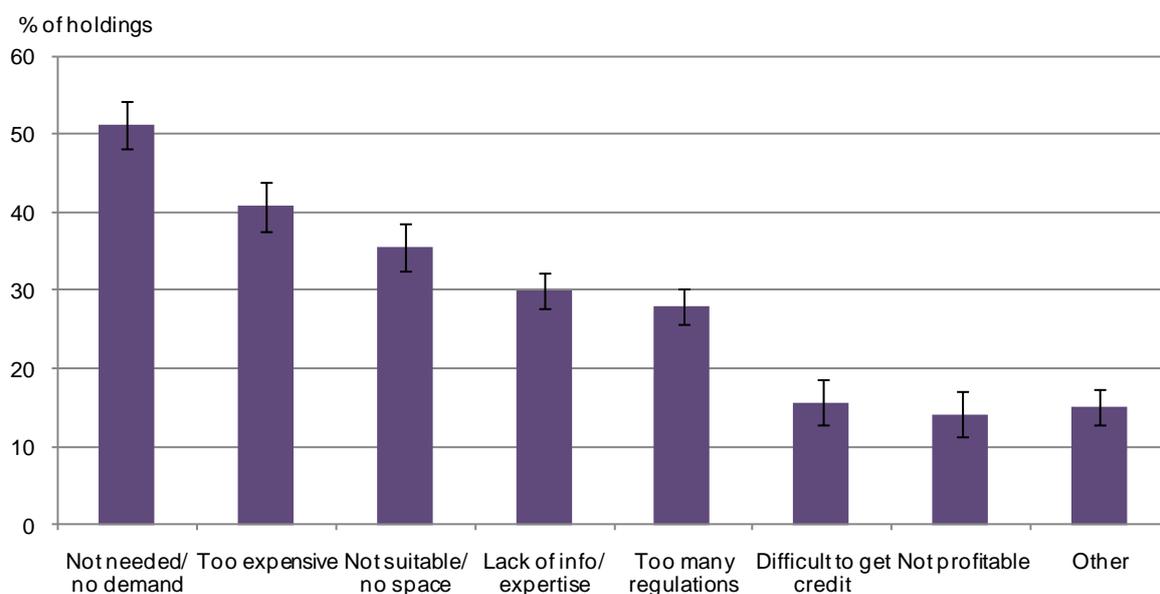
Table 15: Proportion of holdings already, or planning to, process slurries, feedstocks or crops by anaerobic digestion

	2008		2011		2012		2013	
	% of holdings	95% CI						
Already processing	1	± 1	1	± 1	1	± 1	1	± 1
Planning for the future	7	± 2	5	± 1	3	± 1	3	± 2
No plans to use AD	92	± 2	94	± 1	96	± 1	96	± 1

Source: Farm Practices Survey

In 2012, further information was collected on the reasons preventing farmers from processing waste by anaerobic digestion. The most commonly given reason was a lack of demand, although there was some variation by far type and size. Dairy farms and large/medium farms were most likely to cite expense (73%).

Reasons preventing farmers from processing waste by anaerobic digestion, England



Source: Farm Practices Survey 2012

3.3 Farmer attitudes and uptake of on-farm mitigation measures: further developments

Farm Practices Survey

The 2013 FPS repeated many of the questions from previous surveys in 2011 and 2012 but included some additional questions relating to attitudes and awareness of GHG emissions, the upgrading of slurry stores and the calibration of manure and slurry spreaders. Although considered a relevant mitigation measure, it was not possible to include questions on the frequency of manure removal from animal housing on this occasion. In 2013/14, results on soil testing and fertiliser spreaders will be compared with other data sources such as part of the British Survey of Fertiliser Practice in order to better align data collection and presentation.

Farm Business Survey

As part of the 2012/13 Farm Business Survey, detailed information is being gathered on management practices relating to:

- Feed and forage bought, processed and used on farm,
- Animal housing, turn in/turn out dates, start and end dates for lambing,
- Weights of animals.

Results will be available in 2014.

Section 4: Emerging evidence

This section highlights new evidence, research and development around greenhouse gas (GHG) emissions and mitigation in the agricultural sector

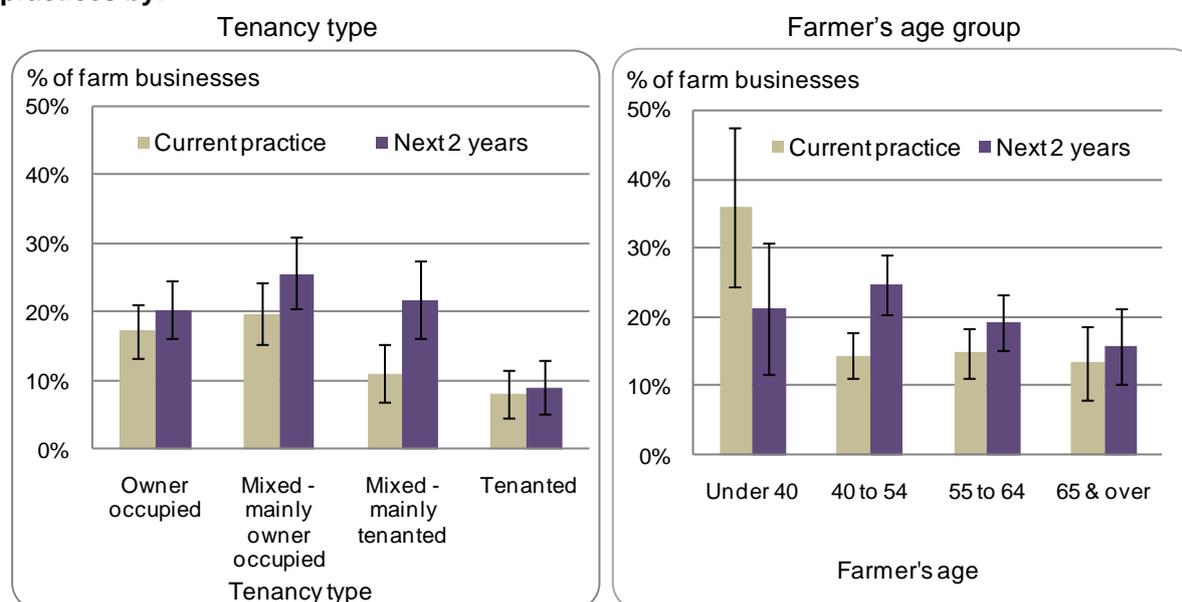
4.1 Activities to generate energy, reduce GHG emissions and adapt to climate change

The business management practices module of the 2011/12 Farm Business Survey⁵⁴ asked farmers in England a series of questions about practices to generate energy, reduce GHG emissions and adapt to climate change⁵⁵. Farmers were asked to identify practices that they had already adopted and those additional practices they intended to carry out in the next 2 years. The results provide a picture of possible factors influencing uptake and profile the type, size and location of farms that have adopted, or are intending to undertake, these practices.

Energy generation

16% of farm businesses were currently undertaking energy generation practices. Farm type, farmer's age, tenancy status, agri-environment scheme participation and economic performance were all significant factors⁵⁶ influencing uptake. Solar panels were the most common practice (by 10% of farm businesses) with uptake greatest by younger farmers (26%) and on poultry farms (24%).

Proportion of farm businesses carrying out / intending to carry out energy generation practices by:



21% of farm businesses indicated that they intended to carry out additional energy generation practices in the next two years.

⁵⁴ Full results from the business management practices module are available on the internet at: <https://www.gov.uk/government/publications/farm-business-management-practices>

⁵⁵ Detailed results for these questions can be found on the internet: <https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/farm-practices-survey>

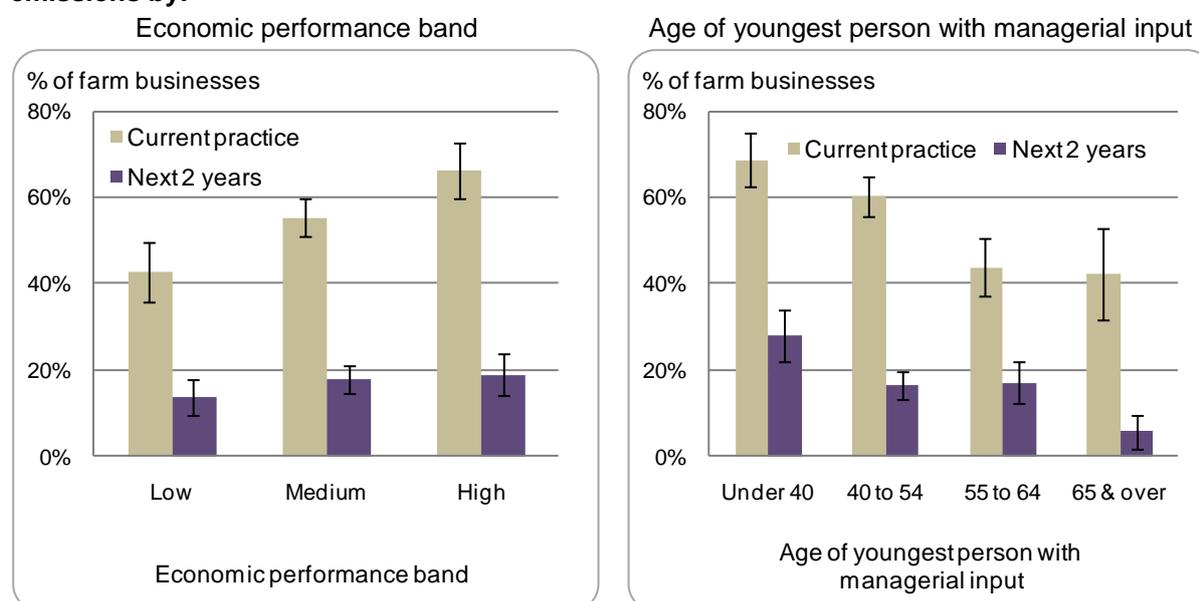
⁵⁶ Poultry farms, those farms with a farmer aged under 40, owner occupied/mainly owner occupied farms, those in agri-environment schemes and high performing farms were more likely to be undertaking energy generation practices.

Practices to reduce GHG emissions

More than half of farm businesses (55%) were undertaking practices to reduce GHG emissions. Improving nutrient management was the most common practice identified (by 32% of farm businesses) with improved soil drainage, improved slurry/manure management and fuel efficient/low emission tractors each being undertaken by 20-25% of businesses. Compared to other farm types, dairy farms were more likely to have at least one GHG mitigation practice (74%) with 58% having 'improved slurry and manure management' and 43% 'improved nutrient management'.

Uptake of mitigation measures increased with economic performance but was not found to be a significant factor influencing overall uptake after allowing for other factors. Those farms where the youngest person with managerial input was aged less than 55 were significantly more likely to be undertaking at least one mitigation practice.

Proportion of farm businesses carrying out / intending to carry out practices to reduce GHG emissions by:



Just 17% of farm businesses indicated that they would undertake additional mitigation measures in the next two years. There was no significant difference in overall intention or in the type of measure between those already undertaking mitigation measures and those not currently doing so.

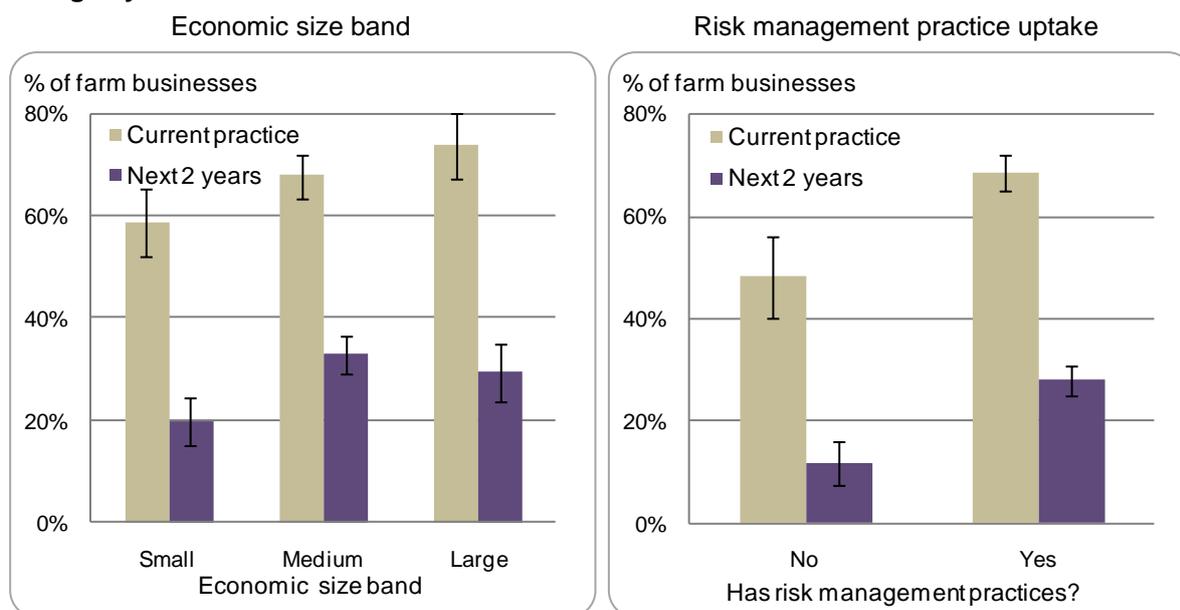
Climate Change adaptation

Overall, 64% of farm businesses were undertaking at least one of the listed practices to adapt to climate change. These farms were more likely to be cropping than livestock farms, to be larger farms, to be in an agri-environment scheme and to be undertaking risk management practices⁵⁷. Whilst low economically performing farms were less likely to be undertaking any of these practices than better performing farms⁵⁸ the difference was not significant after allowing for other factors.

⁵⁷ Defined as undertaking at least one of the following: animal health or crop protection insurance, using bio-security measures, markets or purchases some commodities on contract basis with agreed price, uses selling groups and pools to market commodities, making use of 'options'.

⁵⁸ 54% of low performing farms were undertaking at least one of the listed adaptation practices compared to 67% of medium and 70% of high performing farms.

Proportion of farm businesses carrying out / planning to carry out practices to adapt to climate change by:



A quarter of farm businesses indicated that they would undertake additional climate adaptation practices in the next 2 years.

4.2 Digest of Ongoing Research Projects

A range of ongoing research projects are underway to support the R&D platform and efforts by the agricultural sector to reduce emissions. These cover livestock and forage improvement, crop improvement, more efficient use of fertilisers on crops and protein in animal diets and collation of evidence to encourage implementation of the industry's GHG Action Plan. Evidence generated by these projects will feed into the inventory improvement programme. Details of the projects can be found in the [Appendix at \(vi\)](#).

4.3 Update on the Greenhouse Gas Platform

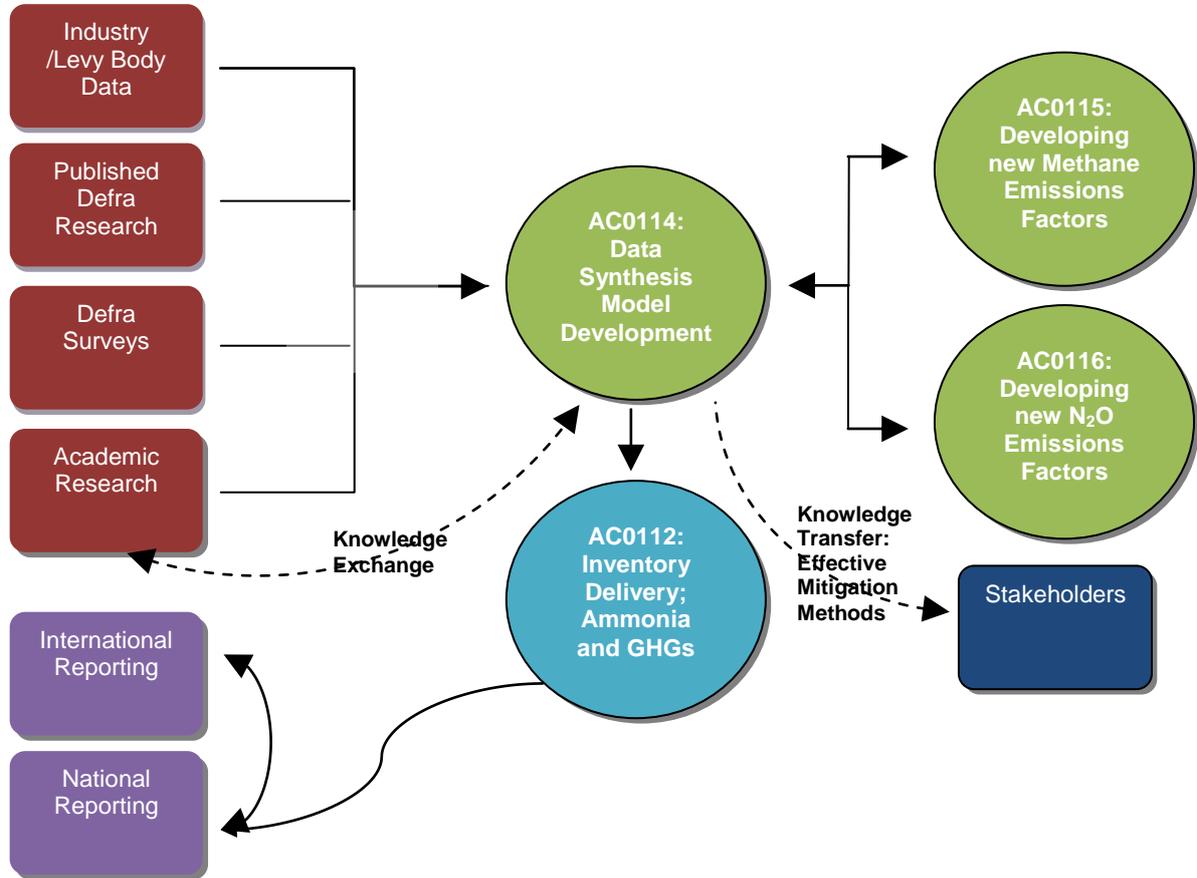
Defra and the Devolved Administration Governments are currently supporting the development of an improved Greenhouse Gas Inventory for direct methane (CH₄) and nitrous oxide (N₂O) emissions from agriculture through a five-year research programme, the Greenhouse Gas Platform. The Platform comprises three, closely-linked projects, which will improve the accuracy and resolution of the United Kingdom's national reporting system. This will be achieved through the development of country-specific emission factors to reflect current and changing specific practices and production systems within agriculture. This will enable forecasting and monitoring of performance against the wider UK target emission reductions set by the UK Climate Change Act (2008).

The Greenhouse Gas Platform consists of the following three projects:

- **Data Management and Modelling:** project AC0114 – brings together existing and newly-researched activity and emissions data to create a new, more-disaggregated inventory model and a set of revised emission factors with an assessment of uncertainty.
- **Methane ResearchCH₄ project:** AC0115 – developing new CH₄ emission factors from different ruminant species, breeds and genotypes (and their manures) under a variety of farming systems and representative farm business structures.

- Nitrous Oxide InveN₂Ory project: AC0116 – improving quantification through measurement and modelling of N₂O emissions from different nitrogen inputs as influenced by season, climate, crop, soil types and conditions, and land management representative of UK farming systems.

Figure 3: GHG Research Platform



Outputs from the three projects are being closely coordinated with concurrent Defra project AC0112 (Inventories of ammonia and greenhouse gases from UK agriculture) which delivers an annual UK GHG reporting mechanism fit for submission to the United Nations Framework Convention on Climate Change (UNFCC).

Considerable progress has been made across the Platform projects. In AC0116, experimental work has continued with measurements of N₂O emissions from a range of fertiliser, manure, urine and dung treatments applied to arable and grassland sites across the UK at different times of the year. These experiments are also assessing a number of mitigation strategies. A complementary laboratory-scale experiment to assess some of the factors controlling the efficacy of the nitrification inhibitor, DCD, to reduce N₂O emissions, has just been completed. Models are being used to explore the effect of soil types and climatic zones on N₂O and the effect of specific mitigation measures. Verification experiments to quantify the spatial and temporal uncertainty of N₂O emissions and the output from models have taken place using a range of methods at the farm and field scale.

In AC0115, measurements of enteric CH₄ emissions from dairy cattle, beef cattle and sheep of different breeds have been made using the SF₆ technique for outdoor grazing animals and more controlled chamber measurements with a range of feedstuffs. Laboratory assessments of the CH₄ producing potential and volatile solids content of manure samples from the animal chamber

experiments are on-going. Pilot-scale measurements of CH₄ emissions from slurry storage have been initiated, assessing the impact of storage temperature and also potential mitigation techniques. A range of novel approaches for measuring methane emissions have been tested, including the online collection of breath in milking machines and feed hoppers.

In AC0114, international literature reviews have been completed for direct N₂O emissions from soils and enteric emissions, to aid interpretation of the UK measurements. Reviews are currently underway exploring the efficacy of on-farm mitigation measures such as the use of cover crops, nitrification inhibitors, manure management techniques and dietary manipulation. Much survey data have been scrutinised to assess their suitability for use in tracking the uptake of these measures in UK. Recommendations have been made on possible questions to add to national surveys on agricultural practices to improve data capture. Revised estimates of uncertainty within the current inventory have been produced and work is underway exploring how best to communicate uncertainty to stakeholders.

The data and metadata generated by all three projects will be held in an online archive being developed to house a number of Defra-funded datasets. This process is managed by project AC0114, and an information model has been produced to capture relevant information about how data was generated together with who, why, where and when it happened. Guidance is being developed in order to instruct scientists about how to document their datasets appropriately to maximise their discovery and re-use.

Annual workshops have been held to present updates on progress within the Platform to representatives of government and industry, and to seek opinions on new methods for collating data on changes in farm practices. Project partners have also represented the UK at Global Research Alliance (GRA) committee meetings and related GRA events. A number of scientific papers have been published in international journals on subjects ranging from an experimental method for measuring N₂O emissions at the field scale to the effect of dietary treatments on rumen fermentation.

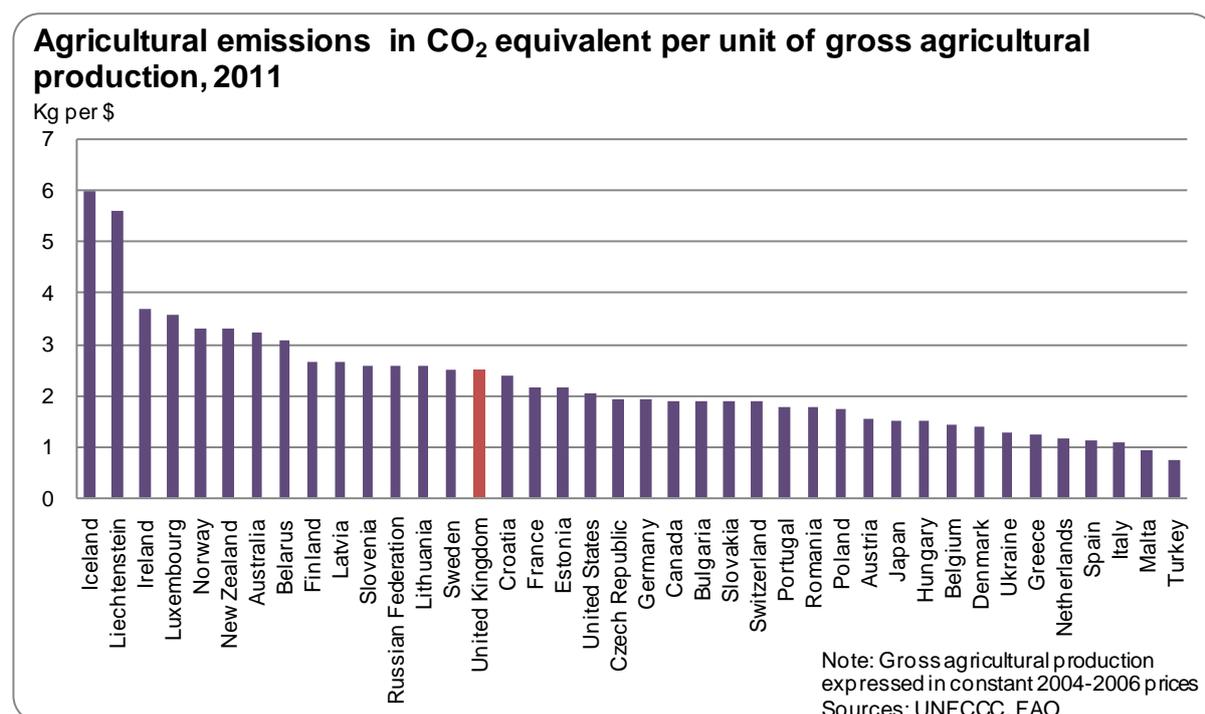
Updates on progress within each of the projects, in addition to newsletters and details of past/future events can be found on the Platform website at: www.ghgplatform.org.uk . More information on the Greenhouse Gas R&D Platform projects can also be obtained by contacting Tom Misselbrook: tom.misselbrook@rothamsted.ac.uk or Laurence Smith: laurence.s@organicresearchcentre.com.

Section 5 International comparisons

This section provides international comparisons of both the productivity and greenhouse gas (GHG) intensity of agriculture. There are many challenges with making international comparisons due to differing farming systems, lack of comparable data and, in some instances, a lack of data. In exploring international comparisons for GHGs, two illustrative examples are given for cereals and milk. Here, where available, yields are considered alongside factors associated with risk of high GHG intensity.

5.1 International comparisons of GHG emissions per unit of agricultural production

Comparisons of GHG emissions from agriculture across countries are difficult, not only because of data availability but also due to the differing types of agriculture undertaken in each country. It is possible to gain some indication of carbon intensity across countries by assessing agricultural emissions on the basis of emissions per unit of output (expressed in financial rather than biological or physical terms) although this is still largely driven by the mix of farming undertaken within different countries. The chart below considers the UNFCCC (Annex1)⁵⁹ countries in this way for 2010.



Spain, Italy and Greece have some of the lowest levels of emissions per unit of gross agricultural production. This reflects the production of high value crops with low emissions (for example, olives and grapes) in these countries. Countries such as New Zealand and Ireland have some of the highest levels of emissions per unit of gross agricultural production reflecting the dominance of

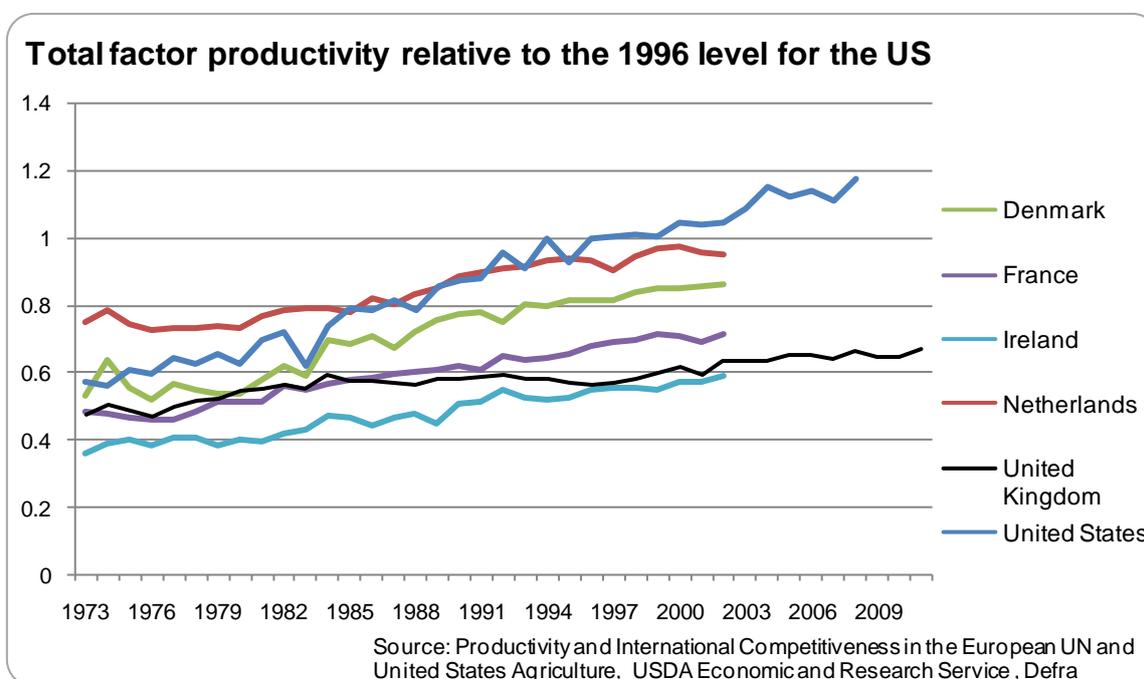
⁵⁹ **Annex I** Parties to the United Nations Framework Convention on Climate Change (UNFCCC) include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

livestock farming in those countries. The varying farming systems found in the UK lead to a lower level of emissions per unit of gross agricultural production. However, the preponderance of grassland, the largest population of sheep in Europe and a large population of suckler cows (which produce methane and are produced largely at very low or negative profit margins even though they may be comparatively efficient in production terms) place the UK amongst the upper half of UNFCCC countries when considering emissions in this way.

5.2 International comparisons of productivity

Total factor productivity provides a measure of the volume of output leaving the industry per unit of all inputs including fixed capital and labour. This measure can be affected by factors outside farmers' control, such as weather events.

The following chart shows trends in agricultural total factor productivity for a selection of countries. This is a relatively simple comparison and it will be affected by random events such as weather. Additionally, it does not take account of regional factors such as differing regulatory environments which may aid or limit productivity.



A more sophisticated approach to assess the efficiency of UK agriculture, which also enables comparison with other EU countries, is published at:
<http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/documents/farmeeficiency.pdf>

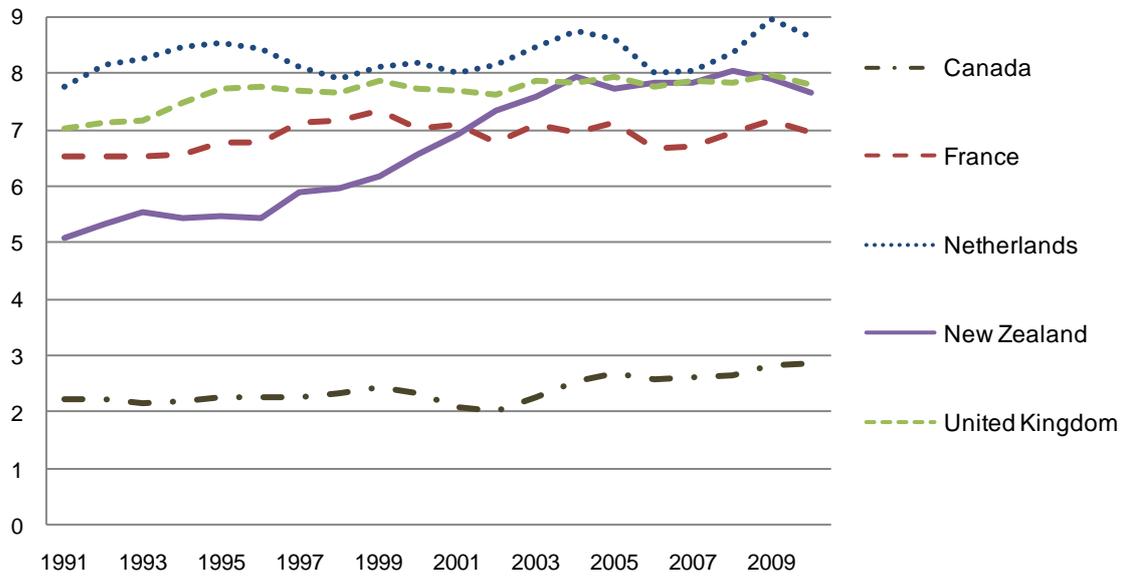
5.3 Yields and GHG risk factors: cereals

Wheat and barley are the main cereal crops produced in the UK. Other cereals which make significant contributions to world cereal production such as maize, sorghum and rice are not included here.

In 2011, the UK accounted for 2% of the world's production of wheat and 4% of barley (source: FAO). The following charts show trends in wheat and barley yields for a selection of countries with broadly similar characteristics (such as climate and type of crops grown) over the last twenty years. UK wheat and barley yields have both risen by around 10% over this period.

Wheat yields (3 year moving average) 1990 to 2011

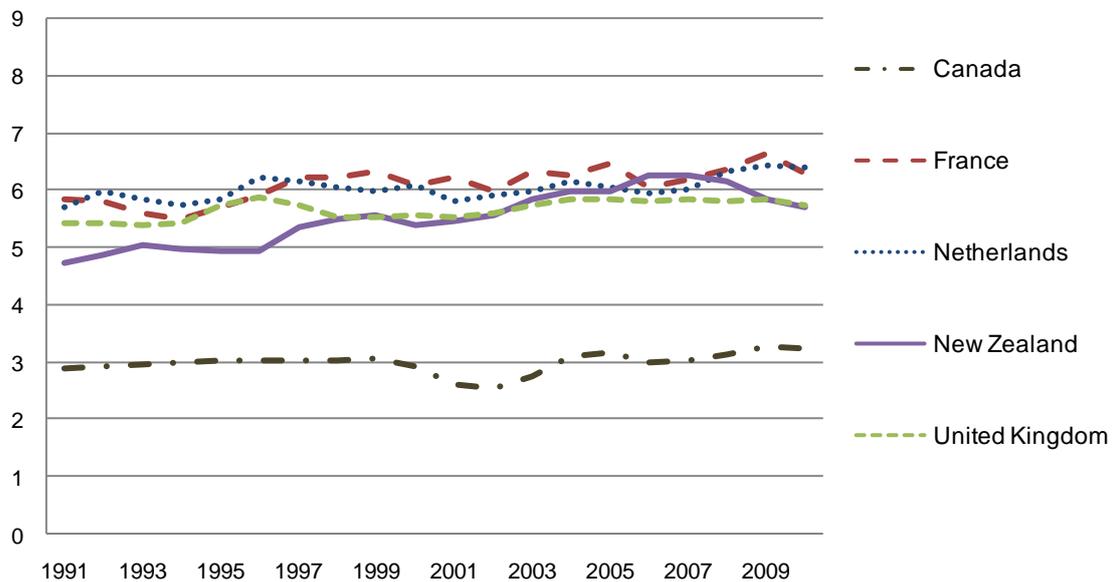
Yield (tonnes per ha)



Source: FAO

Barley yields (3 year moving average) 1990 to 2011

Yield (tonnes per ha)



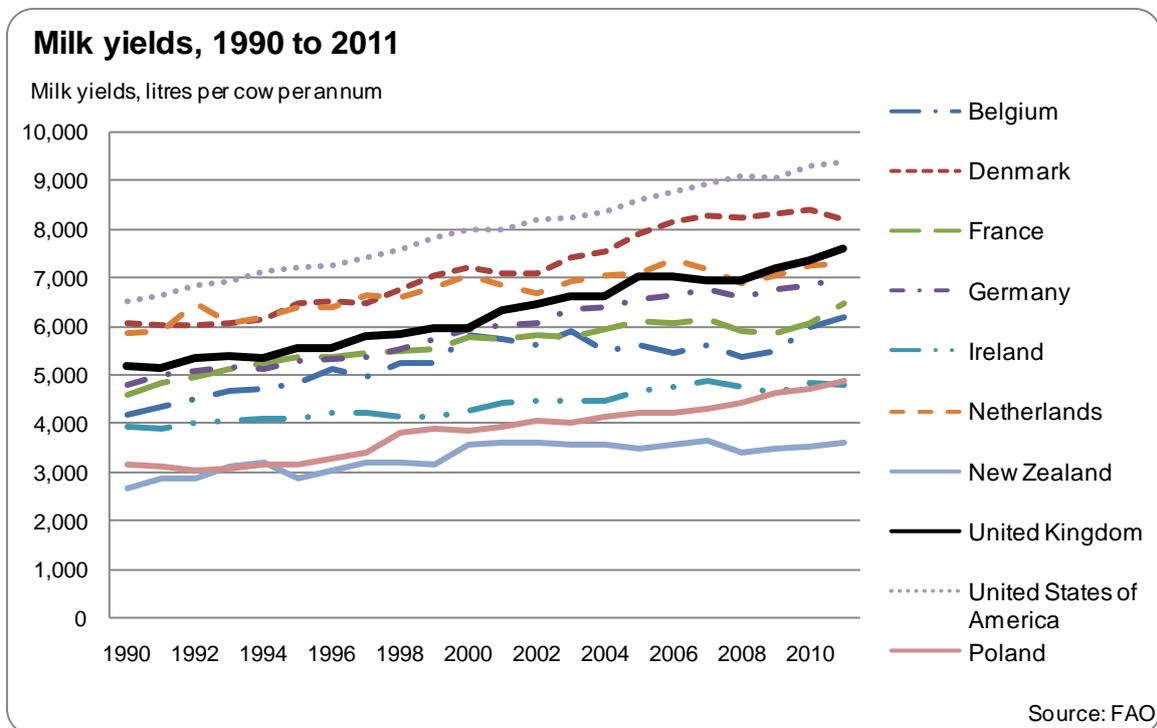
Source: FAO

Focussing on cereal yields has its limitations since nitrous oxide emissions are produced from sources other than cereals such as pastures and fodder crops etc. An approach which considers the efficiency of all nitrogen use (the percentage ratio of total nitrogen uptake by crops and forage to the total nitrogen available from fertiliser, livestock manure and other nitrogen inputs) and the balance is potentially enlightening in understanding risks of high GHG intensity. A comparison illustrating this can be found in Section 5.3 of the 3rd edition of Agricultural Statistics and Climate Change at: <https://www.gov.uk/government/publications/agricultural-statistics-and-climate-change>

5.4 Yields and GHG risk factors: milk

The chart below provides some international comparison of milk yields. Whilst yields do not provide a measures of the intensity of GHG emissions, for the countries shown, yields will be positively correlated with the levels of input (there is limited information available to quantify this). For example:

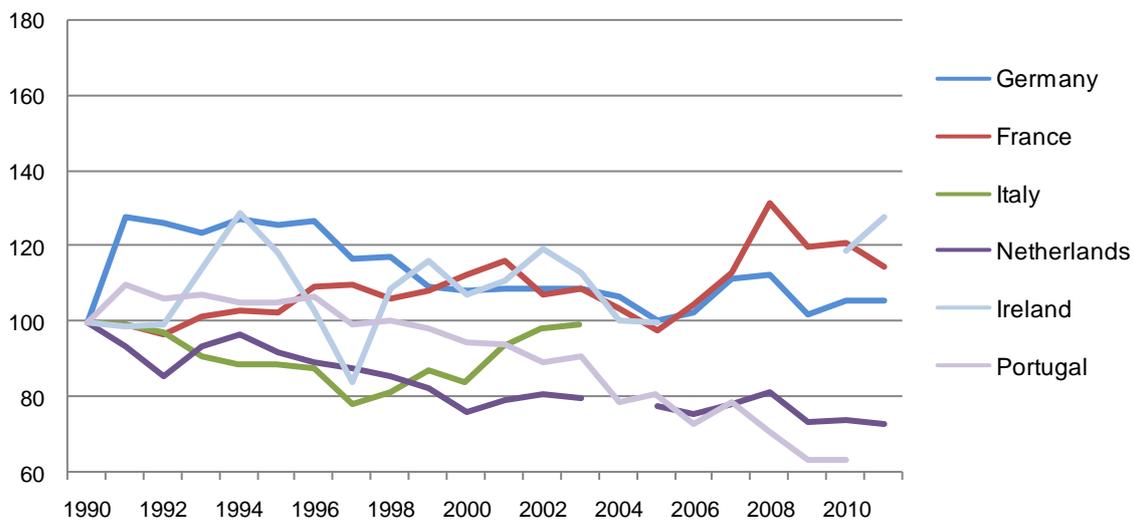
- New Zealand and Ireland's dairy production systems may be defined as low-input/low-output (around 4 thousand litres per cow/ year). Feeding is based mainly on grazing.
- The USA's dairy production systems may be classified as high-input/high-output (around 8,400 litres per cow/year). Feeding is based mainly on grass/maize silage and compound feed.
- Germany's dairy production systems may be classified as high-input/high-output (around 7,100 litres per cow/year). Feeding is based mainly on grass/maize silage and compound feed.



The following chart shows a country level comparison of milk production to dairy cow compound feed production (it is not possible to include the UK on this chart as comparable data are not available across all the years). As explained in Section 2.4 the ratio of milk produced to compound feed production can be used as a proxy measure for the emissions intensity of the dairy sector.

Ratio of dairy cow compound feed production to milk production per annum

Index 1990=100



Source: FAO, European Feed Manufacturers Federation

Appendix

(i) Methodology details for source data

Agricultural Price Index

<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/agricultural-price-indices>

AHDB auction market reports

<http://www.eblex.org.uk/markets/>

British Survey of Fertiliser Practice – section A2

<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/fertiliser-usage>

Cattle Tracing System - see under “cattle populations” heading:

<https://www.gov.uk/structure-of-the-agricultural-industry-survey-notes-and-guidance>

Cereal and Oilseed Rape Production Survey - methodology notes see page 20

<https://www.gov.uk/government/publications/farming-statistics-land-use-livestock-populations-and-agricultural-workforce-at-1-june-2012-uk>

Cereal and Oilseed Rape Production Survey - annual timeseries dataset

<https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june>

Emissions data methodology - compilation and methodology at:

http://www.decc.gov.uk/en/content/cms/statistics/climate_stats/gg_emissions/intro/intro.aspx

Farm Business Survey - data collection and methodology:

<https://www.gov.uk/farm-business-survey-technical-notes-and-guidance>

Farm Practices Survey 2013 (Greenhouse gas mitigation measures) - pages 37- 39,

Farm Practices Survey 2012 (Greenhouse gas mitigation measures) - page 3-4:

<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/farm-practices-survey>

Farm Practices Surveys 2008 - 2011 see under “National Archive” link:

<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/farm-practices-survey>

GB Animal feed statistics - “methodology” tab in GB retail production of animal feed stuffs dataset

<https://www.gov.uk/government/publications/animal-feed-production>

Poultry Slaughterhouse and Hatcheries Surveys - “information” tab in the UK Poultry meat production monthly dataset:

<https://www.gov.uk/government/publications/poultry-and-poultry-meat-statistics>

Integrated Poultry Unit Survey - “methodology” tab in the Integrated poultry feed production dataset:

<https://www.gov.uk/government/publications/animal-feed-production>

June Agricultural Survey:

<https://www.gov.uk/structure-of-the-agricultural-industry-survey-notes-and-guidance>

Market Segmentation in the Agriculture Sector: Climate Change (ADAS, 2010):

<http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17291&FromSearch=Y&Publisher=1&SearchText=market%20segmentation&SortString=ProjectCode&SortOrder=Asc&Paging=10>

Milk production data are from surveys run by Defra, RERAD, DARDNI on the utilisation of milk by dairies. Information on the survey methodology are given at:
<http://www.defra.gov.uk/statistics/foodfarm/food/milk/milk-utilisation/>

National Soils Inventory:
<http://www.landis.org.uk/data/nsi.cfm>

Slaughterhouse Survey - see monthly dataset "information" tab:
<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/cattle-sheep-and-pig-slaughter>

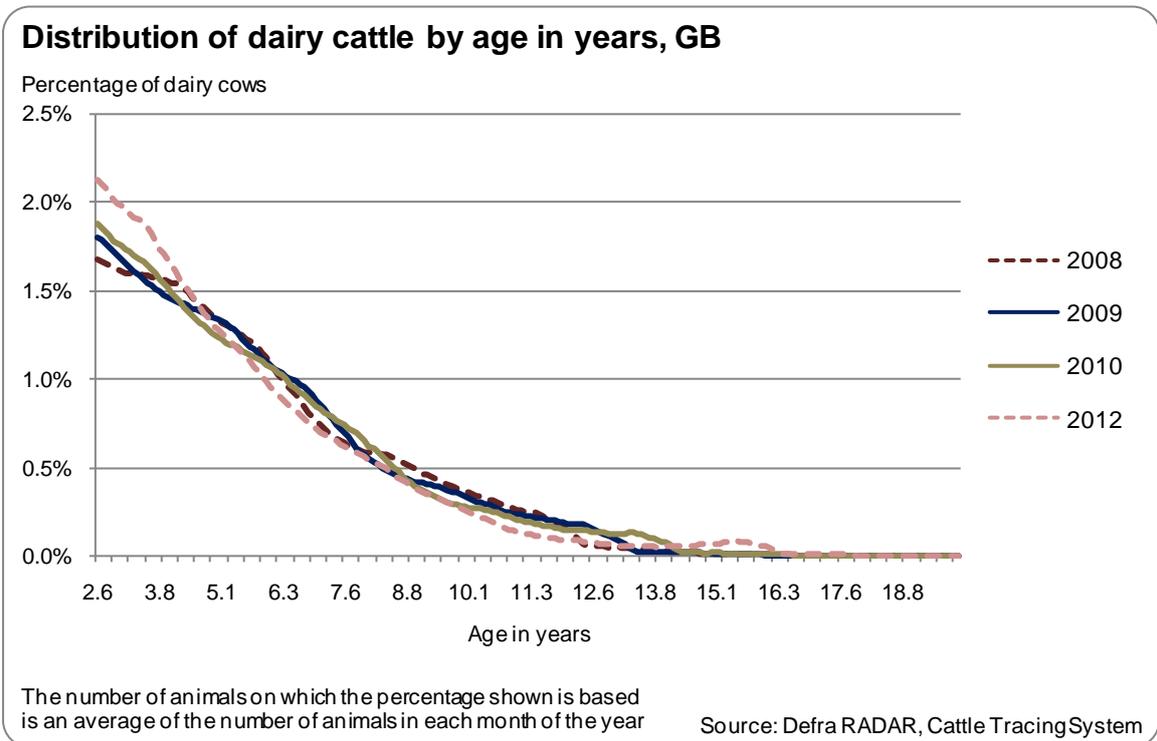
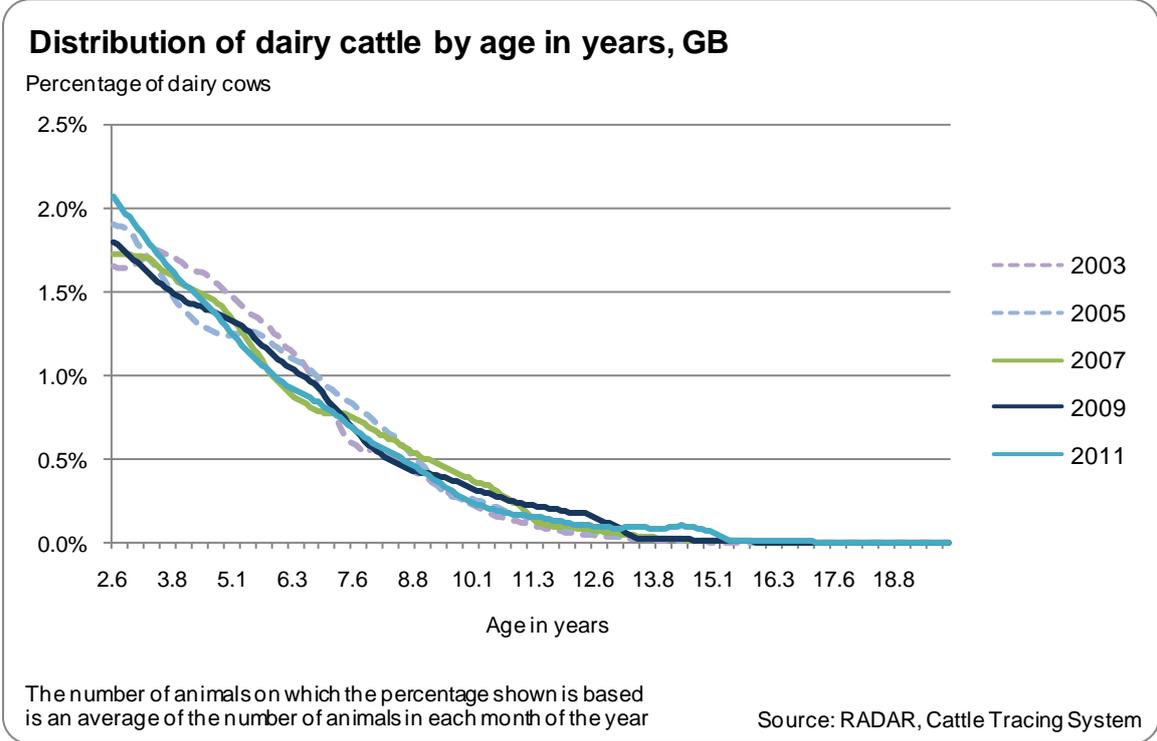
Soil Nutrient Balances

Information on the methodology for deriving Soil Nutrient Balances can be found under "Soils" at:
<https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs/series/agri-environment-analysis> See link "strategic evidence funded project: UK agriculture nutrient balances methodology review" for the ADAS report 'Soil Nutrient Balances Draft Report June 2010' which explores uncertainty.

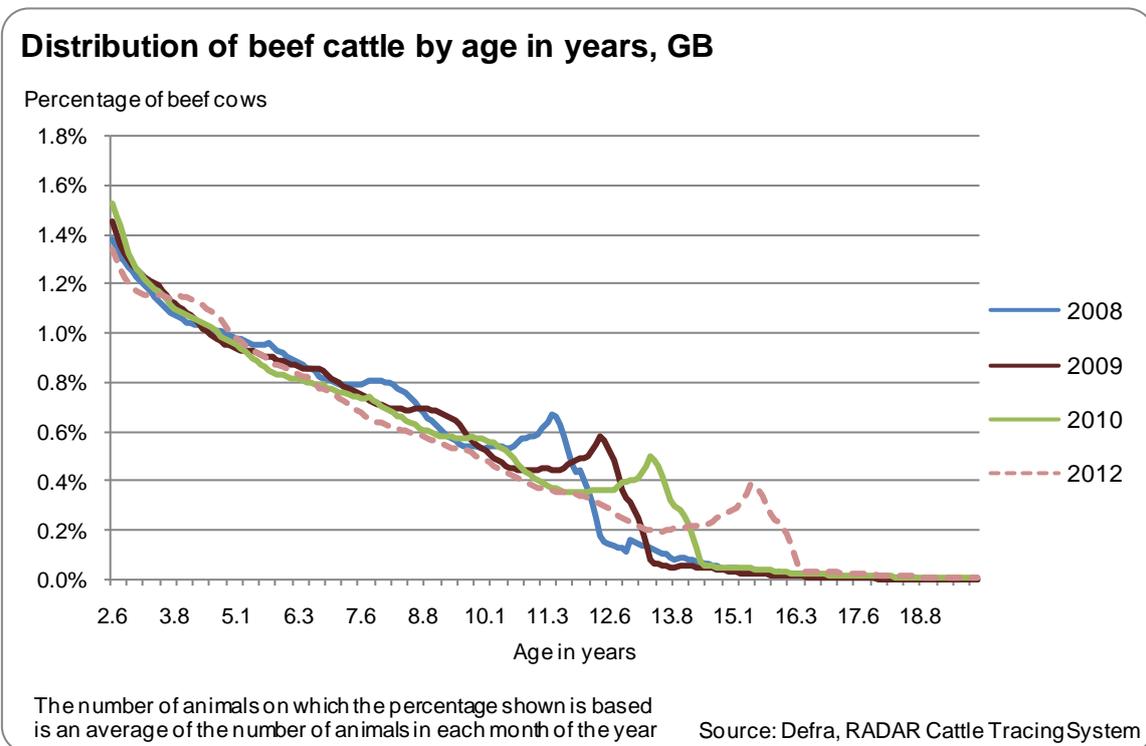
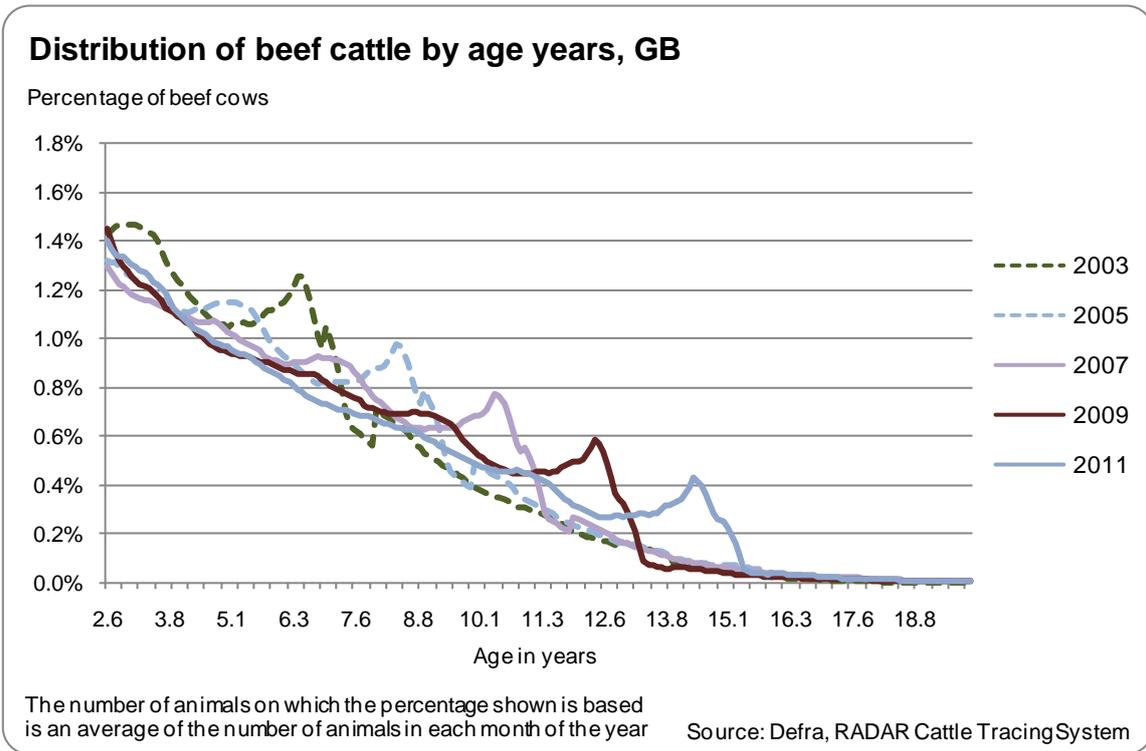
The Countryside Survey:
<http://www.countrysidesurvey.org.uk/about>

Understanding behaviours in a farming context: Bringing theoretical and applied evidence together from across Defra and highlighting:
<http://webarchive.nationalarchives.gov.uk/20130315143000/http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-obs-research-behaviour-aceopaper-nov08.pdf>

(ii) Distribution of dairy cows by age in months



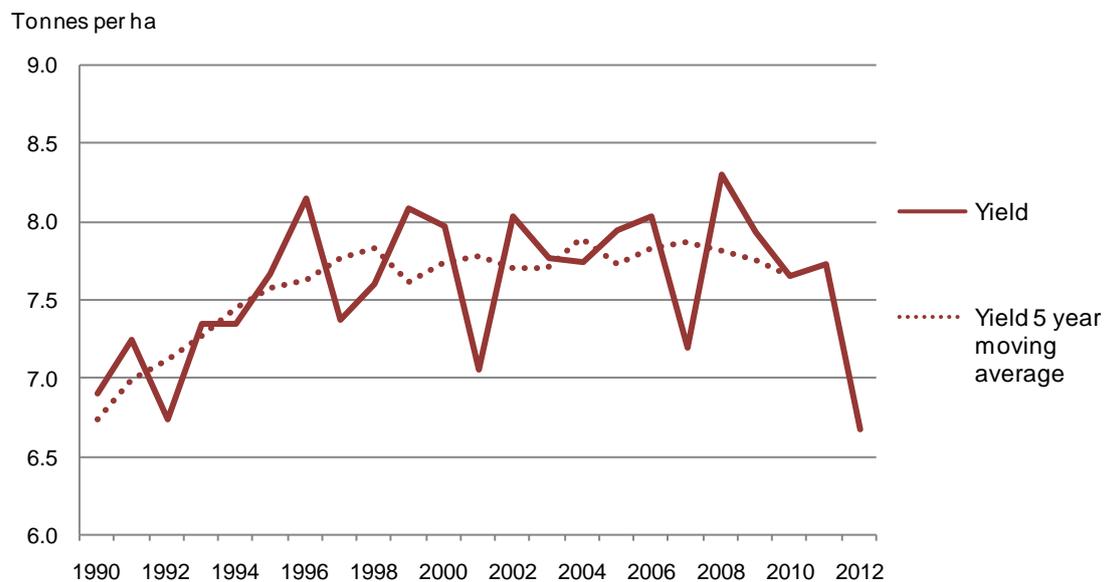
(iii) Distribution of beef cows by age in months



(iv) Wheat production per unit of manufactured N applied

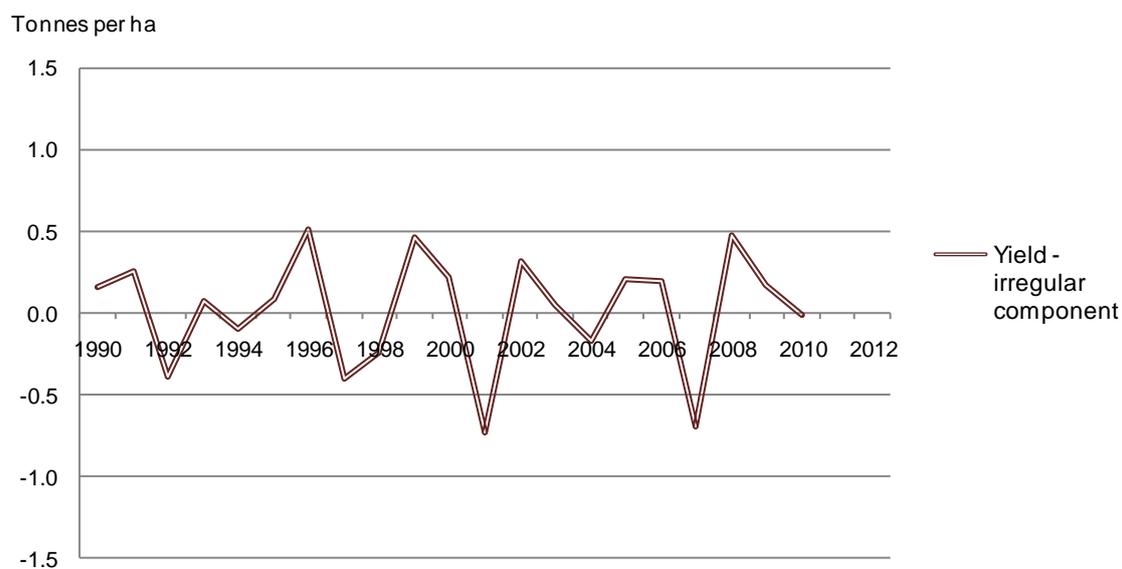
The following charts illustrate the magnitude of the trend and irregular components of the time series given in Section 2.9. The charts show wheat only, similar charts for the other crops shown in Section 2.9 can be obtained by contacting alison.wray@defra.gsi.gov.uk

Wheat yield, England



Source: Defra Cereal Production Survey

Wheat yield irregular component*, England

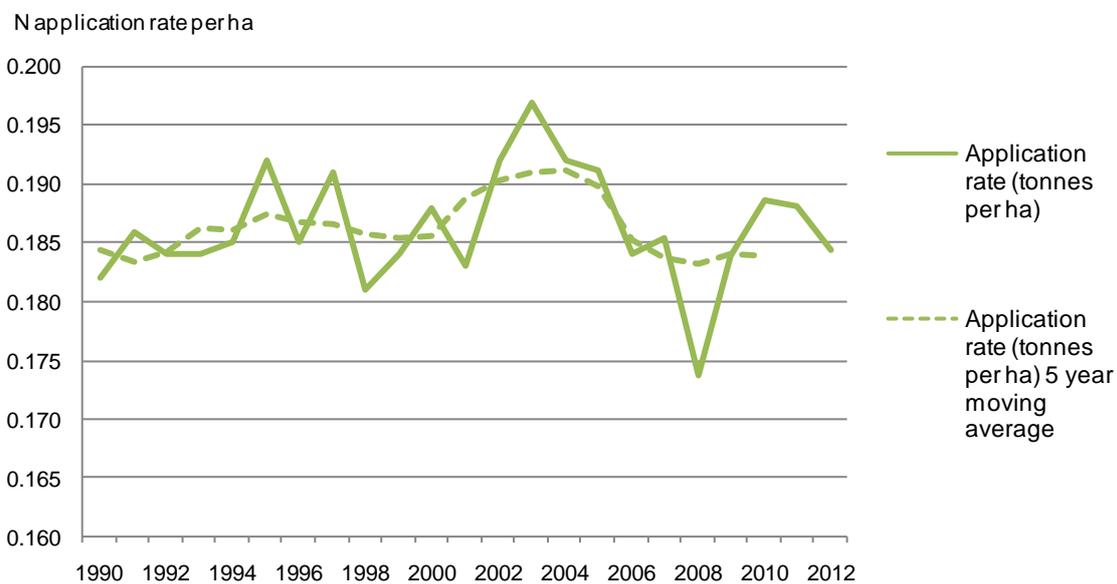


*Yield minus 5 year moving average of yield

Source: Defra Cereal Production Survey

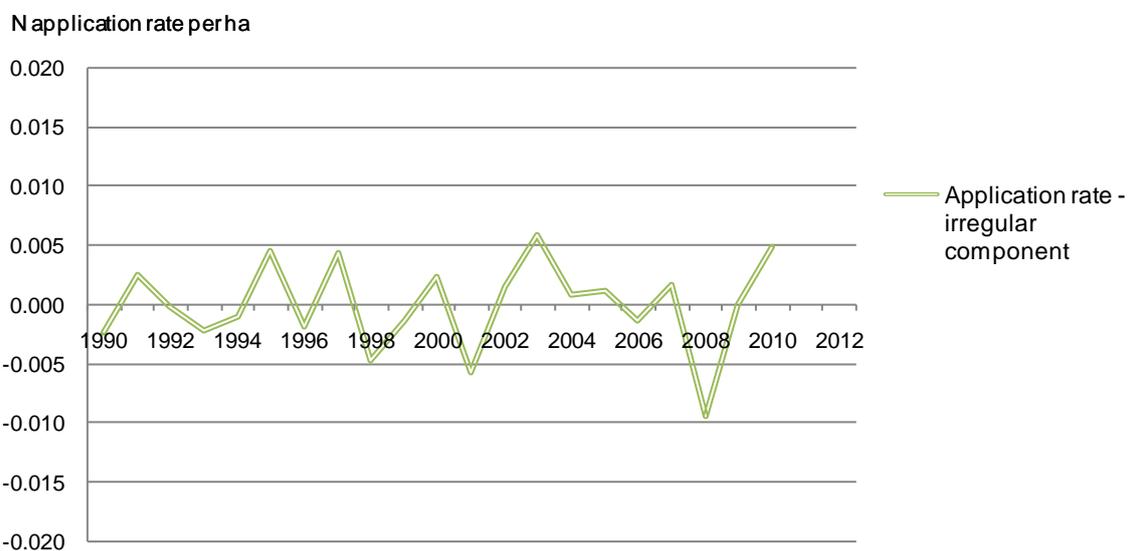
(iv) Wheat production per unit of manufactured N applied
(continued)

Wheat N application rate, England



Source: British Survey of Fertiliser Practice

Wheat N application rate irregular component*, England



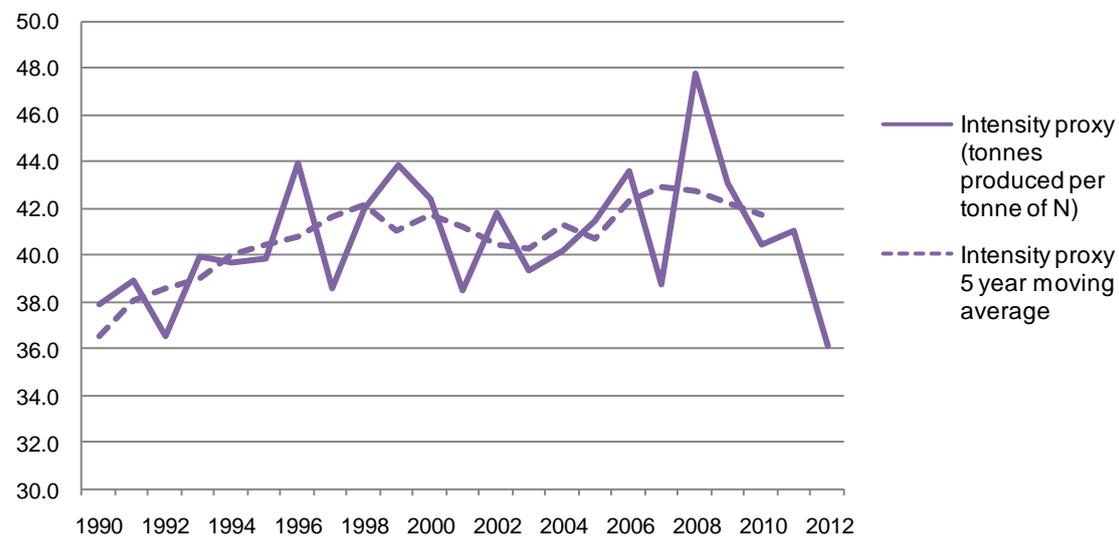
*N application rate minus 5 year moving average of N application rate

Source: British Survey of Fertiliser Practice

(iv) Wheat production per unit of manufactured N applied
(continued)

Wheat N intensity, England

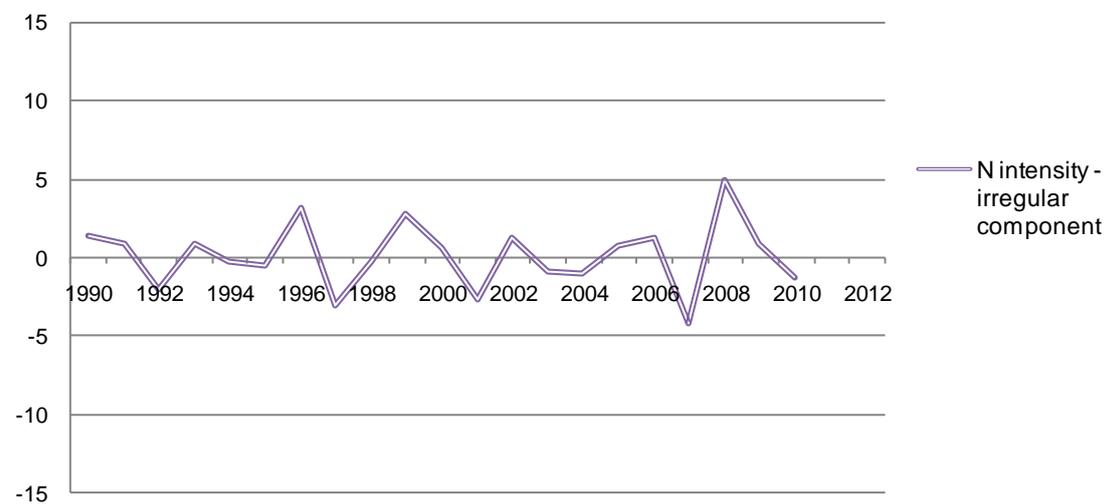
Tonnes of crop per tonne of N



Source: British Survey of Fertiliser Practice, Defra Cereal Production Survey

Wheat N intensity irregular component*, England

Tonnes of crop per tonne of N



*N intensity minus 5 year moving average of N intensity

Source: British Survey of Fertiliser Practice, Defra Cereal Production Survey

(v) Farmer attitudes and uptake of on-farm mitigation measures: confidence intervals

Uptake of nutrient management plans

Farm type	Percentage of holdings						95% confidence interval					
	2006	2007	2009	2011	2012	2013	2006	2007	2009	2011	2012	2013
Cereals	72	73	73	80	84	79	± 5	± 5	± 5	± 3	± 5	± 4
General cropping	71	70	71	78	79	79	± 6	± 7	± 5	± 4	± 7	± 6
Pigs & poultry	13	12	19	41	57	41	± 7	± 5	± 7	± 6	± 12	± 8
Dairy	45	52	60	70	71	68	± 6	± 6	± 7	± 3	± 6	± 5
Grazing livestock (LFA)	15	18	18	19	25	23	± 10	± 7	± 7	± 4	± 8	± 6
Grazing livestock (lowland)	19	16	24	33	37	33	± 8	± 5	± 7	± 4	± 8	± 5
Mixed	61	63	56	67	75	74	± 3	± 9	± 9	± 5	± 8	± 8
All farm types	46	49	50	56	62	57		± 2	± 3	± 1	± 3	± 2

Note: In previous publication, uptake was presented as a percentage of only those holdings considering a plan to be applicable. The results presented here are for the proportion of all farms covered by the FPS. **(Question asked 2009-2013: Do you have a nutrient management plan: “Yes”, “No plan”, “Not applicable”, Question asked 2006 & 2007: Do you have a recognised nutrient management plan?)**

Detailed breakdown of uptake of nutrient management plans in 2013

Farm type	Percentage of holdings			95% confidence interval		
	With a plan	Without a plan	Not applicable	With a plan	Without a plan	Not applicable
Cereals	79	17	3	± 4	± 4	± 2
General cropping	79	17	4	± 6	± 5	± 3
Pigs & poultry	41	26	33	± 8	± 8	± 8
Dairy	68	29	4	± 5	± 4	± 2
Grazing livestock (LFA)	23	58	20	± 6	± 7	± 6
Grazing livestock (lowland)	33	53	13	± 5	± 6	± 5
Mixed	74	20	6	± 8	± 7	± 5

For all holdings that answered the question in the farm type groups. Number of responses used: 2058.

Tools used to create a nutrient management plan, 2013

Farm type	Percentage of holdings						95% confidence interval					
	PLANET	Muddy Boots	Farmade/Multicrop	Tried and Tested	Other	Don't know	PLANET	Muddy Boots	Farmade/Multicrop	Tried and Tested	Other	Don't know
Cereals	31	20	20	15	22	12	± 5	± 4	± 4	± 4	± 4	± 4
General cropping	24	18	21	17	30	10	± 6	± 6	± 5	± 6	± 6	± 4
Pigs & poultry	43	12	13	6	29	14	± 14	± 9	± 10	± 6	± 13	± 9
Dairy	37	13	5	18	31	12	± 6	± 4	± 3	± 5	± 6	± 4
Grazing livestock (LFA)	7	11	3	17	56	21	± 8	± 9	± 3	± 11	± 14	± 11
Grazing livestock (lowland)	19	7	3	19	46	16	± 7	± 4	± 2	± 8	± 10	± 8
Mixed	27	19	9	20	26	14	± 9	± 6	± 4	± 8	± 8	± 7

Results are for holdings that have a nutrient management plan. Number of records used: 1348

Frequency with which the nutrient management plan is updated, 2013

Farm type	Percentage of holdings			95% confidence interval		
	Every year	Every 2 years	Every 3 years of longer	Every year	Every 2 years	Every 3 years of longer
Cereals	85	8	7	± 4	± 3	± 3
Other crops	84	8	9	± 6	± 4	± 4
Pigs & poultry	75	8	17	± 12	± 7	± 11
Dairy	75	14	11	± 5	± 4	± 4
Grazing livestock (LFA)	53	8	39	± 14	± 7	± 14
Grazing livestock (Lowland)	72	13	15	± 9	± 6	± 8
Mixed	79	15	6	± 8	± 7	± 4

Results are for holdings that have a nutrient management plan. Number of records used: 1346.

Frequency with which the nutrient management plan is referred to in a year

Farm type	Percentage of holdings				95% confidence interval			
	More than 10 times	5 to 10 times	Less than 5 times	Never	More than 10 times	5 to 10 times	Less than 5 times	Never
Cereals	13	24	62	1	± 3	± 4	± 5	± 1
Other crops	12	22	62	4	± 4	± 6	± 7	± 3
Pigs & poultry	6	17	72	6	± 6	± 11	± 13	± 6
Dairy	5	17	67	11	± 3	± 4	± 6	± 4
Grazing livestock (LFA)	2	5	72	21	± 3	± 7	± 13	± 12
Grazing livestock (Lowland)	1	10	77	12	± 1	± 5	± 8	± 6
Mixed	5	17	75	4	± 3	± 5	± 6	± 3

Results are for holdings that have a nutrient management plan. Number of records used: 1345.

Proportion of holdings with a manure management plan

Farm type	Percentage of holdings	95% confidence interval
Cereals	75	± 6
Other crops	77	± 7
Pigs & poultry	69	± 9
Dairy	87	± 3
Grazing livestock (LFA)	51	± 7
Grazing livestock (Lowland)	62	± 7
Mixed	83	± 7

For holdings that answered the question and for whom the question is applicable. Number of records used: 1570.

Proportion of holdings using each source of nutrient recommendations for the manure management

Farm size	Percentage of holdings		95% confidence interval	
	Defra recommendations/ manual (RB209), CoGap	Other	Defra recommendations/ manual (RB209), CoGap	Other
Cereals	94	8	± 4	± 4
Other crops	94	11	± 4	± 6
Pigs & poultry	86	16	± 9	± 9
Dairy	89	14	± 3	± 4
Grazing livestock (LFA)	78	22	± 8	± 8
Grazing livestock (Lowland)	78	23	± 7	± 7
Mixed	93	12	± 5	± 7

Results are for holdings that indicated they have completed a manure management plan. Number of records used: 1206

Proportion of holdings testing nutrients of soil and manure

Farm type	Percentage of holdings				95% confidence interval			
	Regularly test nutrient content of soil (at least every 5years)	Regularly test the pH of soil (at least every 5years)	Test nutrient content of manure by taking samples	Assess/ calculate the nutrient content of manure	Regularly test nutrient content of soil (at least every 5years)	Regularly test the pH of soil (at least every 5years)	Test nutrient content of manure by taking samples	Assess/ calculate the nutrient content of manure
Cereals	93	93	38	74	± 3	± 3	± 6	± 6
Other crops	93	96	43	77	± 4	± 3	± 8	± 7
Pigs & poultry	67	70	35	69	± 9	± 9	± 9	± 10
Dairy	77	88	32	68	± 4	± 3	± 5	± 5
Grazing livestock (LFA)	36	48	5	27	± 7	± 7	± 3	± 7
Grazing livestock (Lowland)	57	69	13	42	± 6	± 6	± 5	± 7
Mixed	85	89	24	75	± 7	± 6	± 7	± 8

Results are for all holdings who answered the question and for whom the question is applicable.

Frequency with which farmers calibrate their manure spreader(s)

Farm type	Percentage of holdings				95% confidence interval			
	Never	Whenever there is significant change in manure or slurry characteristics	Whenever manure or slurry is tested	Other frequency	Never	Whenever there is significant change in manure or slurry characteristics	Whenever manure or slurry is tested	Other frequency
Cereals	39	36	7	18	± 8	± 8	± 5	± 6
General cropping	28	41	10	20	± 10	± 10	± 7	± 9
Pigs & poultry	41	35	8	16	± 13	± 13	± 7	± 10
Dairy	60	28	5	7	± 5	± 5	± 2	± 3
Grazing livestock (LFA)	80	14	1	6	± 6	± 5	± 1	± 4
Grazing livestock (lowland)	66	29	1	3	± 7	± 7	± 1	± 3
Mixed	44	34	9	13	± 10	± 10	± 6	± 7

Results are for holdings where the farmer spreads some or all of the manure/slurry. Number of records used: 1167.

Proportion of holdings using a ration formulation programme or nutritional advice from an expert when planning the feeding regime of their livestock by frequency of use

Farm type	Percentage of holdings					95% confidence interval				
	Always	Most of the time	Some of the time	Rarely	Never	Always	Most of the time	Some of the time	Rarely	Never
Dairy	59	18	12	7	3	±5	±4	±3	±3	±2
Grazing livestock (LFA)	7	10	19	22	42	±3	±4	±6	±6	±7
Grazing livestock (lowland)	10	15	20	26	28	±4	±4	±5	±6	±6

Results are for holdings with cattle or sheep. Number of records used: 905.

Proportion of holdings using bulls with a high Profitable Lifetime Index (PLI) when breeding dairy cows by frequency of use

Farm type	Percentage of holdings					95% confidence interval				
	Always	Most of the time	Some of the time	Rarely	Never	Always	Most of the time	Some of the time	Rarely	Never
Dairy	32	30	20	4	14	±5	±5	±4	±2	±3

Results are for holdings with dairy cattle where dairy the predominate activity. Number of records used: 368.

Proportion of holdings using bulls with a high Estimated Breeding Value (EBV) when breeding beef cattle by frequency of use

Farm type	Percentage of holdings					95% confidence interval				
	Always	Most of the time	Some of the time	Rarely	Never	Always	Most of the time	Some of the time	Rarely	Never
Grazing livestock (LFA)	13	14	22	12	38	±5	±6	±7	±6	±9
Grazing livestock (lowland)	12	20	15	8	44	±4	±7	±6	±4	±8

Results are for grazing livestock farms only. Number of records used: 346

Proportion of holdings using rams with a high Estimated Breeding Value (EBV) when breeding lambs by frequency of use

Farm type	Percentage of holdings					95% confidence interval				
	Always	Most of the time	Some of the time	Rarely	Never	Always	Most of the time	Some of the time	Rarely	Never
Grazing livestock (LFA)	8	14	18	14	46	±5	±6	±6	±6	±8
Grazing livestock (lowland)	8	17	22	10	43	±4	±6	±7	±4	±8

Results are for grazing livestock farms only. Number of records used: 372.

Proportion of holdings that have sown their temporary grassland with a clover mix by proportion of grassland

Farm type	Percentage of holdings							95% confidence interval						
	All 100%	81- 99%	61- 80%	41- 60%	21- 40%	1- 20%	None	All 100%	81- 99%	61- 80%	41- 60%	21- 40%	1- 20%	None
Dairy	21	5	12	15	11	15	23	± 5	± 3	± 4	± 4	± 4	± 4	± 5
Grazing livestock (LFA)	37	4	1	9	6	9	34	± 14	± 4	± 3	± 7	± 6	± 7	± 15
Grazing livestock (lowland)	36	11	9	12	9	13	10	± 8	± 7	± 5	± 6	± 5	± 6	± 5

Results are for dairy and grazing livestock farms with temporary grassland. Number of records used: 459.

Proportion of holdings that have sown their temporary grassland with high sugar grasses by proportion of grassland

Farm type	Percentage of holdings							95% confidence interval						
	All 100%	81- 99%	61- 80%	41- 60%	21- 40%	1- 20%	None	All 100%	81- 99%	61- 80%	41- 60%	21- 40%	1- 20%	None
Dairy	21	11	15	12	15	10	15	± 5	± 4	± 4	± 4	± 4	± 4	± 4
Grazing livestock (LFA)	12	4	7	15	5	6	52	± 8	± 4	± 9	± 11	± 5	± 6	± 14
Grazing livestock (lowland)	10	2	11	8	7	15	47	± 5	± 2	± 5	± 4	± 5	± 7	± 9

Results are for holdings with livestock and temporary grassland. Number of records used: 459.

(vi) Digest of ongoing research projects

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
SCF0102	Delivering the Agricultural GHG and Ammonia inventories and projections.	05/2013	This project will provide continuity from AC0112 and will deliver the annual inventories of GHG and ammonia emissions from agriculture. Critically the project will transition from the current IPCC tier 1 system of reporting to a more UK specific reporting structure by operationally deploying the developments arising from AC0114, AC0115 and AC0116		31/03/2016
SCF0103	Scoping the extent to which Earth Observation data can cost effectively provide agricultural activity information	05/2013	This project will undertake a review of key data requirements for GHG inventory reporting, and the availability of satellite remote sensing data streams to satisfy these. The project will draw on international experience on the use of Earth observation in other countries. The project will assess the extent to which data gaps can be filled with existing technologies, and if doing so would provide better value for money than traditional survey techniques.		31/03/2014
AC0111	Air quality measurements on cracking clay soils	01/04/2008	To quantify air quality and green house gas emissions from heavy clay soils under drained and un-drained conditions.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15541&FromSearch=Y&Publisher=1&SearchText=AC0111&SortString=ProjectCode&SortOrder=Asc&Page=10#Description	31/03/2013

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
AC0112	Producing inventories of ammonia and greenhouse gasses from UK agriculture for international reporting requirements	01/04/2008	To deliver the annual inventories of ammonia, nitrous oxide and methane emissions from UK agriculture at a devolved administration level for each of the years 2007 - 2011, providing revised projections to 2020 with each submission.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15542&FromSearch=Y&Publisher=1&SearchText=AC0112&SortString=ProjectCode&SortOrder=Asc&Page=10#Description	31/03/2013
AC0114	GHG platform - Data management	01/11/2010	Data synthesis and model development hub for an improved inventory of GHGs	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17179&FromSearch=Y&Publisher=1&SearchText=AC0114&SortString=ProjectCode&SortOrder=Asc&Page=10#Description	30/06/2015
AC0115	GHG Platform - Methane Emissions Factors	01/11/2010	To deliver baseline values for methane emissions and estimates of currently unknown effects of animal breeds and genotypes, age, diet, seasonality and regional variation.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17180&FromSearch=Y&Publisher=1&SearchText=AC0115&SortString=ProjectCode&SortOrder=Asc&Page=10#Description	31/03/2015
AC0116	GHG Platform - Nitrous Oxide Emissions Factors	01/11/2010	Targeted measurements of emissions from representative UK soils after application of organic and manufactured N sources to develop new EFs for the UK inventory.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17181&FromSearch=Y&Publisher=1&SearchText=AC0116&SortString=ProjectCode&SortOrder=Asc&Page=10#Description	31/03/2015

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
AC0119	Feed management on livestock farms	01/10/11	<p>To disseminate the results of research undertaken on feed management so that farmers can improve feed utilisation and conversion efficiency, thereby reducing GHG emissions and other environmental burdens.</p> <p>This required a review and synthesise of the evidence base on livestock feed management best practice including significant recent Defra projects, with particular emphasis on ruminants. The main output of the work will be the publication by the research contractor(s) of detailed guidelines for feed management aimed at farmers and advisors.</p>	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17790#Description	<p>30/4/2012</p> <p>Final report received and being reviewed for publication</p>
AC0120	LCA of endemic diseases on GHG emissions intensity	01/10/11	<p>The objectives of this study are to model the impact of controlling selected endemic cattle diseases and conditions on cattle productivity in GB, agricultural performance and GHG emissions. Results are required at sub-sector (dairy, suckler beef and beef finisher) and for each of the Devolved Administrations of Great Britain (England, Wales and Scotland).</p>	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17791	<p>30/9/2012</p> <p>Project extended to 31 March 2013 (no-cost)</p>

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
AC0122	Increasing efficiency of dietary nitrogen use in dairy systems	1 April 2012	<ol style="list-style-type: none"> 1. Determine the scope for increasing efficiency of N use in dairy systems. 2. Determine, in multi-lactation studies, the longer-term effects of reductions in dietary intake of protein on longevity, reproductive performance, health, welfare, milk output and milk composition of dairy cows. 3. Determine the effects of reduced dietary intake of protein on excretion of N in faeces and urine, on N balance, and on efficiency of N use by dairy cows and growing cattle. 4. Determine the extent to which dietary manipulation can influence the composition and total volume of excreta and the consequences of such changes on N excretion and on predicted emissions of greenhouse gases and NH3, and diffuse pollution from NO3. 5. Assess the potential economic consequences of reductions in total dietary N intake. 	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17793	2019
AC0123	Developing new ammonia emissions factors for livestock housing and manure management systems	Summer 2011	To measure ammonia emissions from novel animal housing and manure/slurry management systems to update the emissions factors implemented in the ammonia inventory. New legislation, industry action and changes in consumer preference have transformed livestock management practices and these must be reflected in national reporting. The project will proceed in two phases: A literature review and stakeholder consultation process to establish the requirements for new emissions factors (gap analysis) followed by a field campaign to establish new emissions factors where required.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17811&FromSearch=Y&Status=2&Publisher=1&SearchText=AC0123&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	March 2014

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
AC0124	Scoping project: Regional Validation of CH4 inventory	Summer 2011	This project will examine the scope for networks of sensors to produce regional scale inventory validation. The project will use the NAME model in the inverse model to attribute emissions of methane to source at high resolution. The work will allow an assessment of the necessary network to achieve cost effective validation of inventory estimates of methane emissions.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=17816	Summer 2013
AC0213	Potential for nitrification inhibitors and fertiliser nitrogen application timing strategies to reduce direct and indirect nitrous oxide emissions from UK agriculture	01/01/2010	Assess the potential for nitrification inhibitors (NIs) and fertiliser nitrogen (N) application timing to reduce greenhouse gas (GHG) emissions from UK agriculture.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=16481&FromSearch=Y&Publisher=1&SearchText=AC0213&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	31/03/2014
AC0226	Quantifying, monitoring and minimising wider impacts of GHG mitigation measures	Dec 2011	To assess the wider implication of the GHG action plan to ecosystem services. Whilst good evidence exists for GHG, ammonia and nitrate reductions, less is known about potential biodiversity, product quality, landscape value, rural social impacts etc. This project seeks to clarify some of these issues in response to the RSPB report on the action plan.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17780	March 2013
AC0227	Case studies of mitigation method implementation	Summer 2011	To assess the impacts of sets of multiple mitigation measures implemented on farms in line with the Industry GHG Action Plan. A nitrogen balance approach will be used to quantify the change in N surplus before and after method implementation. Simple modelling approaches will be taken to examine the fate of the excess nitrogen (i.e. emissions to air and water).	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17814&FromSearch=Y&Status=2&Publisher=1&SearchText=AC0227&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	Awaiting Publication

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
AC0314	Identification of important crop traits for adaptation to climate change	01/04/2010	To test the hypothesis that traits for water or nutrient use efficiency identified at current CO ₂ levels are the same as those that are relevant under high CO ₂ using wheat as an example of a cereal seed crop and Brassica oleracea as a leafy vegetable crop. A range of genotypes will be screened for growth, productivity and water use efficiency in glasshouses at ambient (~380 ppm) and elevated (550 ppm) CO ₂ and at different levels of irrigation and nutrition alone or in combination. A series of growth parameters, photosynthetic rates, compositional quality and yield will be monitored. From the results of these experiments it will be possible to devise crop improvement strategies for productive and robust genotypes.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17247&FromSearch=Y&Status=2&Publisher=1&SearchText=AC0314&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	30/04/2013
AC0410	Comparative LCA of on farm AD	01/01/2013	Previous research in other EU countries has indicated AD may be the most sustainable on farm renewable option but work is required to confirm that this is also the case in the UK. The aim of this project is to identify the impacts of AD on individual farm businesses as compared with other renewable energy technologies. The work will focus on the environmental and competitiveness benefits of the technologies. Two case studies will be considered based on scenarios outlined in the draft industry code of practice for AD: a large East Anglian arable business and a medium to large scale dairy business in the south west. The project will develop tools to help farmers select the best renewable diversification options for their business and manage any potential environmental or production issues relating to their implementation.	http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18631	31/07/2013

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
AC0114 (Extension)	International collaborative research and knowledge exchange networks	July 2012	Administrative and funding support for international collaborative projects (Global Research Alliance or European JPI-FACCE led) that add value to the ACC R&D or Soils (especially peatlands) programmes. The GRA on Agricultural GHGs has established Livestock and Crops Research Groups and two cross-cutting groups (Inventories and Measurements and Soil Carbon and Nitrogen Cycling). The JPI-FACCE group is intended to add value to national and EU R&D programmes on Food Security and Climate Change. It is co-funded by BBSRC and INRA. Defra funding is needed to encourage UK researcher participation in international actions and to co-fund on a case by case basis with global partners where necessary where there is benefit to UK R&D effort.	http://www.globalresearchalliance.org http://www.faccejpi.com/	Ongoing
AC0116 (Extension)	International DNDC Modelling Network	June 2013	The aim is establish a vibrant network of specialist researchers, model developers, students and users who can work together to look more strategically at what the various versions of the DNDC model can deliver in accounting for the effect of agricultural management practices on emissions, in identifying promising mitigation options and in assessing the effect of future climate on emissions. The work involved is principally to stimulate communication between model users and research teams with a specific interest in GHG measurement and mitigation from cropping systems and may involve regional groupings of countries that could share experiences and benefit from working together (e.g. those with similar climates, soils, ecosystems etc).		tbc
SCF0101	Costs of Extreme Weather	08/01/2013	The overall aim of this study is to research the evidence of past extreme weather events and their impacts along with forecast events to 2050 and to establish a methodology for estimating economic impacts on the farming sector, taking account of attitudes and behaviours in relation to mitigation.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18670	05/04/2013

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
SCF0104	Development of the Farmscoper decision support tool	01/01/2013	The aim of this research is to develop the Farmscoper decision support tool developed under WQ0106. Improvements will be made to the costs associated with implementation of pollution mitigation measures on farm and a new upscaling function will be added to allow assessment of policy impacts at regional to national scales.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18702	31/10/2013
SCF0301	A review of non-NPKS nutrient requirements of UK cereals and oilseed rape	01/11/2012	This project will review the importance of non-NPKS fertilisers within present day cereal and oilseed rape production systems. The review will consider crop requirements, taking account of increased yields, other sources of these elements and recent data on soil fertility. Occurrence and diagnosis of nutrient deficiencies and strategies for avoiding/rectifying deficiencies will be considered, with the aim of identifying knowledge gaps requiring further research and updating recommendations to growers and consultants.		Awaiting Publication
WR1212 (variation)	Digestate Ammonia Emissions Measurements	01/02/2013	This extension will establish optimal application techniques to reduce ammonia losses from digestate application. Digestates may have high available nitrogen contents and high pH, favouring ammonia emissions. Preliminary results from WR1212 indicate that poor application practice and timing could result in significant ammonia emissions. This work will establish the efficacy of improved application techniques to mitigate this risk.		31/03/2016

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
IF01121	Validation of fertiliser manual (RB209) recommendations for grasslands	19/12/2011	The Fertiliser Manual (RB209) (8th edition, Defra 2010), provides industry standard recommendations for grassland in England and Wales. Recently revised, the nitrogen (N) recommendations for grassland were substantially changed and restructured. This project will provide an evidence base for validating and assessing the effectiveness of these recommendations for grassland farmers.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17803&FromSearch=Y&Publisher=1&SearchText=IF01121&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	31/03/2015
IF0145	Understanding and dissecting the genetic control of key "environmental impact" traits in forage grasses and legumes	01/04/2008	Modern techniques in plant breeding (non GM) will be used to develop germplasm with the potential to make a significant contribution in three key areas: (i) Adaptations to climate change through improved grassland design to reduce soil compaction and overland flow that leads to flooding, and soil and nutrient run-off. Changes in shoot and root architecture will also be used to reduce soil erosion and improve soil stability to aid compliance with the EU Water Framework Directive. (ii) Enhancing the carbon sequestration potential of grasslands as a contribution to climate change mitigation. Genetic variation for key traits involved in C sequestration will be identified. (iii) Improving the stability and resilience of grasslands through the use of multi-species swards in comparison with monocultures or grass/clover swards to deliver ecosystem services (e.g. clean water).	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15840&FromSearch=Y&Publisher=1&SearchText=IF0145&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	31/03/2013

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
LK0686	Genetic improvement of perennial ryegrass and red clover to increase nitrogen use efficiency and reduce N losses from pastures and silo	01/04/2008	<ol style="list-style-type: none"> 1. Develop new varieties of perennial ryegrass with NUE 10-15% higher than in current varieties. 2. Reduce N leaching losses from red clover by deployment of new varieties. 3. Develop new red clover varieties with a 15% enhancement in PPO activity and use a digestion study in steers to quantify the impact of differences in PPO activity on N losses to the environment. <p>Expected benefits of this research include reduced N pollution of watercourses and a lower requirement for N fertilisers. The latter will lead to considerable financial savings for UK livestock farmers. There will also be production benefits from the reduction in protein degradation likely as a result of enhanced PPO activity.</p> <p>Note: Enzyme polyphenol oxidase (PPO) in red clover, plays an important role in reducing protein degradation in the silo and hence cutting nitrogenous losses.</p>	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15739#RelatedDocuments	31/03/2013
LK0687	Genetic improvement of perennial ryegrass and white clover to increase the efficiency of nitrogen use in the rumen	01/04/2008	<ol style="list-style-type: none"> 1. Using marker assisted selection based approaches to develop a range of perennial ryegrass varieties with enhancement of WSC levels 8% beyond that seen in material currently available to farmers. 2. Developing and evaluating white clover varieties with 5-10% reduction in leaf protein content. 3. Carrying out an experiment with dairy cows to test combinations of WSC: protein dietary ratios at levels of WSC made possible by germplasm development in this programme. <p>Expected benefits from the work include reduced emissions to air and water, and increased efficiency of nitrogen use for the production of meat and milk.</p>	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15740	31/03/2013

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
LK0697	Environmental and Nutritional Benefits of Bioethanol Co-products (ENBBIO)	01/10/2010	Quantify sources of variability in W-DDGS, identify opportunities to enhance their value, to consider innovative processes to reduce fibre content (for non-ruminants) and to quantify the contribution of the co-products to the overall GHG balance of UK crop, livestock and ethanol production.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17089	30/09/2013
LK09128	Minimising nitrous oxide intensities of arable crop products (MIN NO)	01/07/2009	Improve estimates of N ₂ O emissions associated with production of UK arable crops, and to develop strategies	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=16501&FromSearch=Y&Publisher=1&SearchText=LK09128&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	30/06/2014
LK09134	Reducing GHG emissions, nitrate pollution and lost productivity by fully automating N fertiliser management	01/10/2009	Develop and validate a comprehensive N management protocol, which will be automated as much as possible, using spatial data on crop history, remotely sensed crop information and weather data.	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=16914&FromSearch=Y&Publisher=1&SearchText=LK09134&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	30/09/2014

Glossary

BSE

Bovine spongiform encephalopathy is a fatal disease in cattle that causes degeneration in the brain and spinal cord. BSE is commonly known as 'mad cow disease'.

Carcase weights

The weight of the meat produced from an animal. Cold dressed carcass weights are recorded.

Cattle Tracing System (CTS)

The CTS records births, deaths and all movements of cattle as well as breed types and gender. It is mandatory for every bovine animal to have a passport and ear tag and for owners to report every movement via the CTS.

Clean pigs

Pigs bred purely for meat production.

Dairy herd and beef herd

Unless otherwise stated, the dairy herd refers to those breeding animals which produce milk, and the beef herd refers to those breeding animals which produce offspring for slaughter. The beef herd is also commonly referred to as the suckler herd.

Estimated Breeding Values (EBV)

Estimated Breeding Values estimate the genetic worth of animals using desirable traits such as meat production.

Feed conversion ratio (FCR)

A measure of an animal's efficiency in converting feed mass into increased body mass expressed as feed per kg of liveweight; a low FCR is more efficient than a high FCR.

Finishing

Finishing is the feeding process used prior to slaughter for cattle or sheep intended for meat production.

Greenhouse gas intensity

Greenhouse gases produced per tonne of grain or litre of milk or kilogramme of beef. This may also be referred to as GHG efficiency.

Less favoured areas (LFA)

Less favoured areas are land that is classified as difficult to farm due to limitations such as climate, location or features of the landscape (e.g. mountainous or hilly areas).

Marketing pattern

The pattern of animals slaughtered per month over the course of a year.

Over thirty month scheme (OTMS)

In March 1996 the EU imposed a worldwide ban on the export of bovine and bovine products from the UK due to BSE in UK cattle. The Over Thirty Month (OTM) Rule prohibited beef from animals aged over thirty months from entering the food chain. The Over Thirty Month Slaughter Scheme (OTMS) provided a disposal outlet for OTM cattle which could not be sold for the food chain. Cattle entering the scheme were slaughtered and destroyed with compensation paid to the farmer.

Pig fattening herd

Pigs intended for meat production.

Profitable Lifetime Index (PLI)

PLI is a scoring system to identify cattle with the best 'genetic merit'. It is used when choosing bulls to breed with dairy cattle. The PLI uses a combination of attributes including life expectancy, health, fertility and milk production.

Soil nitrogen balance

The soil nitrogen balance is a measure of the total loading of nitrogen on agricultural soils over the crop year.

Total Factor Productivity (TFP)

Total factor productivity shows the volume of output leaving the industry per unit of all inputs including fixed capital and labour. It includes all businesses engaged in farming activities including specialist contractors.

UNFCCC countries

Parties to the United Nations Framework Convention on Climate Change (UNFCCC) include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.