

Agricultural Statistics and Climate Change

5th Edition
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Department
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Food & Rural Affairs

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No data in this section are 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 fifth edition of Agricultural Statistics and Climate Change. This edition includes links to the results from the 2014 Farm Practices Survey, the 2013 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 faces unique challenges 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 (or 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 emissions resulting from 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 so, 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 greater 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 GHG Action Plan is now one of several industry led initiatives working within the Campaign for the Farmed Environment¹.

The individual sector-bodies are also taking action to reduce emissions through environmental product roadmaps². The Dairy, Beef and Lamb, and Pig meat product roadmaps all encourage farmers to employ better management techniques and farming practices. While work by the Agricultural and Horticultural Development Board on the Farm Scale Resource Use Efficiency Calculator³ looks to build awareness on the way farm management decisions can impact on the environment and the economy.

¹ <http://www.cfeonline.org.uk/>

² Down to Earth - The Beef and Sheep Roadmap Phase 3: https://www.google.com/url?q=http://www.eblex.org.uk/wp/wp-content/uploads/2013/04/roadmap_3_-_down_to_earth_180112-final-report.pdf&sa=U&ei=uJdwU46WMoPIsASxhoKABA&ved=0CAYQFjAB&client=internal-uds-cse&usq=AFQjCNHZZx62oOPqefUngdNcSJorf9ptUQ
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
Positive Progress - an update on the roadmap for the environmental sustainability of the English Pig industry - The British Pig Executive (BPEX) 21 January 2014 <http://www.bpex.org.uk/environment-hub/climate-change/PigIndustryRoadmap.aspx>

³ <http://www.ahdb.org.uk/projects/ResourceUseEfficiency.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 report⁴, 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.

Accessing the best advice 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 set out 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-focussed 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.

Research highlights the value of integrated environmental advice (including how to reduce GHG emissions)⁷. Integrated and prioritised environmental messages now form 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.

⁴ 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>

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 links to statistics on farmer attitudes to climate change mitigation and uptake of mitigation measures. It also incorporates information on 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 from 2013 onwards 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 2014, a 1.15Mt CO₂ equivalent reduction in GHGs had been achieved, around 33% of the estimated maximum technical potential¹⁴. This is a slight increase on the 2013 estimate of reduction in GHGs achieved. 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	...

Methodology 2013 onwards

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 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 prerequisite 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"> • 7% 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, 59% of farmers were taking actions to reduce emissions. Of these, larger farms were more likely to be taking action than smaller farms. • For those farmers not undertaking any actions to reduce GHG emissions, informational barriers were important, with both lack of information (26%) and lack of clarity about what to do (31%) cited as barriers by this group. 41% did not believe any action was necessary, virtually no change on 2013. 			
More details on farmer attitudes can be found in Section 3.1 .			
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 2014, approximately 1Mt 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 (1.4Mt CO₂e). By 2014, uptake of these methods has been assessed to have delivered an estimated GHG reduction of 0.5Mt CO₂e, around 37% of the maximum technical potential reduction. 			
More details on uptake of mitigation methods can be found in Section 3.2 .			
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 (kg/ha) in England has fallen by 18% since 2000. The main drivers have been reductions in the application of inorganic (manufactured) 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 (kg/ha) has decreased by 2% between 2012 and 2013. This has been mainly driven by small reductions to inputs from inorganic (manufactured) nitrogen fertilisers, partially offset by reductions in offtake (particularly harvested crops and crop residue).

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. It is also not possible within this measure to reflect changes in the type of feed used (such increasing use of feed sourced from co-products) which may have a bearing on the emissions intensity of production. Since 2010 there has been some improvement in the FCR, although with the fluctuations. 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 2014, bulls and rams with a high EBV were used at least “most of the time” on 34% of farms breeding beef cattle and 22% of those breeding lambs. This was no change on 2013 for bulls, but a reduction of 5% for rams.
- 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.

- There has been an upward trend in both the average milk yield and in the production of compound and blended feed production per cow over the period.
- The ratio is currently at the highest level since 1990. Although there have been some fluctuations over the period; since 2005 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 also increased. However, the picture is complex because compound and blended feed production is strongly influenced by changes in the availability of on-farm feeds, forages and grazed grass for which data are not currently available.

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. More recently, a reduction in the yield trend (particularly due to weather conditions in 2012) has led to less wheat being produced per tonne of nitrogen applied.
- 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 2014 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 2014, 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 2014, 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 estimated emissions

For the UK, between 1990 and 2012²²:

- Total greenhouse gas emissions from agriculture are estimated to have fallen by 20% to 56.6 million tonnes CO₂ equivalent²³ in 2012.
- Emissions of nitrous oxide fell by 20% to 30.3 million tonnes CO₂ equivalent.
- Emissions of methane fell by 21% to 22.2 million tonnes CO₂ equivalent.
- Emissions of carbon dioxide reduced by 21% to 4.1 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); research²⁴ 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 estimated 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 The entire time series is revised each year to take account of methodological improvements in the UK emissions inventory.

²³ 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.

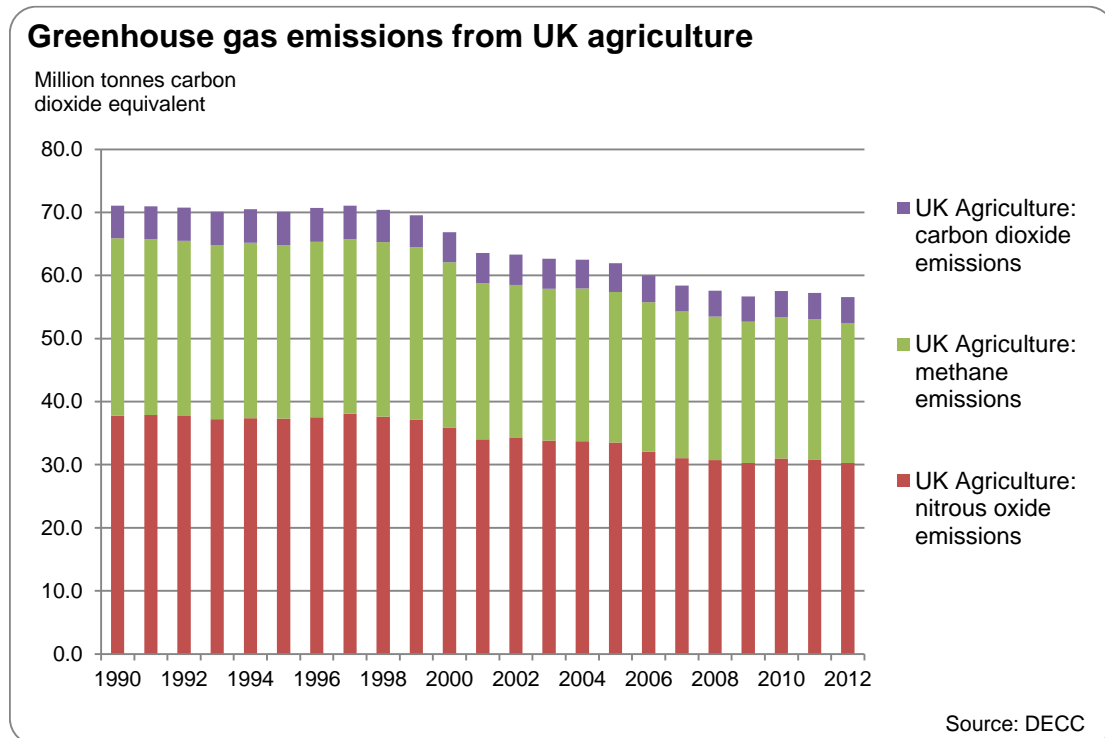
Carbon dioxide equivalent estimates are derived by applying a factor of 21 for methane, and 310 for nitrous oxide. These factors are in accordance with international reporting. These factors denote methane as having a 100-year global warming potential 21 times more powerful than carbon dioxide, and nitrous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

²⁴ www.ghgplatform.org.uk

1.1 Total emissions

The chart below provides an overall picture of the level of estimated greenhouse gas (GHG) emissions from agriculture. In 2012, agriculture was the source of:

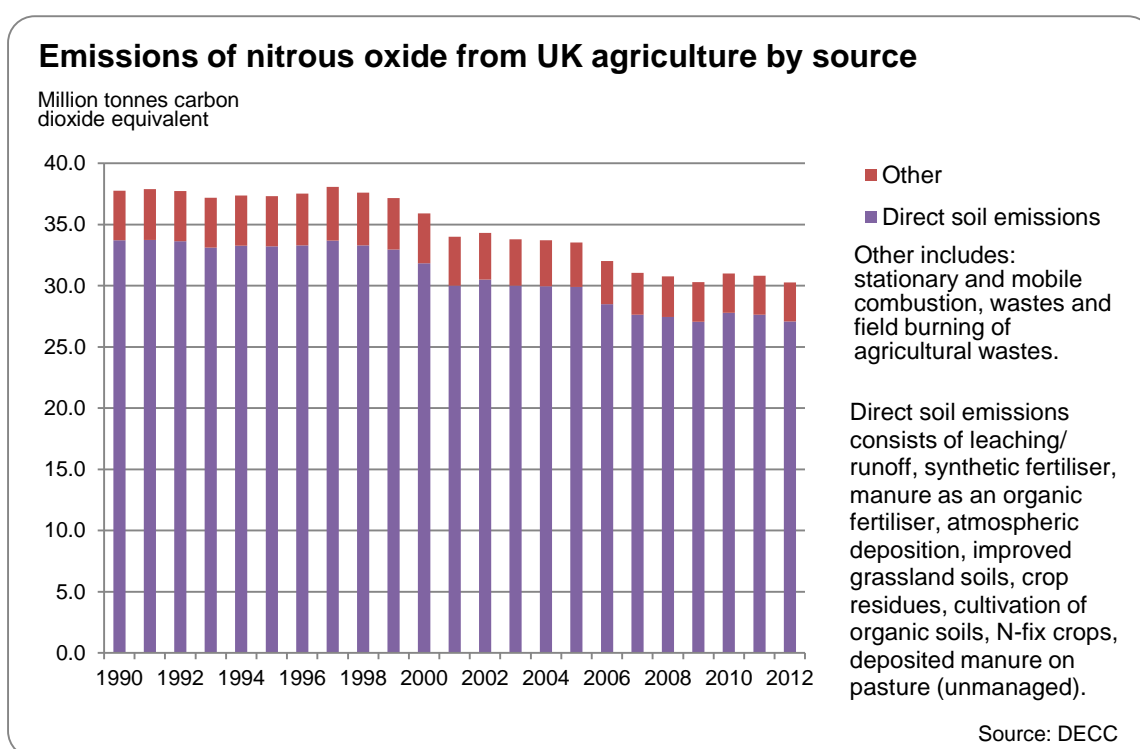
- 10% of total GHG emissions in the UK,
- 84% of total nitrous oxide emissions,
- 44% of total methane emissions,
- and 0.9% of total carbon dioxide emissions.



1.2 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.

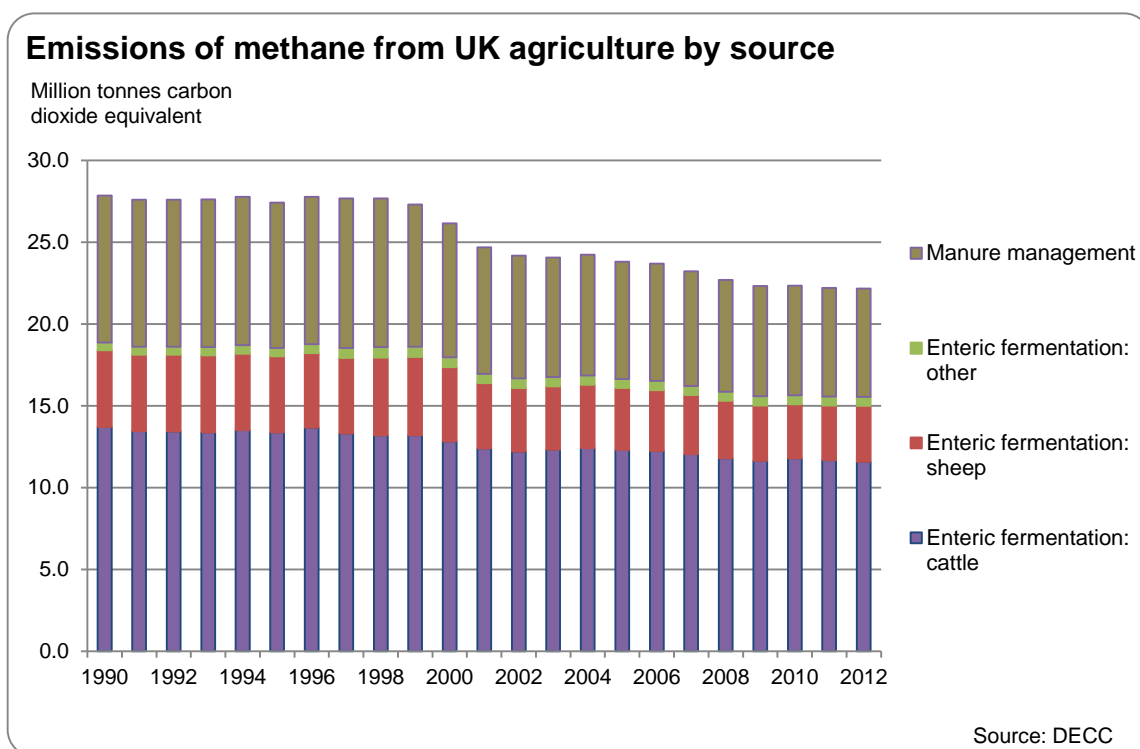
The fall in estimated N₂O emissions over the last twenty years has been driven by substantial reductions in the overall application rate for nitrogen fertilisers, particularly to grassland; whilst arable application rates have remained relatively stable, grassland application rates have reduced. Over 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](#).



1.3 Methane emissions

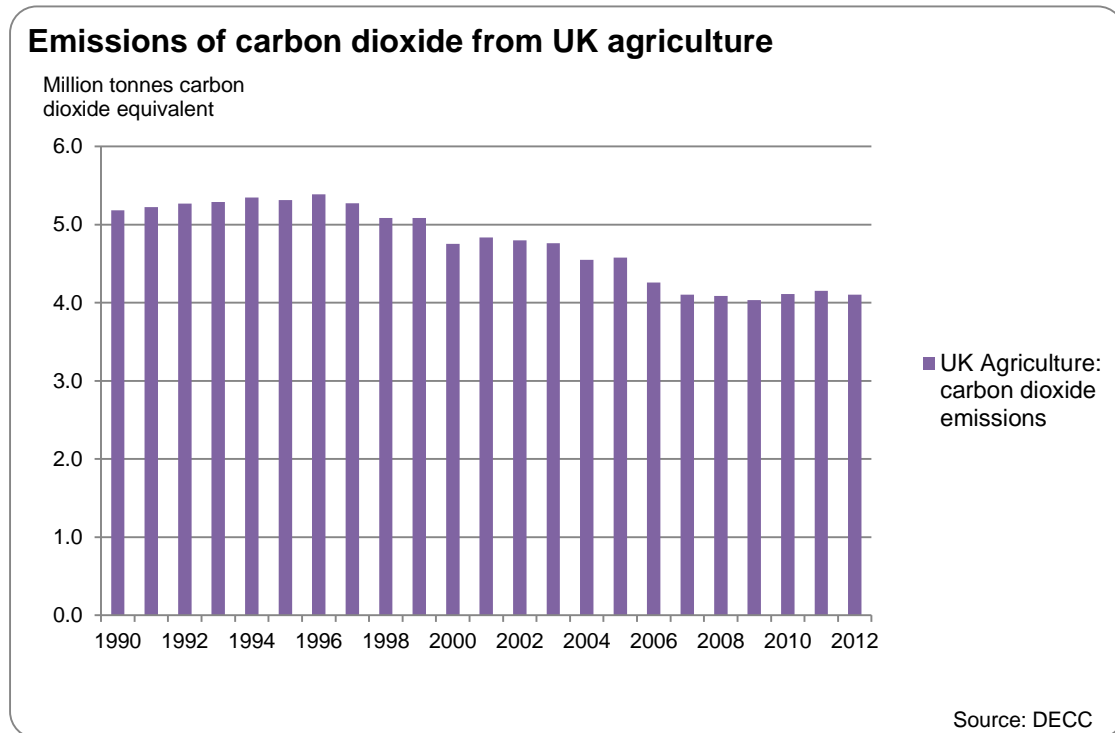
Agriculture is estimated to have been the source of 44% of the UK's methane (CH₄) emissions in 2012. CH₄ is produced as a by-product of enteric fermentation and from the decomposition of manure under anaerobic conditions. Enteric fermentation is a digestive process whereby feed constituents are broken 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 estimated CH₄ emissions since 1990 is due to 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](#).



1.4 Carbon dioxide emissions

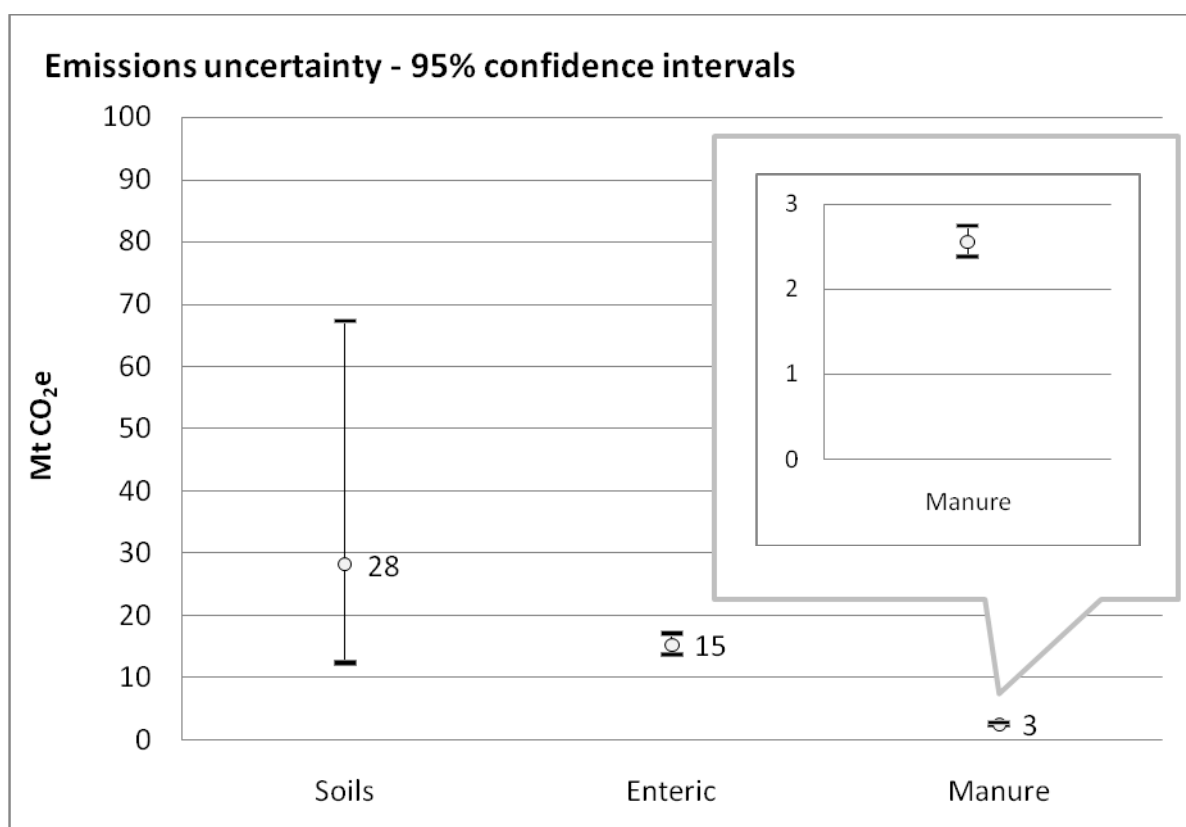
Only around 1% of carbon dioxide (CO₂) emissions in the UK are attributed to agriculture, these relate mainly to fuel use. Since 1990 there has been an overall decline in estimated CO₂ emissions from agriculture.



1.5 Uncertainty in emissions²⁵

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. Uncertainties around N₂O emissions are particularly large; they 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 have undergone further research as part of the current inventory improvement programme.

The chart below illustrates the uncertainties in the current methodology and reflects recent improvements in the analysis^{25, 26} although, 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 out

²⁵A. E. Milne, M. J. Glendining, P Bellamy, T. Misselbrook, S. Gilhespy, M. Rivas Casado, A. Hulin, M. van Oijen, A. P. Whitmore (2014) "Analysis of uncertainties in the estimates of nitrous oxide and methane emissions in the UK's greenhouse gas inventory for agriculture" *Atmospheric Environment* 82:94-105

²⁶The 95% confidence interval given in the "Analysis of uncertainties in the estimates of nitrous oxide and methane emissions in the UK's greenhouse gas inventory for agriculture" for the estimate of total N₂O emissions from soils in 2010 is (-56%, +143%). This reduced uncertainty reflects improved analysis and is substantially different to that given by Brown et al. (2012). Their confidence interval, based on expert opinion, was (-93%, +253%). However (-56%, +143%) is still much larger than that derived by Monni et al. (2007) who quote a 95% confidence interval of (-52%, +70%). Their analysis was based on more conservative estimates for the uncertainty in emissions factors (from IPCC 1997) whereas the 95% confidence interval of (-56%, +143%) was derived using more recent IPCC guidelines (Eggleston et al., 2006).

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. Failure to take 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 overseas.

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

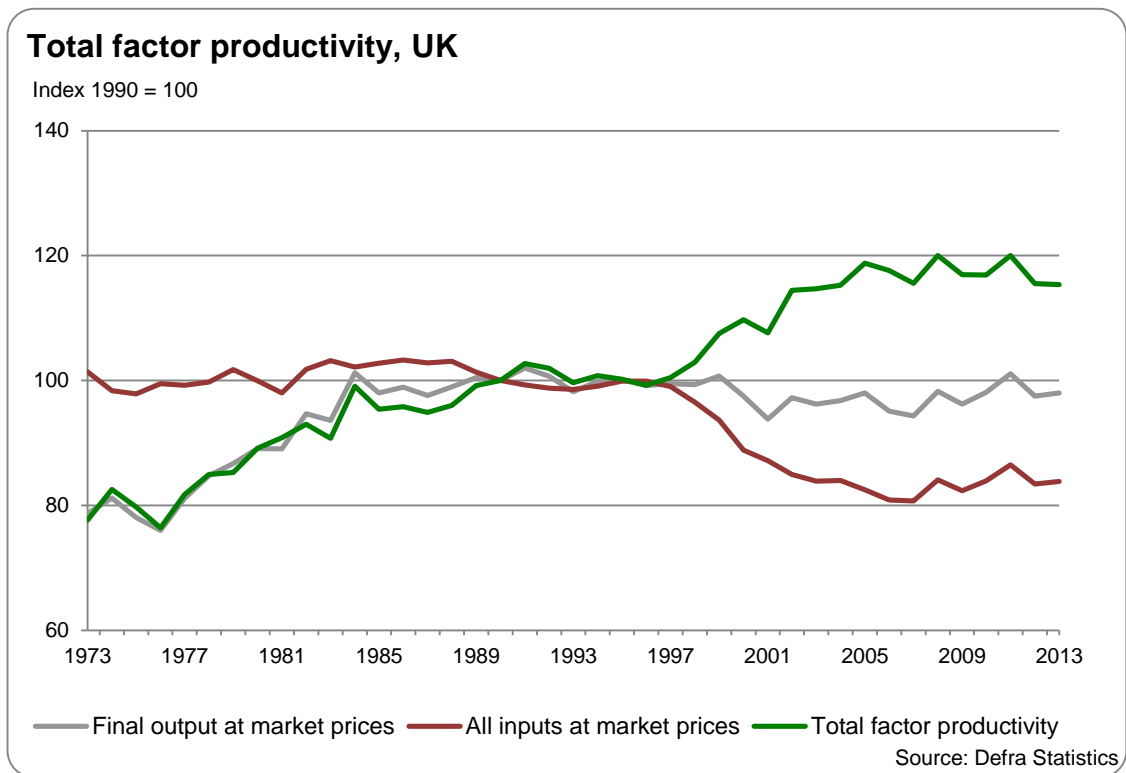
- ensuring that all nutrients are in balance to ensure maximum uptake by the crop,
- ensuring that the correct quantity of nitrogen (manufactured and organic) is applied to match crop growth needs,
- ensuring that nutrients are applied to the crop at the right time and in a manner most likely to ensure 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 productivity²⁷

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 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. Since 2005 total factor productivity has remained mostly level with some year to year variations. 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.

²⁷ Measuring productivity is not straightforward and comparisons need to be interpreted carefully because performance is often shaped by factors outside farmers' control, such as climate, topography and location.

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 indices²⁸. 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 it 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 since 1990, 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	2011	2012	2013
Headline measures								
Output		100.0	97.5	98.0	98.1	101.1	97.5	98.0
Input		100.0	88.8	82.5	83.9	84.2	84.4	85.0
Total Factor Productivity		100.0	109.7	118.8	116.9	120.0	115.5	115.4
Main outputs		Approx. contribution to output (based on 1990 - 2013 average)						
Output of cereals	12%	100.0	110.7	98.9	100.0	100.8	91.6	93.7
Output of vegetables & horticultural products	10%	100.0	79.5	76.1	73.6	71.9	71.7	72.0
Livestock output primarily for meat	28%	100.0	94.6	94.0	91.7	94.4	94.3	94.7
Milk	17%	100.0	94.7	94.3	90.8	92.2	90.7	91.3
Main inputs		Approx. contribution to input (based on 1990 - 2013 average)						
Energy	6%	100.0	88.8	71.7	75.5	72.2	72.2	74.8
Fertiliser	8%	100.0	77.7	65.4	56.8	58.7	55.6	56.4
Animal feed	25%	100.0	103.9	110.4	117.0	107.7	109.8	118.3
Maintenance	9%	100.0	77.2	65.5	71.5	71.3	71.1	71.2
Equipment	10%	100.0	92.4	84.7	89.8	95.8	99.4	97.7
Other goods and services	18%	100.0	97.3	96.2	93.2	95.5	95.1	94.2

Source: Defra statistics

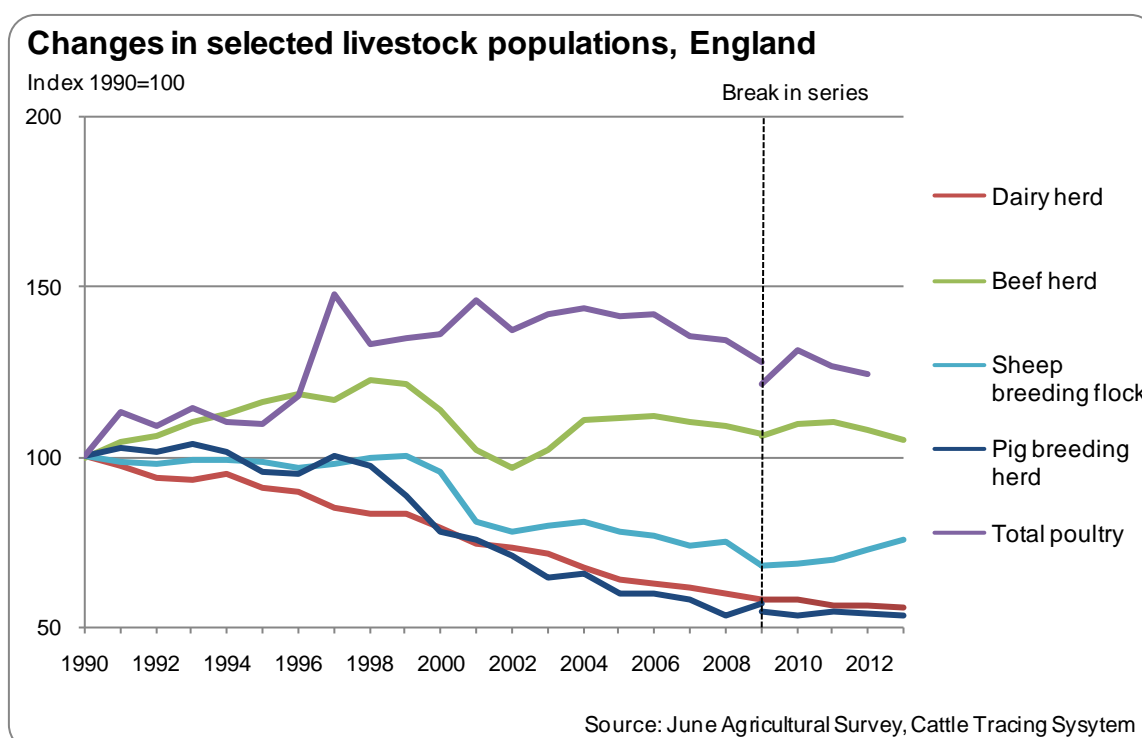
²⁸ Volume indices are calculated by taking a weighted average of volume relatives (volume relatives are the volume in year n / volume in year n-1) using the monetary values of components of the aggregated index as weights.

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

Indices of breeding livestock

Rationale

Livestock, particularly cattle²⁹, are a major source of greenhouse gas (GHG) emissions and a direct determinant of levels of methane (from enteric fermentation³⁰) 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.

²⁹ Both ruminant animals (e.g. cattle and sheep), and non-ruminant animals (e.g. pigs and horses) produce methane, although ruminants are the largest source per unit of feed intake.

³⁰ 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.

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.

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 four years.

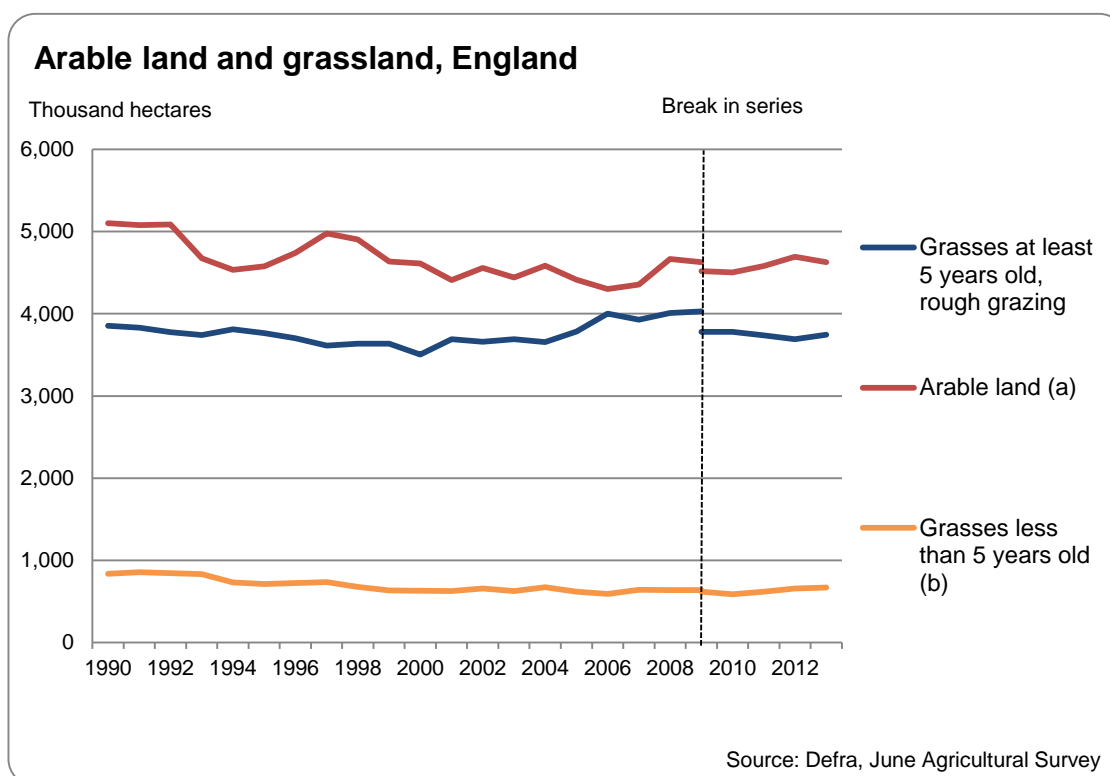
The breeding pig population shows an overall downward trend, particularly since the mid 1990s. This is due to a number of factors including problems with disease, high feed prices and the strength of Sterling.

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

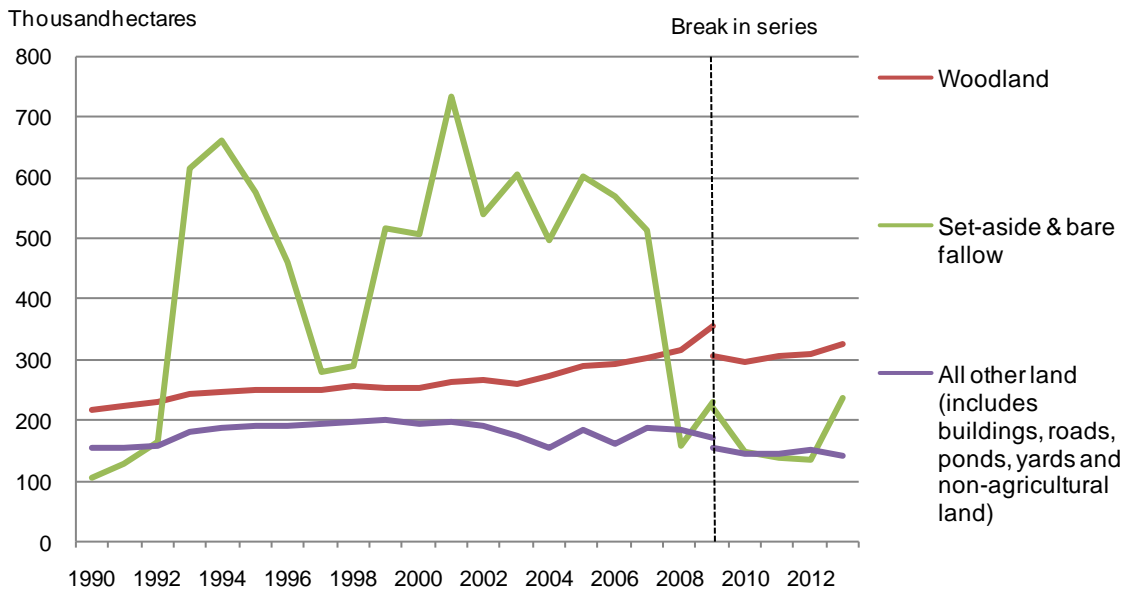
Trends in crop and grass areas are shown to illustrate the basic drivers of emissions. Levels of emissions are dependent on a range of factors including the nitrogen quantity applied, timing and application method used. Nitrogen requirements differ between the type of "crop" grown (including grass).



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

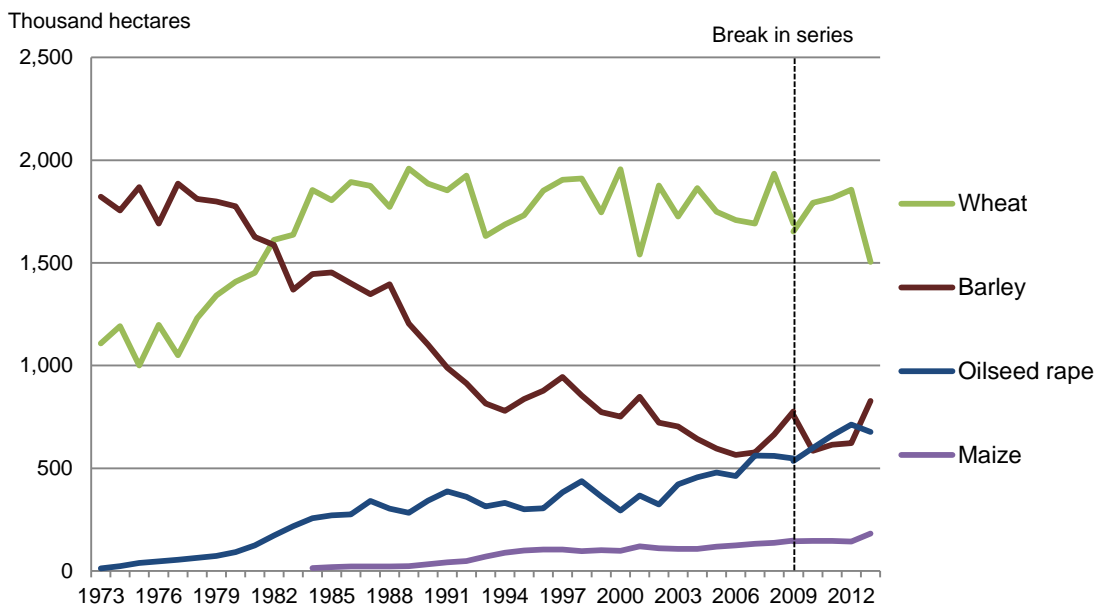
(b) Grasses less than 5 years old are shown separately but are also included within "Arable land".

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



Source: Defra, June Agricultural Survey

Wheat, barley, maize 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 33% of utilised agricultural land in 2013.

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 182 thousand hectares in 2013. 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 cows³¹.

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.

³¹ <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.

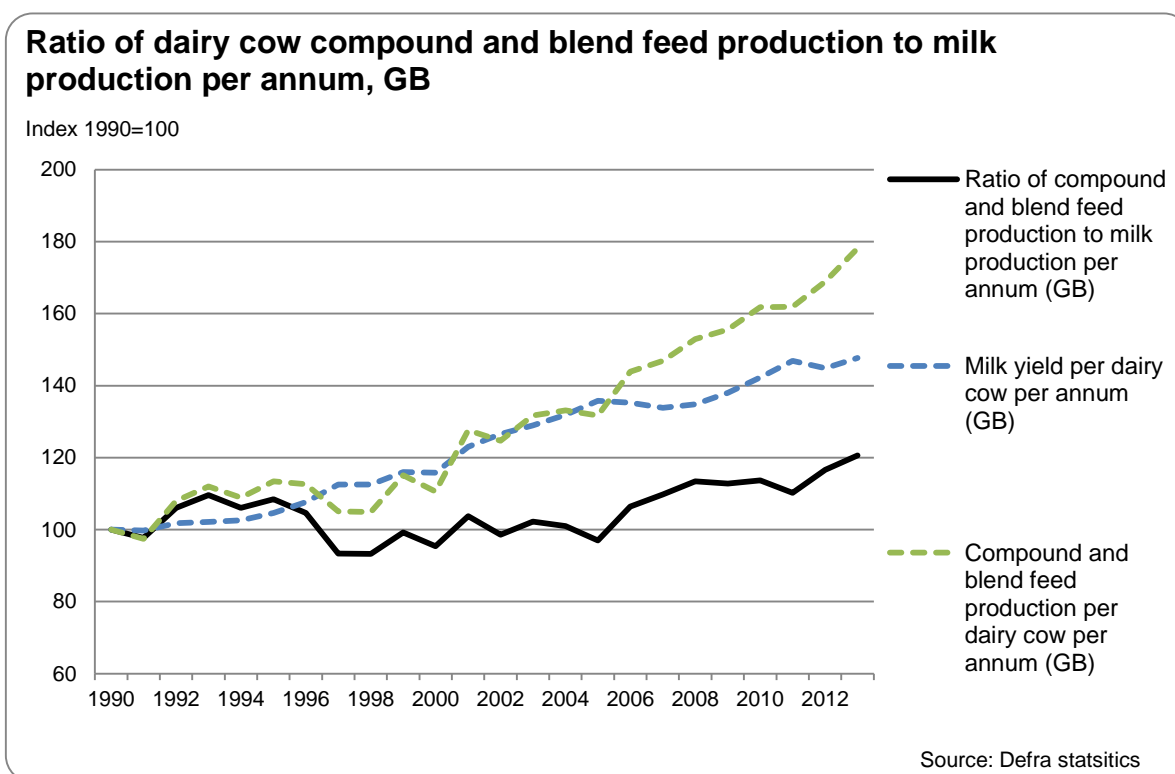
2.4.1 Dairy: efficiency of output

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.

The ratio of dairy cow feed production to milk production is the GHG indicator³² for the dairy sector. More details of this can be found in the [Summary](#) earlier in the publication and in the full indicator text at: <https://www.gov.uk/government/statistical-data-sets/greenhouse-gas-emissions-from-agriculture-indicators>



³² The ten GHG indicators cover farmer attitudes and knowledge, uptake of mitigation methods and the GHG emission intensity of production across key agricultural sectors.

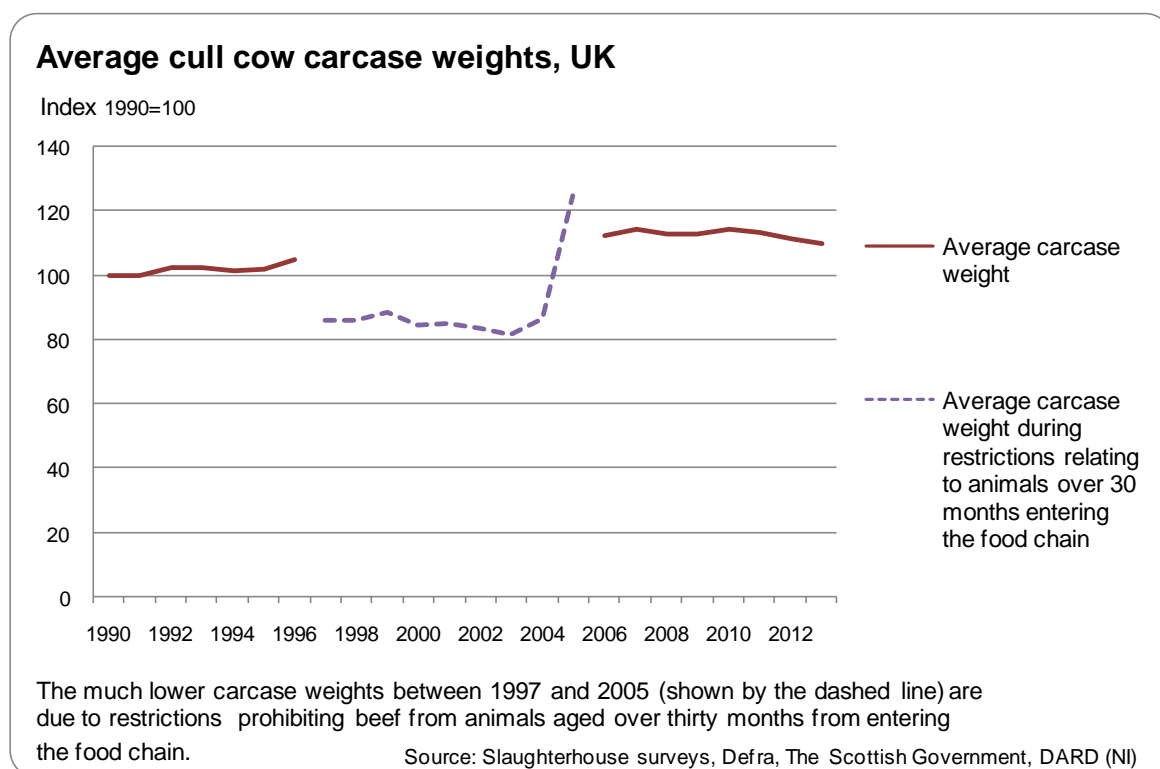
Trends

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.

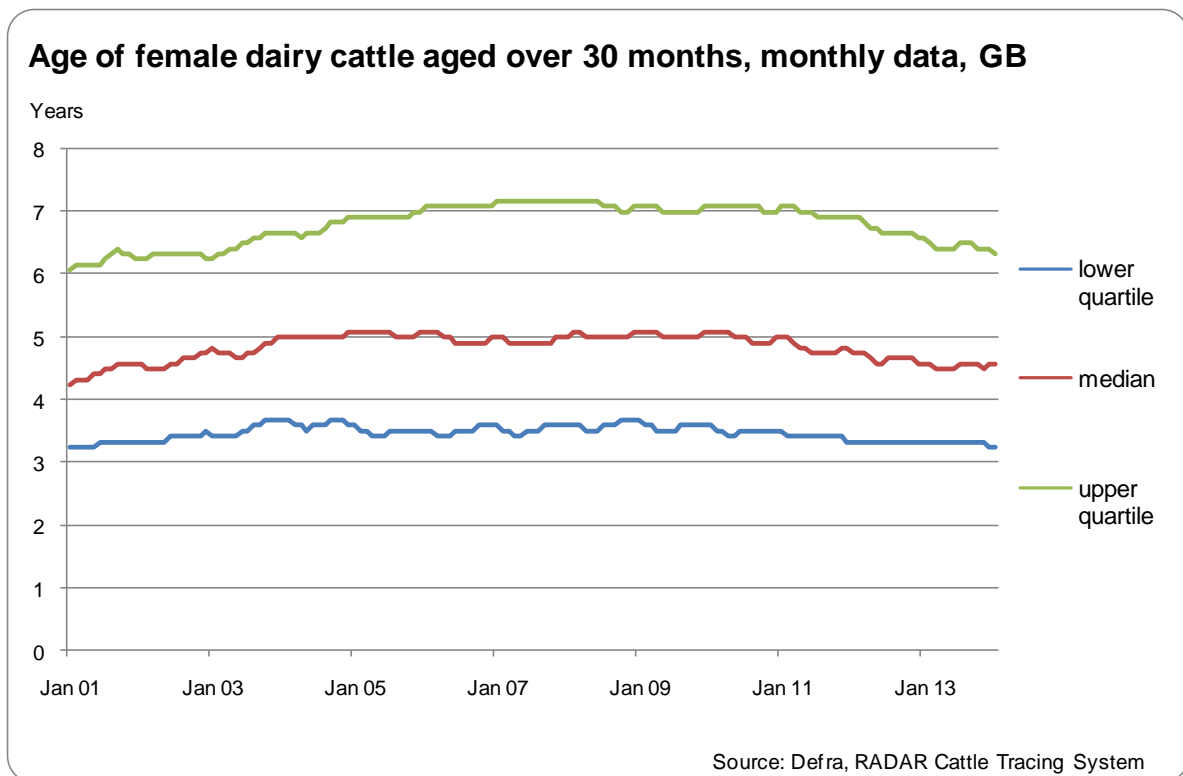
2.4.2 Dairy: longevity and fertility

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.



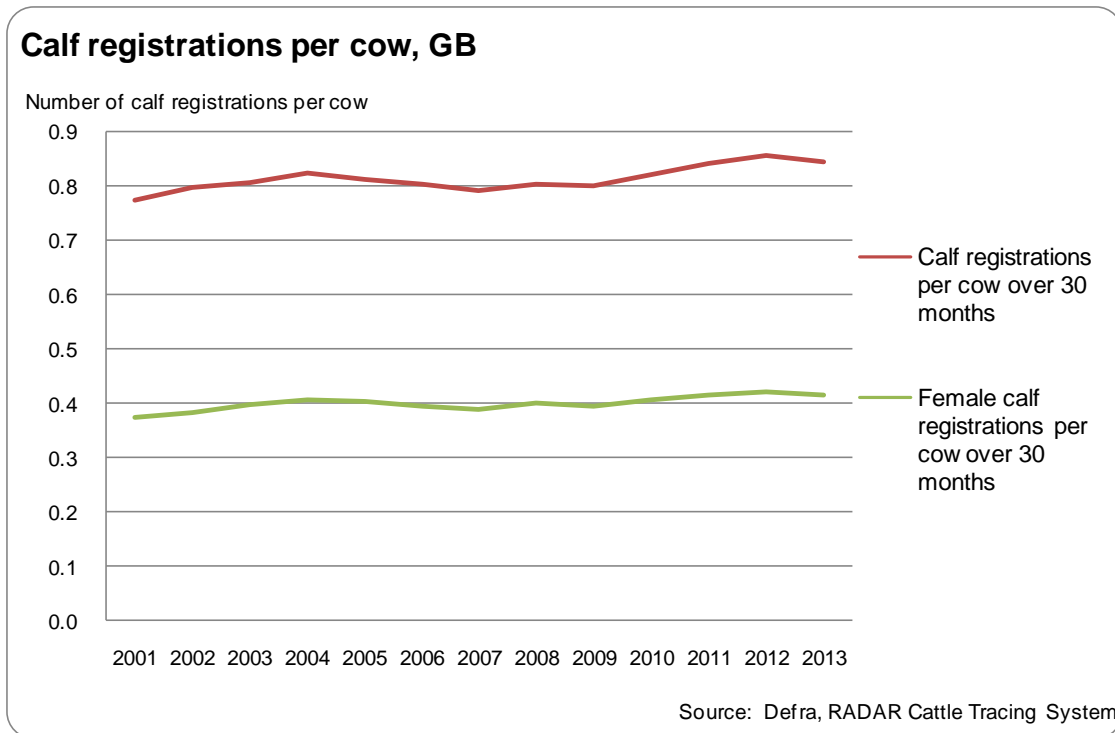
Trends

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 four 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 cattle³³)

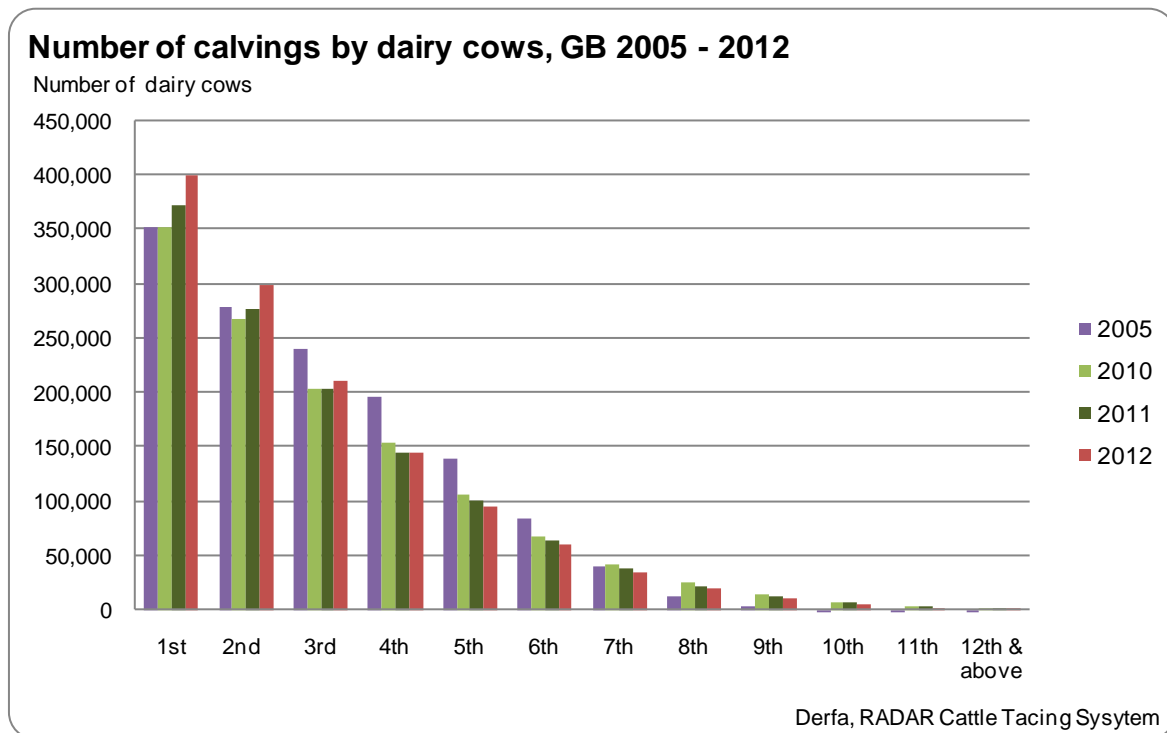


Trends

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.

³³ 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.

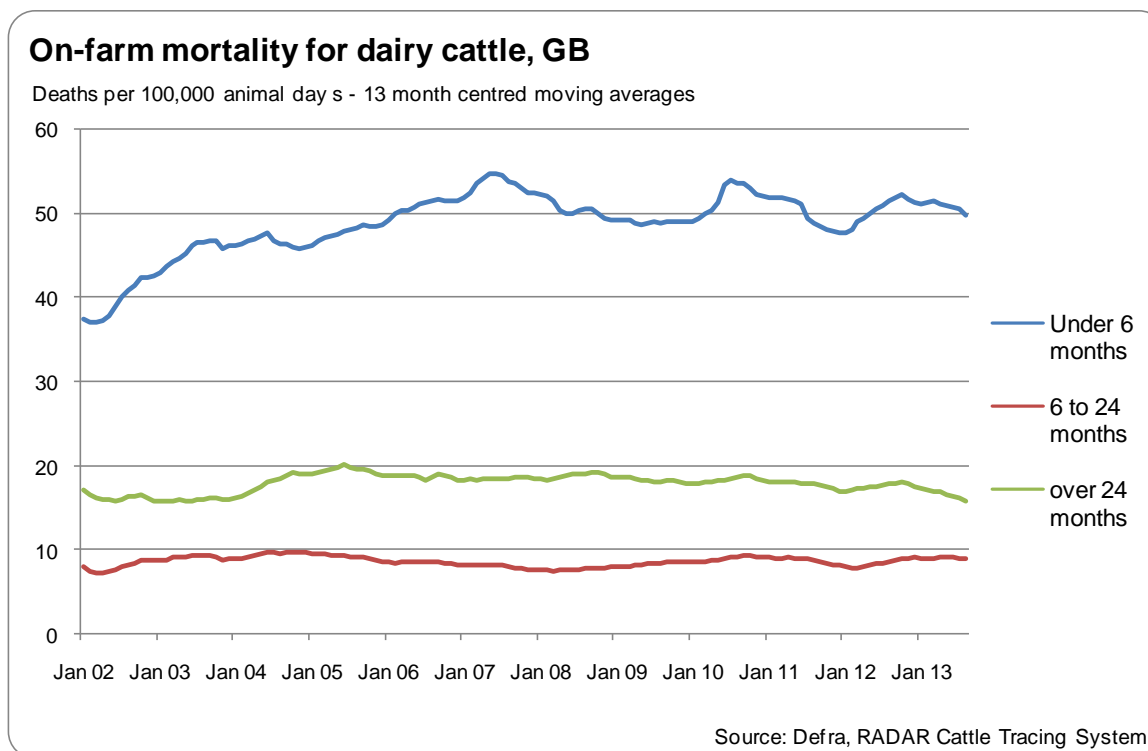
Data for 2012 suggest a slight decrease in the number of dairy cows having 4 or more calves compared to the previous years.

2.4.3 Dairy: animal health

On-farm mortality

Rationale

Reductions in on-farm mortality³⁴ 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.



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. Although there has been some fluctuation, levels are now around 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.

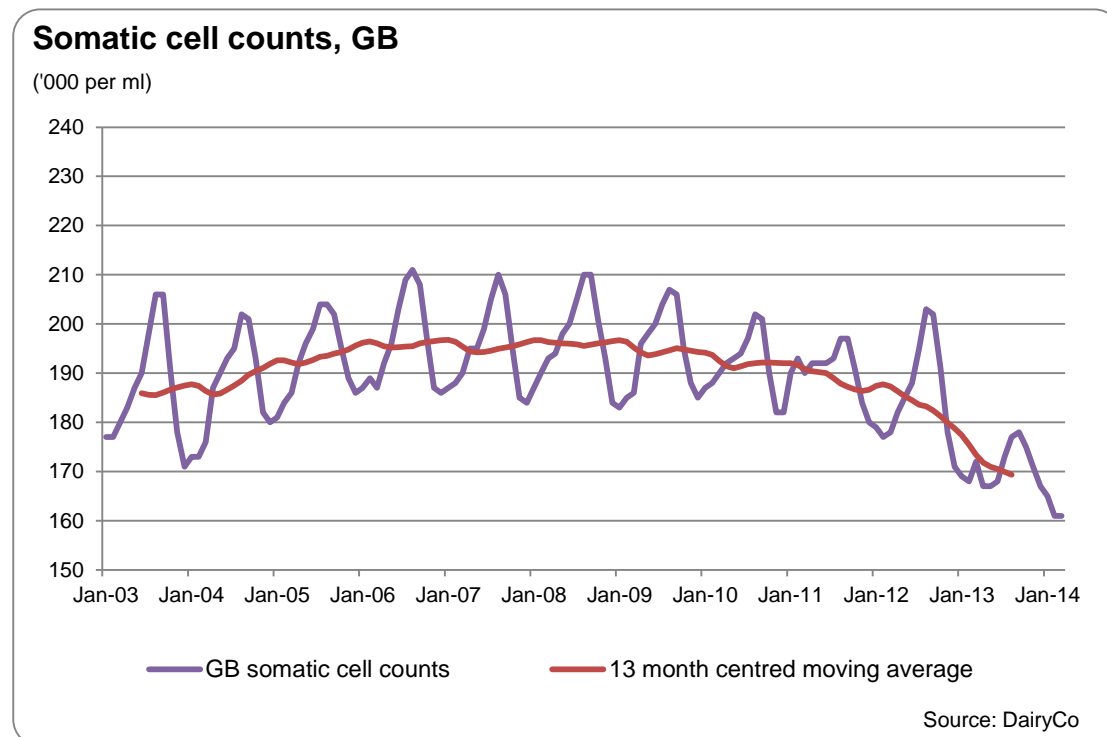
³⁴ On-farm mortality rate is defined as the number of deaths per 100,000 days at risk on agricultural premises. It is calculated using the number of cattle deaths divided by the number of cattle days in the period. The number of cattle days in the period represents 1 day for each animal each day. For 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.

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.



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.

Questions relating to slurry and manure storage were reworded on the 2014 Farm Practices Survey (FPS) to include greater detail on types of storage and covers. As a result the data may not be fully comparable with previous years.

In terms of solid manure systems, the 2014 Farm Practices Survey (FPS) reported that:

- 65% (+/-5%) of dairy farms had facilities to store solid manure in heaps on a solid base. Overall 9% (+/-4%) of such stores were covered.
- 63% (+/-5%) of dairy farms could store solid manure in temporary heaps in fields.

In terms of slurry based systems, the 2014 FPS reported that:

- 55% (+/-7%) of dairy farms had facilities to store slurry in a tank. Of these around 12% (+/-5%) were covered.
- 69% (+/-7%) could store slurry in lagoons and 18% (+/-4%) had facilities to store slurry in

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)	2011/12			2012/13		
	Low performers (bottom 25%)	High performers (top 25%)	All	Low performers (bottom 25%)	High performers (top 25%)	All
Average herd size	52	234	138	49	252	140
Forage area (hectares per head)	0.8	0.5	0.6	0.7	0.5	0.5
Yield (litre per cow)	5,782	8,383	7,619	5,622	8,062	7,531
Price (pence per litre)	27	29	28	27	30	29
Milk sales	1,540	2,399	2,149	1,524	2,389	2,183
Calf sales & transfers out	105	90	97	113	105	112
Miscellaneous output	0	3	1	0	2	1
Less herd depreciation	-152	-248	-224	-233	-229	-232
Enterprise output/cow	1,493	2,243	2,023	1,404	2,267	2,063
Variable costs						
Concentrates	430	705	609	528	731	691
Conc/litre(pence)	7	8	8	9	9	9
Coarse fodder	32	41	36	42	49	48
Vet and medicine costs	36	98	75	65	879	80
Other livestock costs	146	197	171	190	183	180
Forage variable costs	71	93	88	95	97	99
Fert/litre (pence)	1	1	1	1	1	1
Total variable costs/cow	716	1,134	979	920	1,146	1,098
Gross margin/cow	777	1,109	1,043	484	1,121	966
Variable costs pence/litre	12	14	13	16	14	15

Source: Farm Business Survey

Table 3 provides a comparison of gross margins for dairy herds between low and high economic performance groups. Data from the Farm Business Survey indicates that the average milk yield for high performing farms was around 45% higher than low performing farms in both 2011/12 and 2012/13. 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 also similar for low and high performing groups in 2011/12 although reduced for higher performing farms in 2012/13. Concentrated feed is the greatest input cost for both groups. 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. In terms of gross margin per cow the overall gap between the high and low performers has widened between the 2 years which is in line with longer term trends³⁵.

³⁵ 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 2012/13 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 terms of gross margin per cow, the overall gap between the high and low performers widened between 2011/12 and 2012/13, in line with longer term trends. 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 been relatively stable at around 5 years although recent decreases may suggest a slight decline in longevity. Overall, calf registrations have increased slightly in the last 5 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 been stable over recent years before reducing from 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](#).

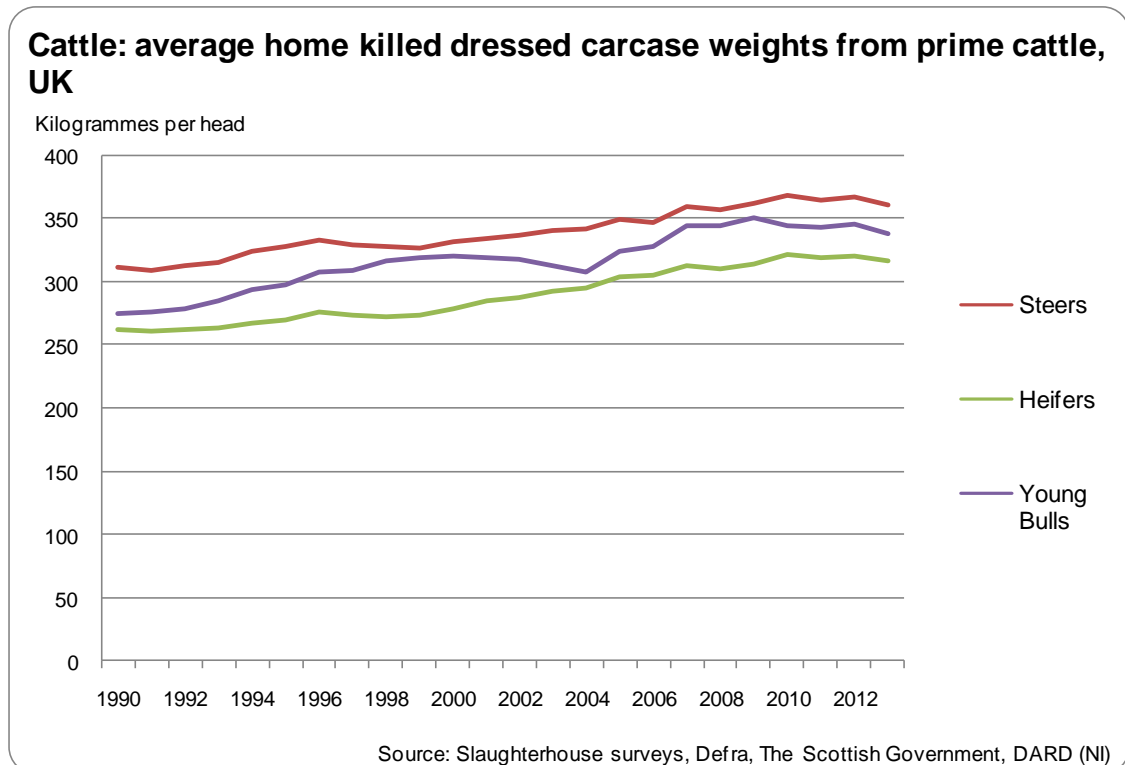
2.5 Beef

2.5.1 Beef: efficiency of output

Weight at slaughter

Rationale

More efficient finishing³⁶ 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

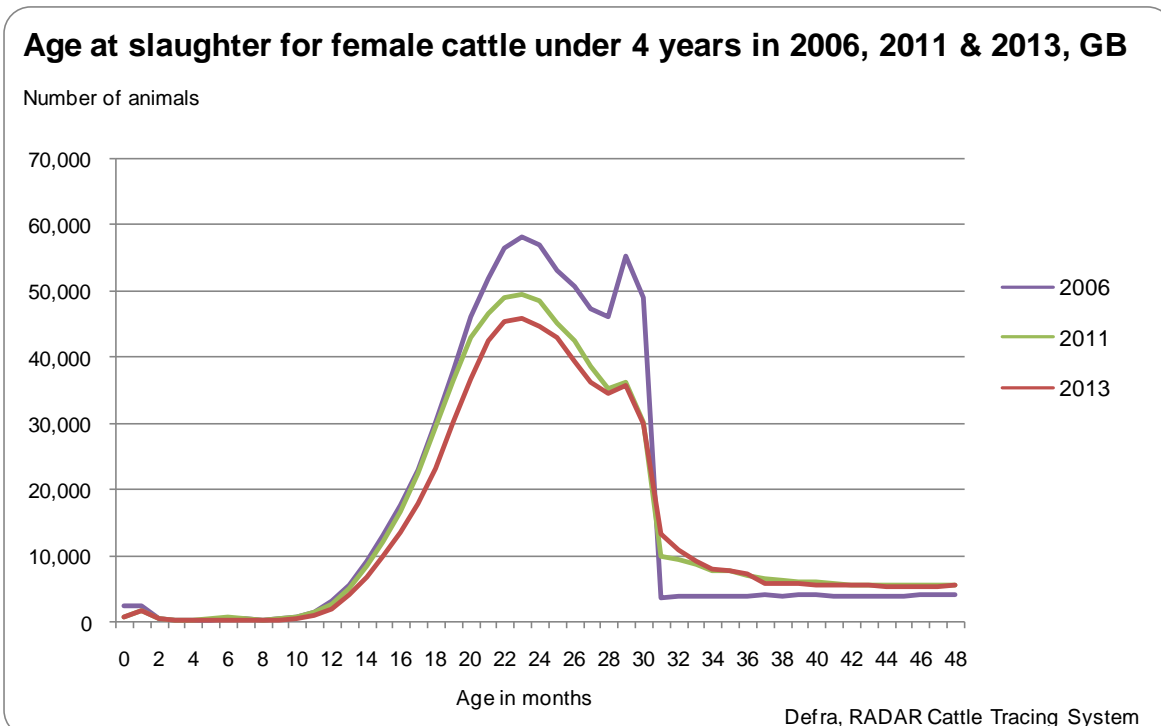
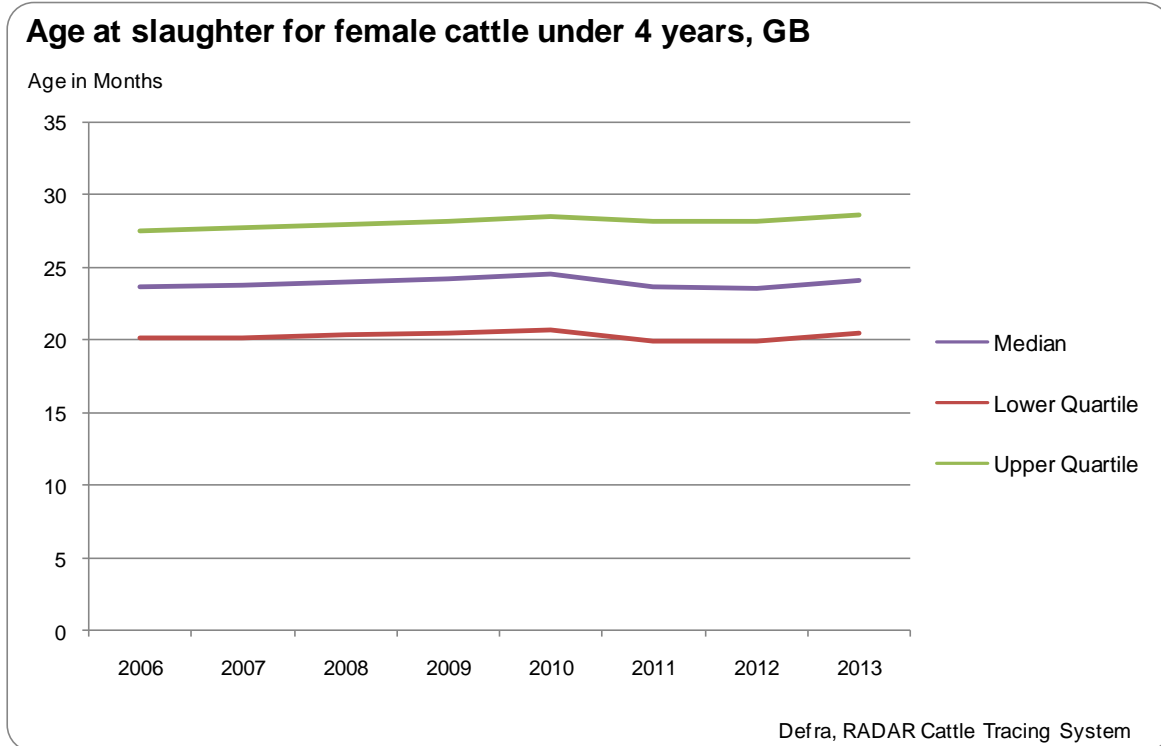
Since 1990 there has been an overall increase in the average carcass weight of prime beef cattle although little change has been seen in more recent years.

³⁶ Finishing is the feeding process used prior to slaughter for cattle or sheep intended for meat production.

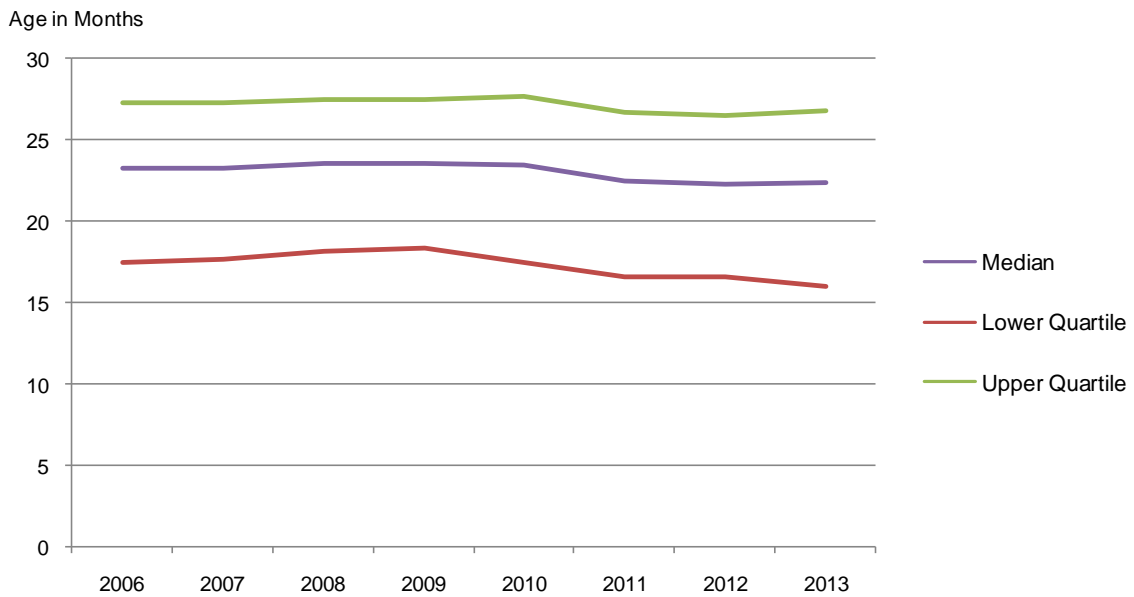
Age at which cattle under 4 years are slaughtered

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 8 years. Cattle over 4 years have been excluded as these will primarily be breeding animals.

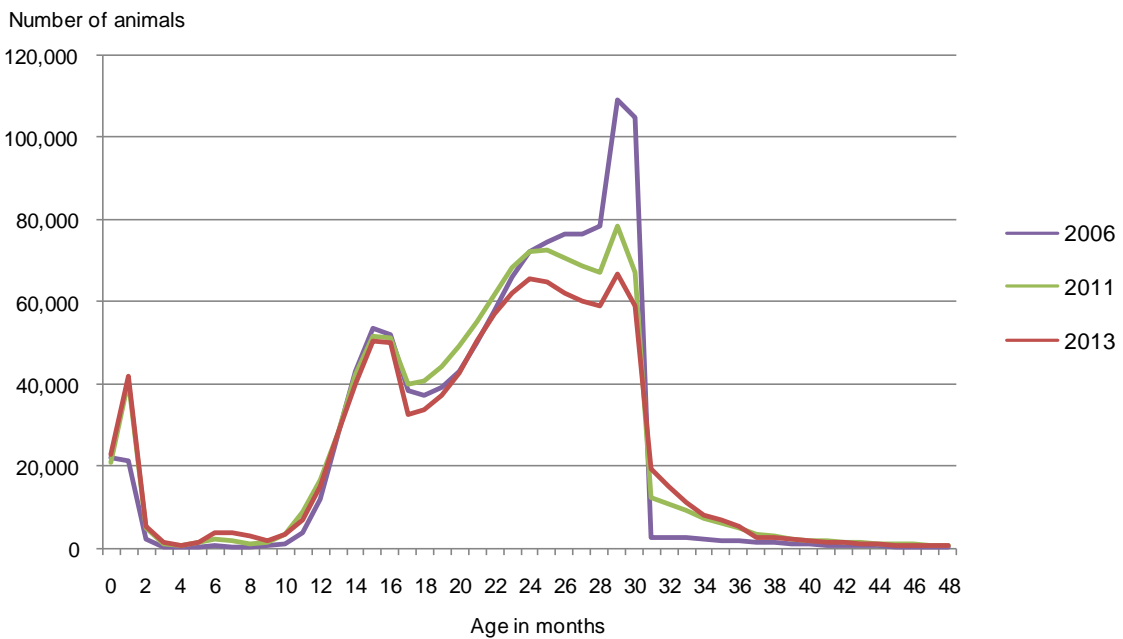


Age at slaughter for male cattle under 4 years, GB



Defra, RADAR Cattle Tracing System

Age at slaughter for male cattle under 4 years in 2006, 2011 & 2013, 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.

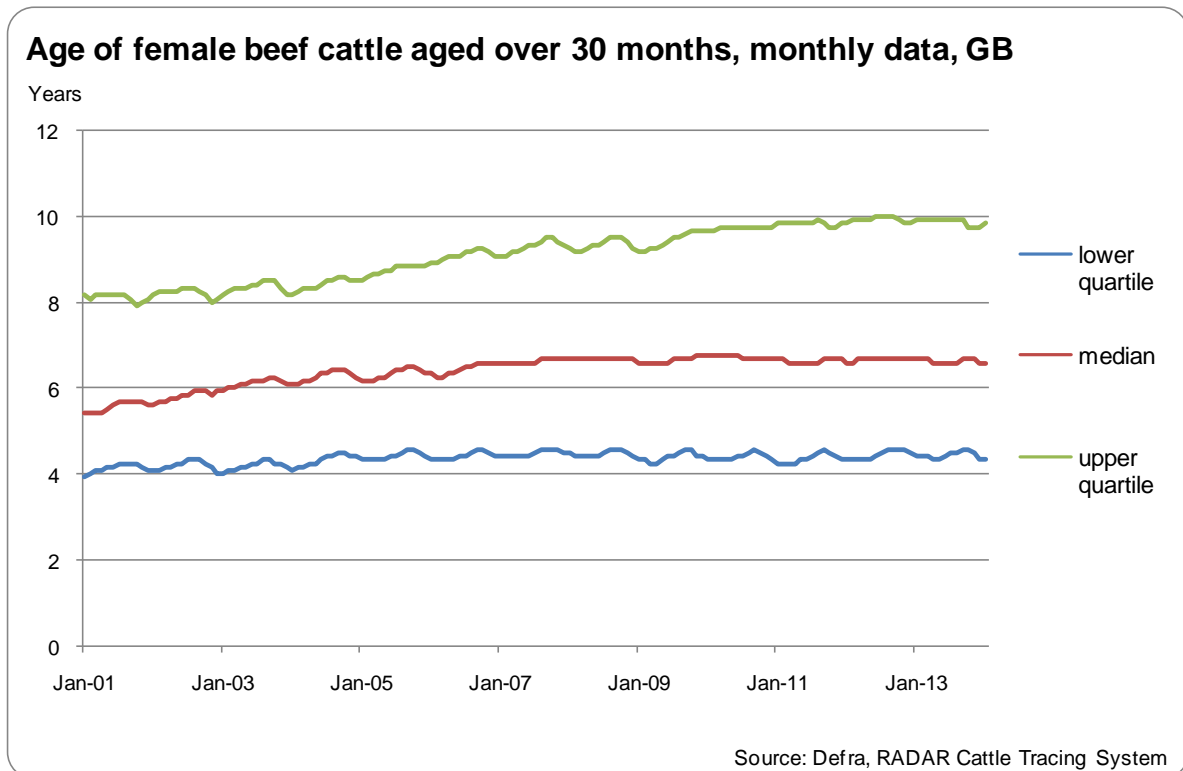
2.5.2 Beef: longevity and fertility

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

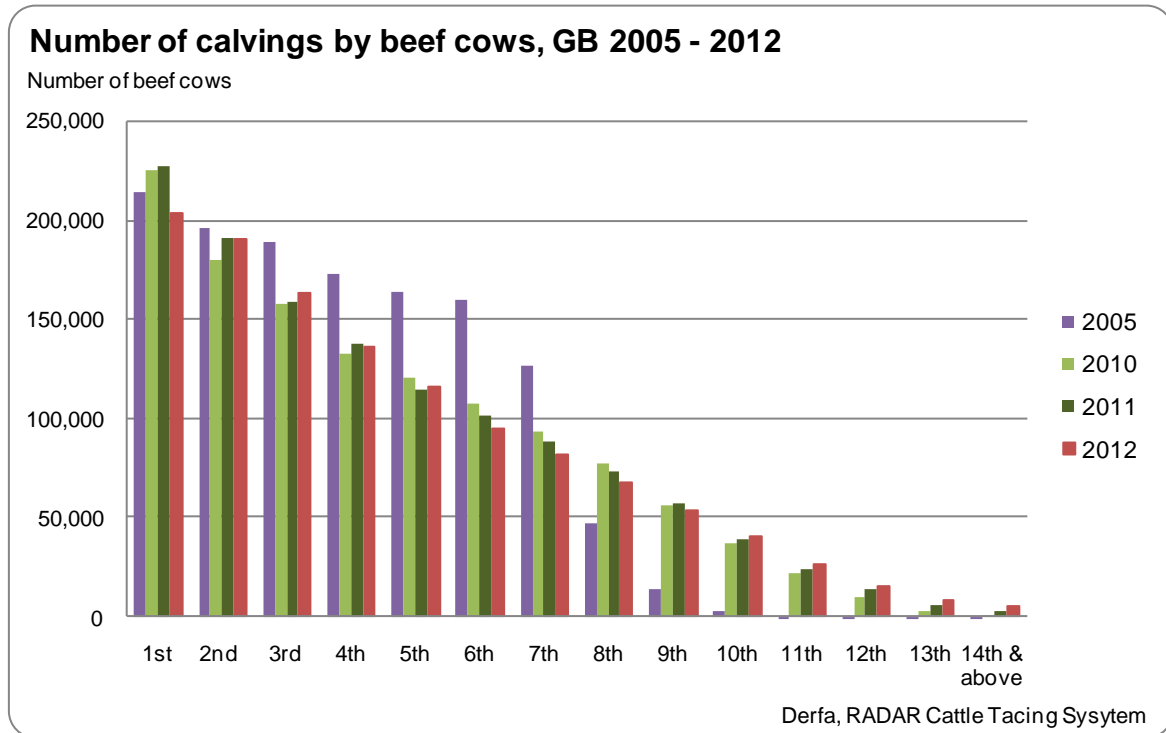
The median age of the beef breeding herd (cows aged over 30 months) has increased since 2001 but has remained relatively stable since 2007. This rise is thought to be due to a recovery following Foot and Mouth (FMD) and changes to restrictions associated with Bovine Spongiform Encephalopathy (BSE) (where 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.

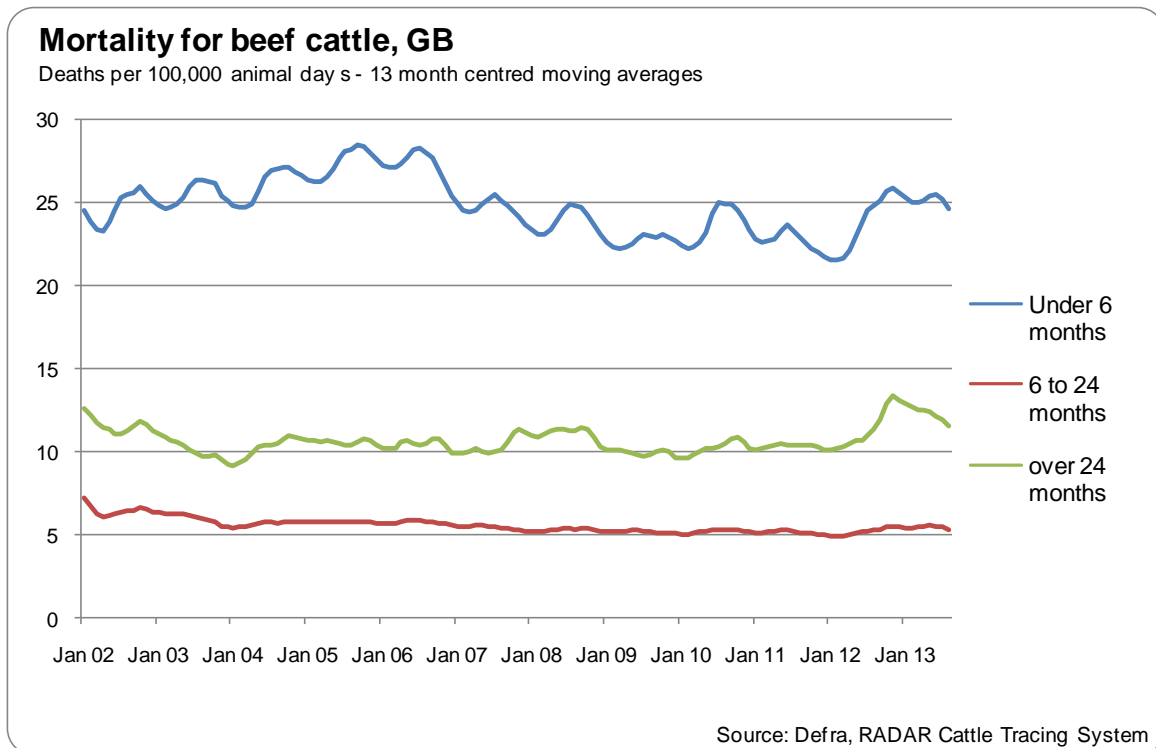
In recent years there has been an increase in the number and proportion of beef cows calving at least 8 times; from around 47 thousand in 2005 to 67 thousand in 2012. This trend suggests increased longevity within the breeding herd.

2.5.3 Beef: animal health

On-farm mortality

Rationale

All other things being equal, reductions in on-farm mortality³⁷ will lead to fewer animals being required for food production. In addition, reduced disease should lead to greater productivity. For cattle, overall mortality 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) between 2006 and 2012. It is not clear why the increases towards the end of 2012 occurred as there are no obvious causes, such as a disease outbreak. For beef cattle aged 6 months and above there have again been fluctuations but overall there has been little change in on-farm mortality since 2002.

³⁷ 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 premises that were registered as being an agricultural premise. Therefore, this data excludes deaths at slaughter houses.

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.

Questions relating to slurry and manure storage were reworded on the 2014 Farm Practices Survey (FPS) to include greater detail on types of storage and covers. As a result the data may not be fully comparable with previous years.

For grazing livestock farms the 2014 Farm Practices Survey (FPS) reported that:

- 50% (+/-7%) of lowland farms had facilities to store solid manure in heaps on a solid base. For those in less favoured areas (LFA) the proportion was 74% (+/9%) in 2014. These stores were covered on 18% (+/- 6%) of LFA and 13% (+/-6%) of lowland farms.
- 70% (+/-6%) of lowland farms had facilities to store solid manure in temporary heaps in fields. For LFA farms the proportion was 42% (+/-8%).
- 24% (+/-8%) of LFA farms had facilities to store slurry in tanks, of these 36% (+/-15%) were covered. 8% (+/-3%) of lowland grazing livestock farms were able to store slurry in a tank, of these 38% (+/-20%) 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), 2009/10 - 2012/13 England

	Finished cattle from calves & stores from the dairy herd				Finished cattle from calves & stores from the suckler herd			
	09/10	10/11	11/12	12/13	09/10	10/11	11/12	12/13
Average herd size	156	170	146	137	111	116	99	102
Finished livestock sales	455	544	529	572	855	990	1,055	1,203
Other cattle/ throughput	140	47	160	154	117	-40	183	8
Less herd depreciation /calf & store cattle purchases	-222	-203	-161	-192	-598	-598	-698	-707
Enterprise output	373	388	529	534	375	369	540	505
Variable costs								
Concentrates	151	190	209	227	131	166	149	195
Coarse fodder	6	7	6	13	6	6	13	8
Vet and medicine costs	11	11	13	16	11	10	12	12
Other livestock costs	47	56	53	53	54	68	73	73
Forage variable costs	37	34	37	44	36	32	38	44
Total variable costs	251	298	318	352	238	283	285	333
Gross margin per cow	122	90	211	181	137	90	255	172

Source: Farm Business Survey

Table 4 provides a comparison of beef cattle gross margins from the Farm Business Survey based on standard output typology³⁸. 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 across the period for finished calves and stores from both the dairy herd and the suckler herd. Enterprise output rose significantly between 2010/11 and 2011/12 however, offsetting these increases and resulting in gross margins more than doubling for both categories in 2011/12. This was followed by a fall in enterprise output in 2012/13 which, combined with increased variable costs (particularly concentrates), led to a drop in gross margins. This was particularly marked for finished calves and stores from the suckler herd.

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.

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) between 2006 and 2012. For beef cattle aged 6 months and above there has been little overall 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

³⁸ 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

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](#).

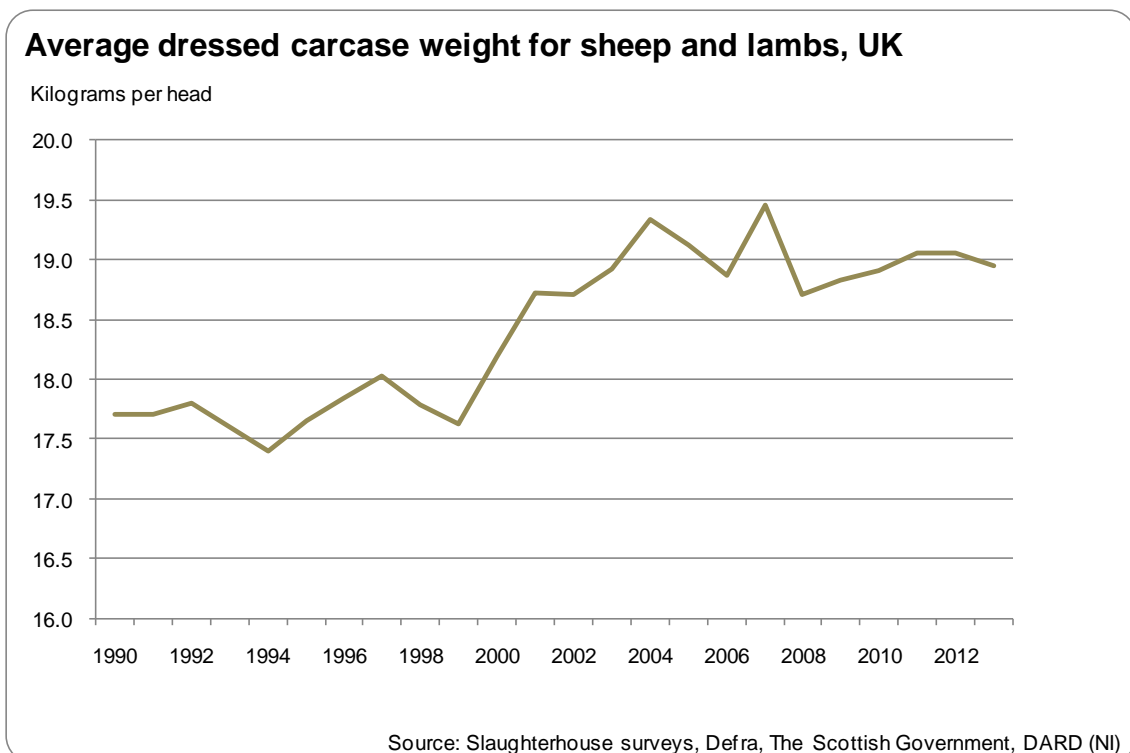
2.6 Sheep

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 carcass 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.

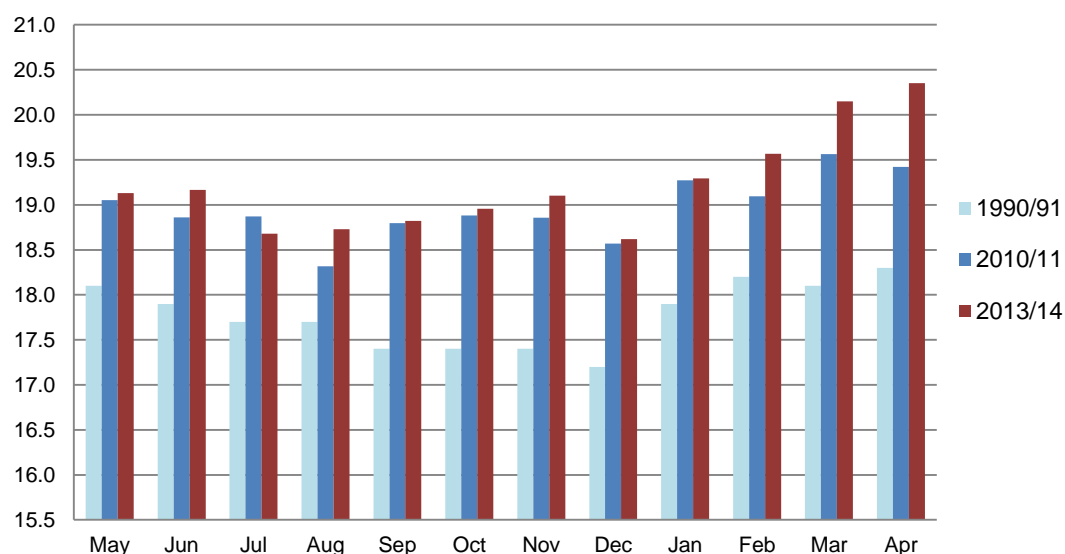


Note: excludes ewes and rams

Monthly distribution of slaughter weights and marketing pattern

Average dressed carcasse weights for clean sheep and lambs, UK

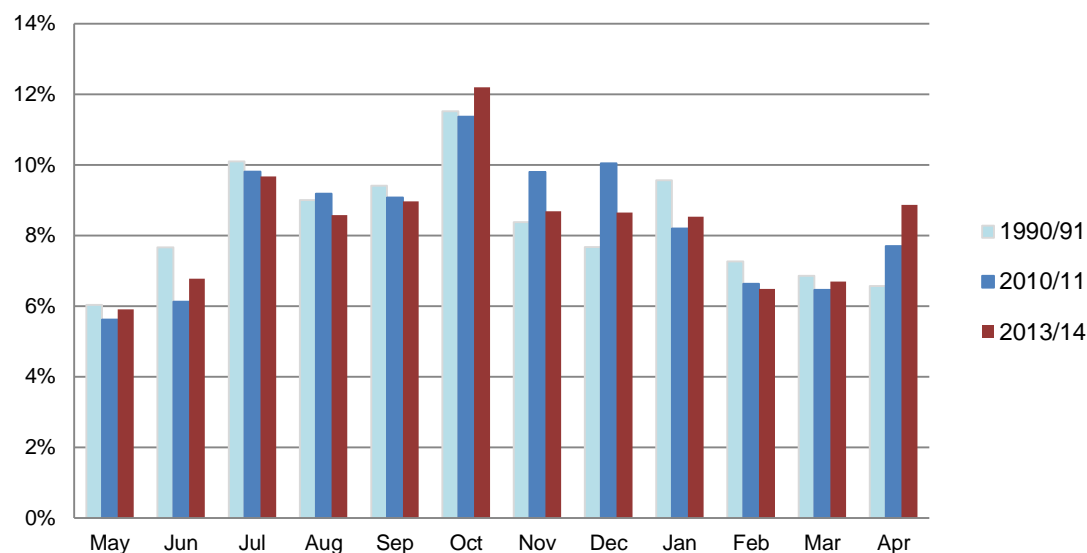
Kilogrammes per head



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

Monthly marketing pattern for clean sheep and lambs, UK

Per cent



Source: Slaughterhouse 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 carcasse weights has taken place across the year with no sustained changes to the monthly marketing pattern

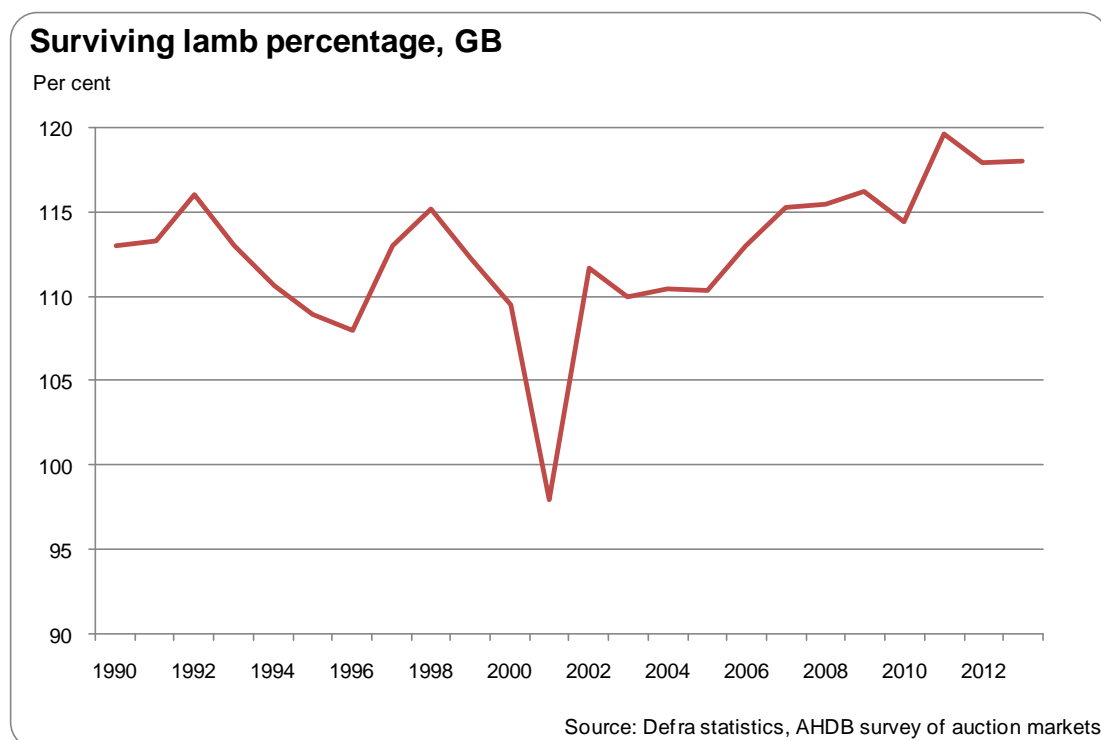
over time to suggest a move to later finishing. Changes within years tend to be shorter term reactions to weather and prices. For instance, the wet summer of 2012 led to problems finishing lambs and resulted in delayed marketings and lower carcass weights than in 2011.

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 and remained unchanged at this level in 2013.

Definition of the surviving lamb percentage

The lambing percentage is calculated as $(A + B)/(C + D) \times 100$, 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 2009/10 - 2012/13

	Lowland breeding ewes				LFA breeding ewes			
	09/10	10/11	11/12	12/13	09/10	10/11	11/12	12/13
Average flock size	258	271	265	282	409	507	451	464
Forage area (hectares per head)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Finished livestock sales	75	82	92	76	35	41	43	42
Store sales	11	7	12	11	18	13	22	15
Other lamb throughput	12	14	19	19	17	21	23	20
Miscellaneous revenue	1	2	3	4	0.7	1	2	3
Less flock depreciation	-9	-10	-12	-13	-10	-10	-10	-11
Enterprise output	90	94	114	98	61	66	79	69
Variable costs								
Concentrates	15	17	19	20	10	11	12	14
Coarse fodder	1	2	2	2	3	4	4	5
Vet and medicine costs	6	6	6	7	5	5	6	6
Other livestock costs	10	11	12	12	6	8	9	8
Other crop costs	9	8	9	9	3	4	5	4
Total variable costs	40	44	48	49	28	33	35	37
Gross margin/ewe	50	50	67	48	33	33	44	32

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.

Following increases in 2011/12 gross margins per ewe decreased in 2012/13 for both lowland and LFA ewes to £48 per ewe and £32 per ewe respectively, a fall of 28% in each case. The decrease reflects a fall in 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 finished³⁹ 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.

³⁹ Finishing is the feeding process prior to slaughter for cattle and sheep intended for meat production.

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](#).

2.7 Pigs

2.7.1 Pigs: efficiency of output

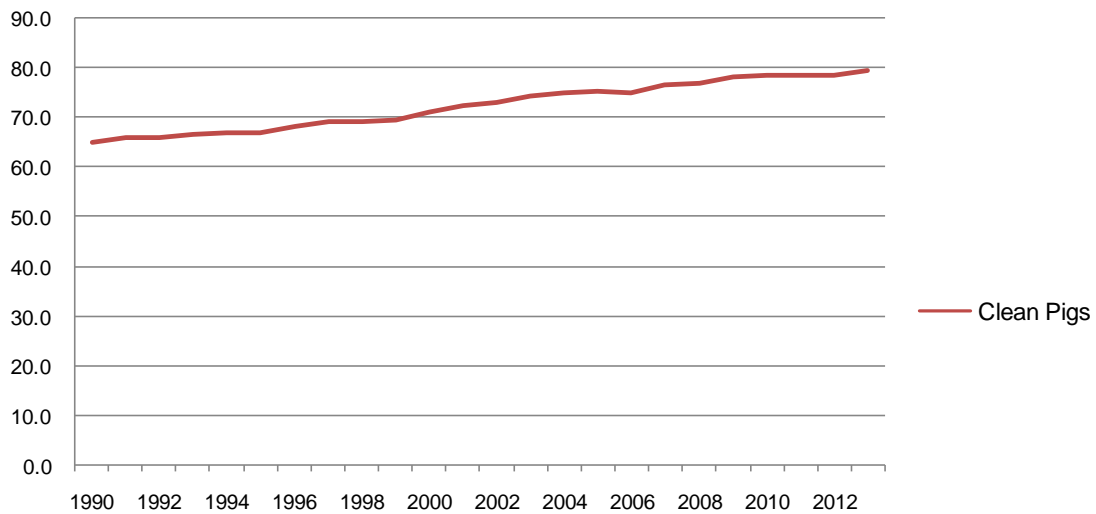
Weight at slaughter and daily live weight gain

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

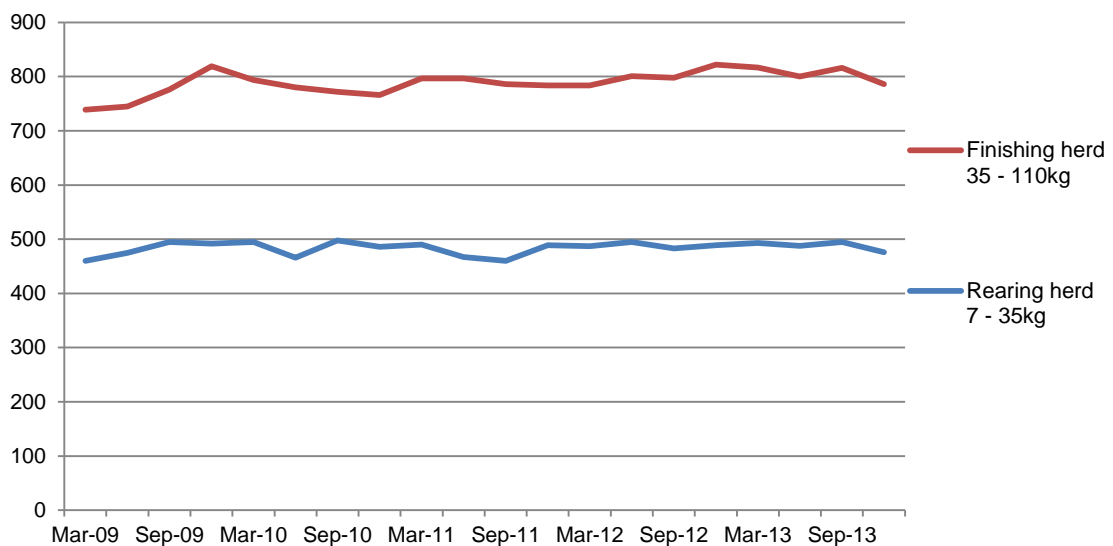
Kilogrammes per head



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

Daily live weight gain rearing and finishing herds, GB

Grammes per day



Source: BPEX and Agrosoft Ltd

Trends

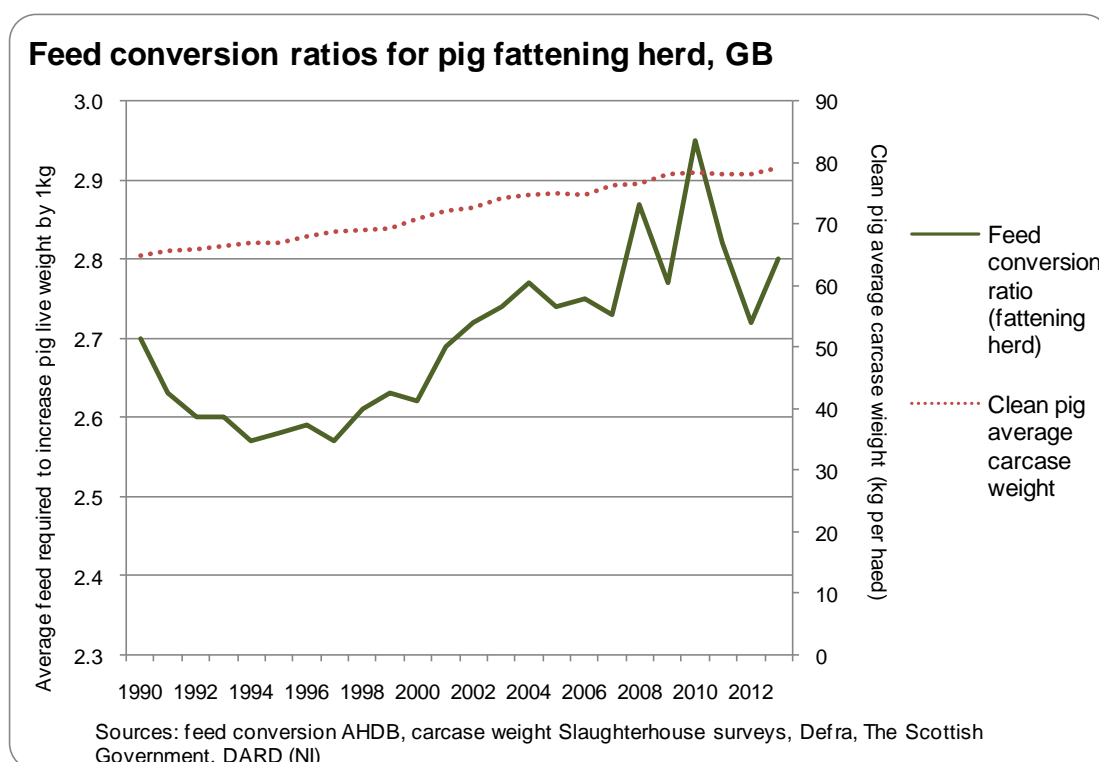
Average carcass weights have increased consistently since 1990. Increases in daily live weight gain were seen in both the rearing and finishing herd during 2009. Since then levels have remained relatively stable.

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.

The feed conversion ratio of the fattening herd is the GHG indicator⁴⁰ for the pig sector. More details of this can be found in the [Summary](#) earlier in the publication and in the full indicator text at: <https://www.gov.uk/government/statistical-data-sets/greenhouse-gas-emissions-from-agriculture-indicators>



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. It is also not possible within this measure to reflect changes in the type of feed used (such increasing use of feed sourced from co-products) which

⁴⁰ The ten GHG indicators cover farmer attitudes and knowledge, uptake of mitigation methods and the GHG emission intensity of production across key agricultural sectors.

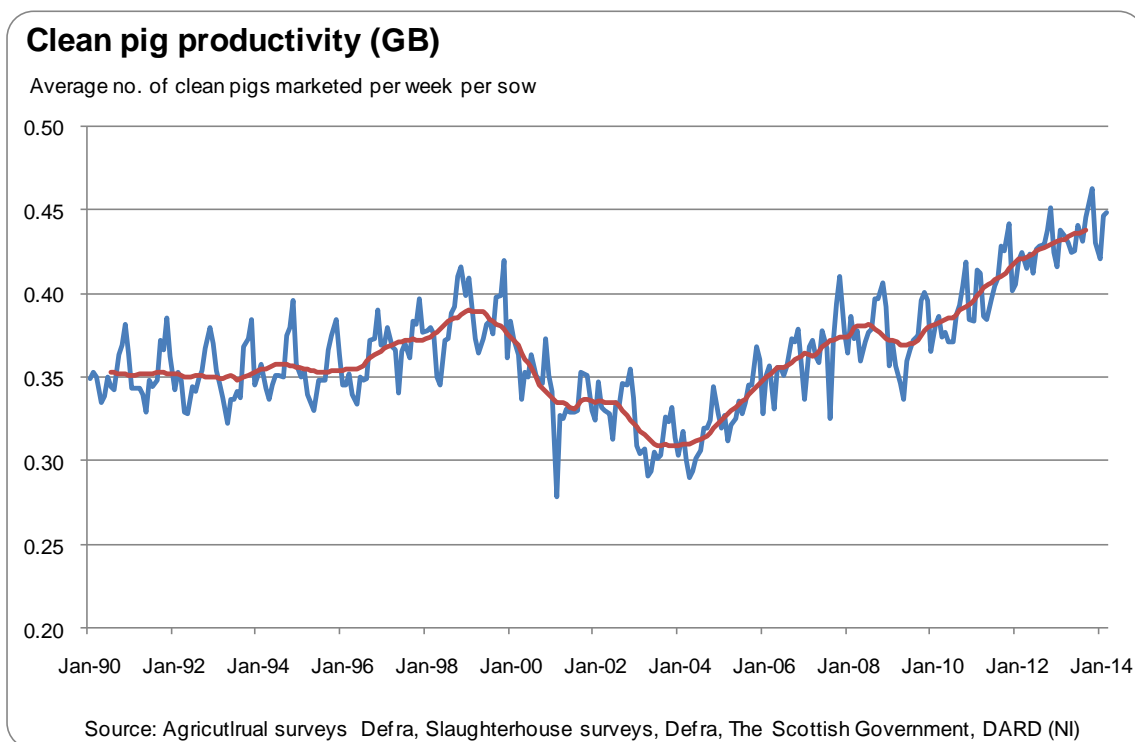
may have a bearing on the emissions intensity of production. Since 2010 there has been a reduction in the FCR (suggesting a possible improvement in feed efficiency and reduction in emissions intensity) with some fluctuations. It is too early to say if this trend will be maintained.

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.

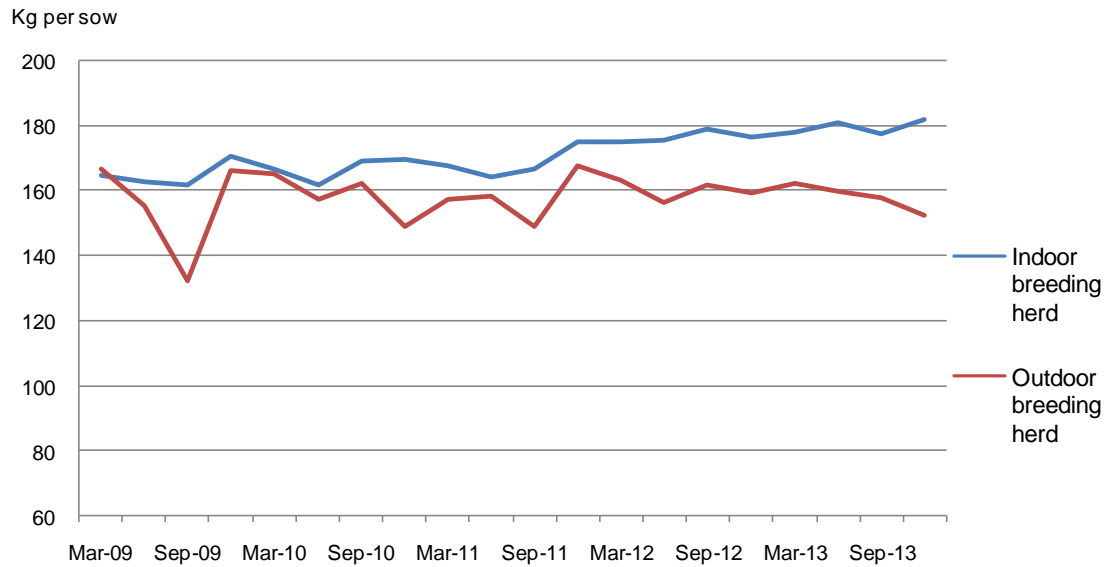


Trends

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 following chart illustrates the variation in kilogrammes weaned per sow per year in the outdoor breeding herd. There are numerous reasons for this difference between indoor and outdoor systems including: the impact of adverse weather conditions on piglet survival, lighter piglet weaning weights due to differences in nutrient intake and energy balance and differing selection objectives (with indoor genotypes selected for prolificacy and outdoor for robustness).

Average kilogrammes weaned per sow per year, GB



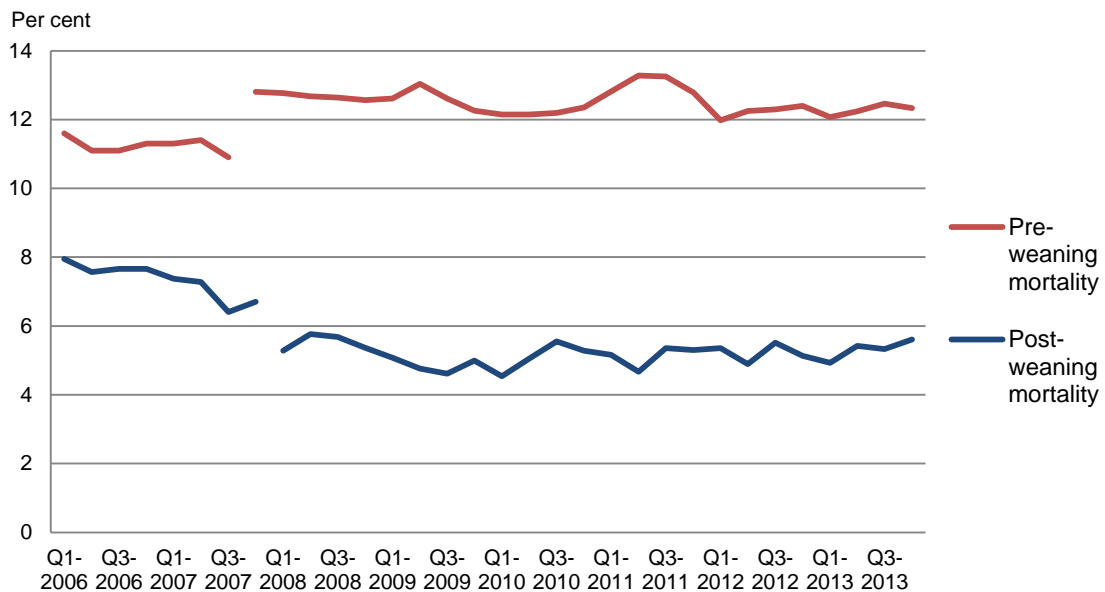
Source: BPEX and Agrosoft Ltd

Mortality

Rationale

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

Average pig mortality, GB



Source: BPEX and Agrosoft Ltd

Note, the break in the series indicates a change in methodology, including a change in the sample size which increased from the breeding herd in Q4 2007 to the rearing and feeding herd in Q1 2008.

Trends

The data suggests that there appears to have been little change in pre weaning mortality over the last 6 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/departement-for-environment-food-rural-affairs/series/agricultural-statistics-and-climate-change>

Questions relating to slurry and manure storage were reworded on the 2014 Farm Practices Survey (FPS) to include greater detail on types of storage and covers. As a result the data may not be fully comparable with previous years. The 2014 FPS surveyed 195 holdings with pigs. From this relatively small sample it is difficult to draw a precise conclusion; however, they do provide an approximate indication that:

- 49% (+/-9%) of pig holdings had storage facilities for solid manure on a solid base.
- 21% (+/-7%) could store slurry in a tank; of these 30% (+/-15%) were covered.
- 15% (+/- 6%) could store slurry in a lagoon and 15% (+/-5%) 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	2012/13
Average herd size	143	118	135	134
Finished livestock sales	2,269	2,279	2,025	1,958
Store sales	110	73	141	186
Miscellaneous revenue	0.5	2	1	1
Less herd depreciation	11	36	-12	-1
Enterprise output	2,368	2,318	2,155	2,145
Variable costs				
Concentrates	1,221	1,386	1,380	1,389
Vet and medicine costs	69	69	58	51
Other livestock costs	141	153	135	145
Heating	3	1	2	0
Total variable costs	1,434	1,609	1,602	1,586
Gross margin/sow	934	709	587	560

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 £560 in 2012/13. 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. More recently there has been 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

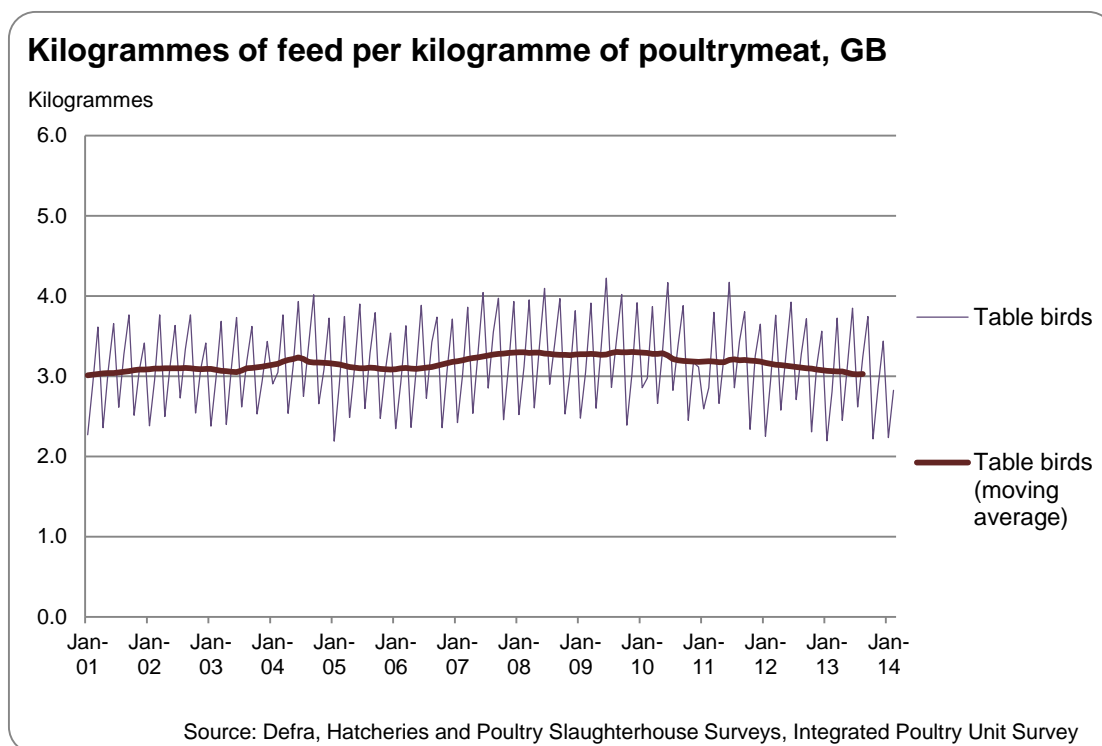
Feed conversion ratio⁴¹

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 carcase 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.

The feed conversion ratio for table birds is the GHG indicator⁴² for the poultry sector. More details of this can be found in the [Summary](#) earlier in the publication and in the full indicator text at:

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



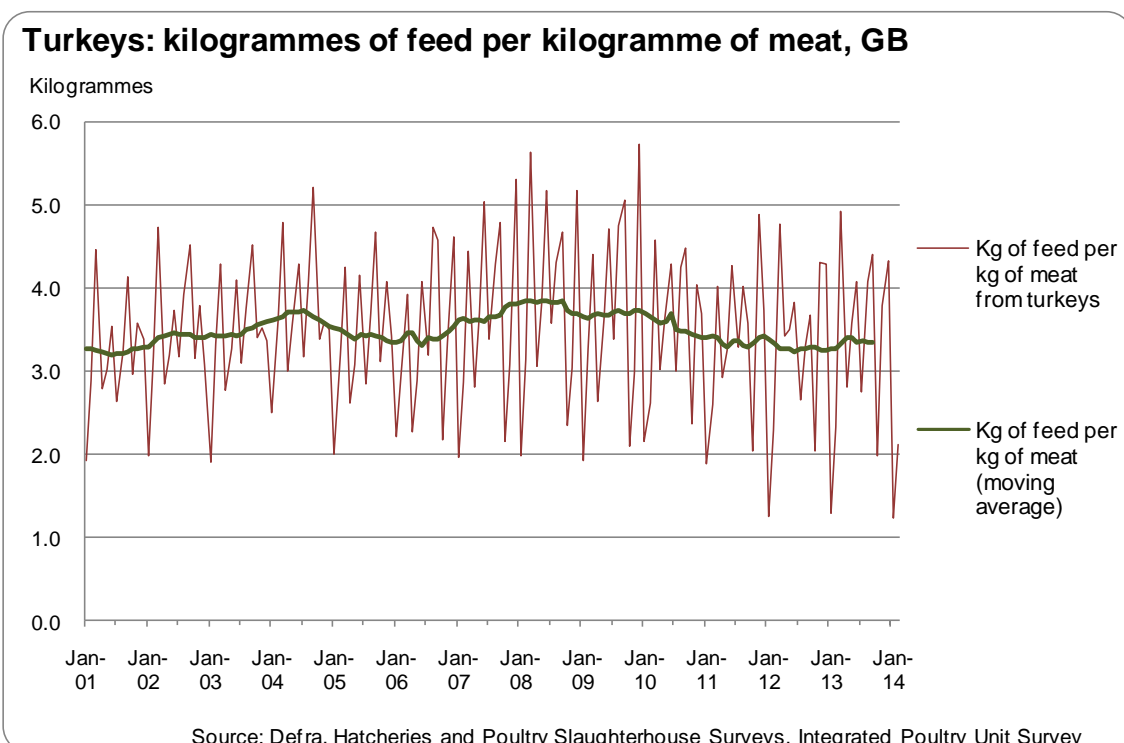
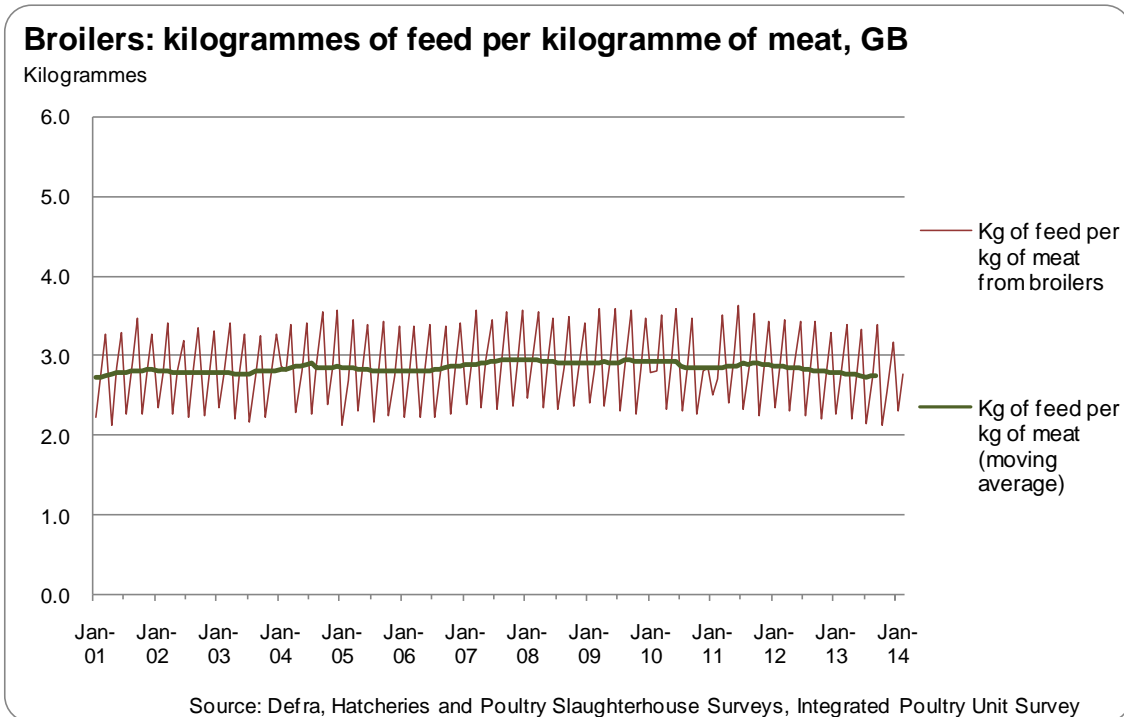
Trends

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 2013, although the change is well within the year on year variation.

⁴¹ For data availability reasons the feed conversion ratio (FCR) shown is kilogrammes of feed per kilogrammes of meat based on carcase weights. The FCR is more usually expressed in relation to live weight. Carcase weight is approximately 75% of the live weight which would give a lower ratio feed per kilogrammes of meat produced.

⁴² The ten GHG indicators cover farmer attitudes and knowledge, uptake of mitigation methods and the GHG emission intensity of production across key agricultural sectors.

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.



The average turkey FCR is higher than that for chickens. The trend has fluctuated over the period, but has generally declined over the last 5 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](#).

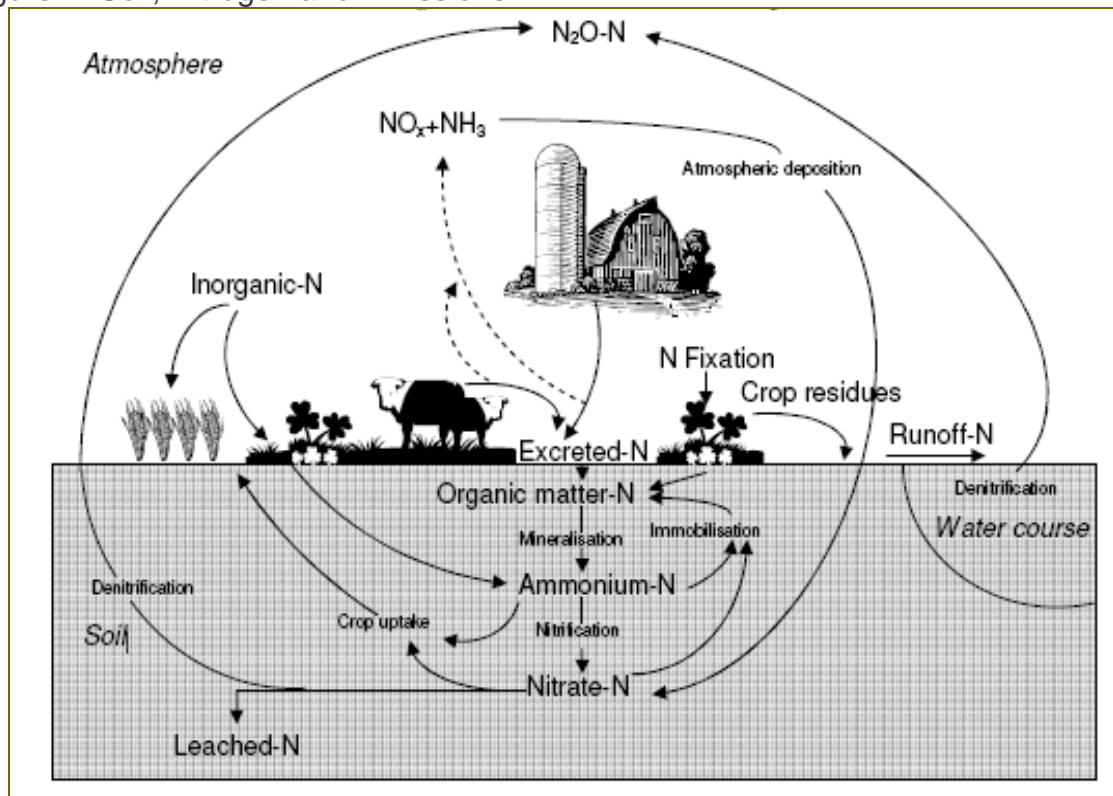
2.9 Land and Nutrient Use

Background information

Inputs of manufactured or livestock derived nitrogen fertilisers are critical to maintain yields of food and fodder crops⁴³, 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 on-farm efficiency measures and best practice management techniques. This section covers the outcomes associated with the uptake of these practices by considering GHG intensity measures, while Section 3 presents information on 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 a given level of 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).

Within this publication we focus on GHG intensity, a reduction in absolute levels of nitrogen would however provide multiple environmental benefits.

⁴³ <http://www.bis.gov.uk/assets/foresight/docs/food-and-farming/science/11-573-sr31-fertiliser-availability-in-resource-limited-world.pdf>

2.9.1 Land and nutrient use: efficiency of output

Long term measure of change: Crop production per unit of manufactured N applied⁴⁴

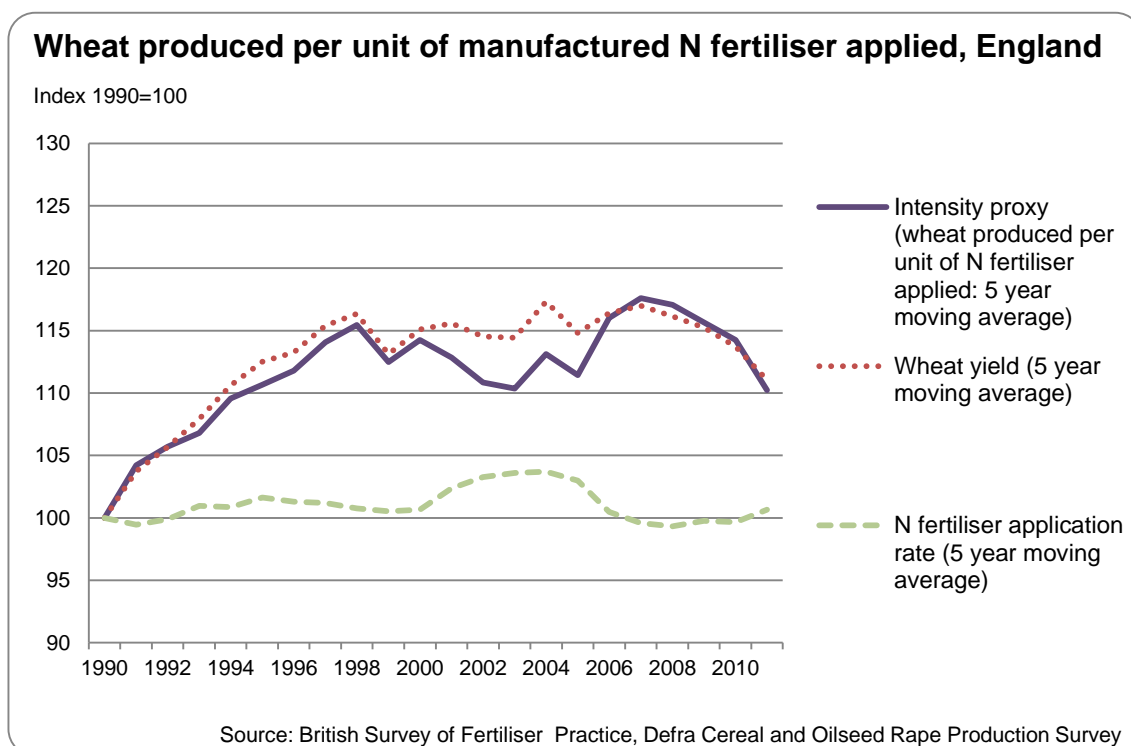
Rationale

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](#).

Manufactured fertiliser application is the GHG indicator⁴⁵ for the cereal and other cropping sector. More details of this can be found in the [Summary](#) earlier in the publication and in the full indicator text at: <https://www.gov.uk/government/statistical-data-sets/greenhouse-gas-emissions-from-agriculture-indicators>

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 2011. Any later estimates of the trend are less certain as these cannot use a 5 year trend so are annual point estimates only and as such are relatively volatile and influenced by external factors

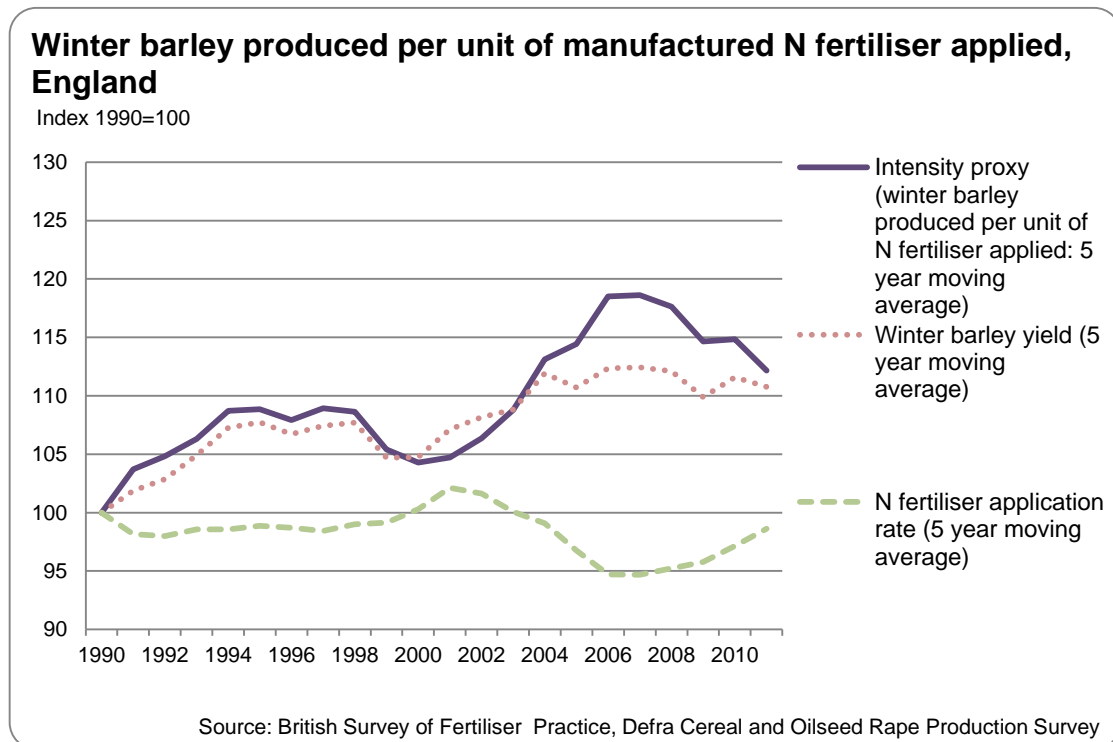
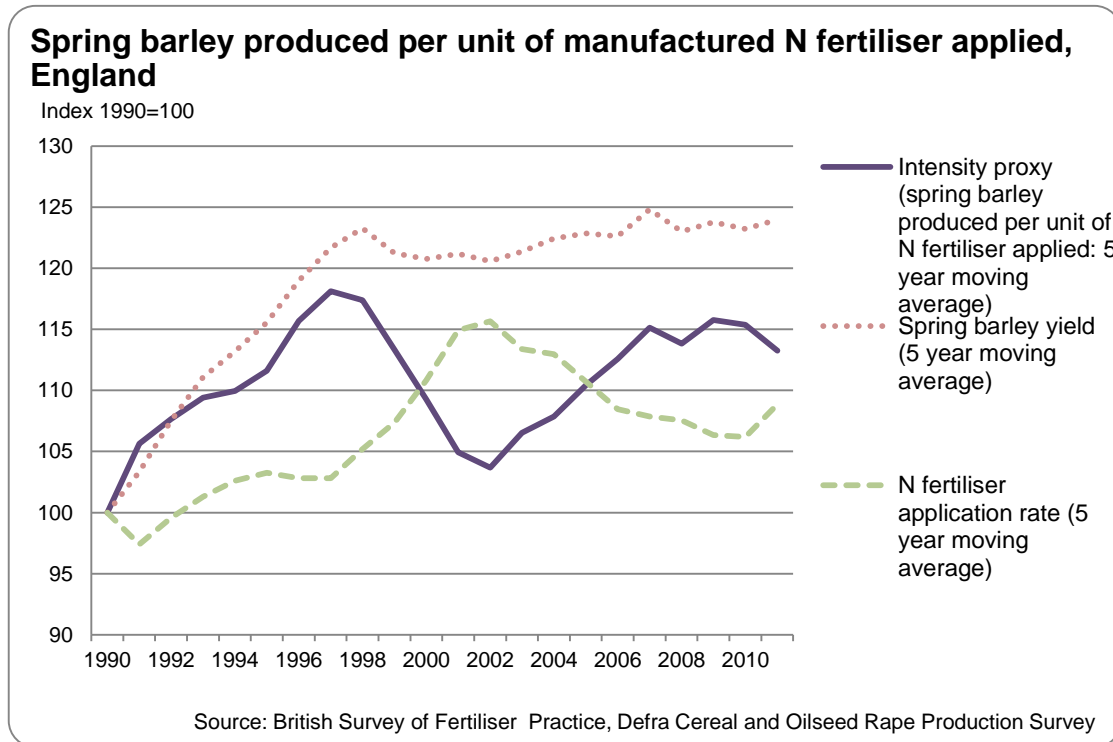
Application rates of nitrogen based fertiliser per hectare provide an indication of short term changes (year on year) and are explored later in this section.



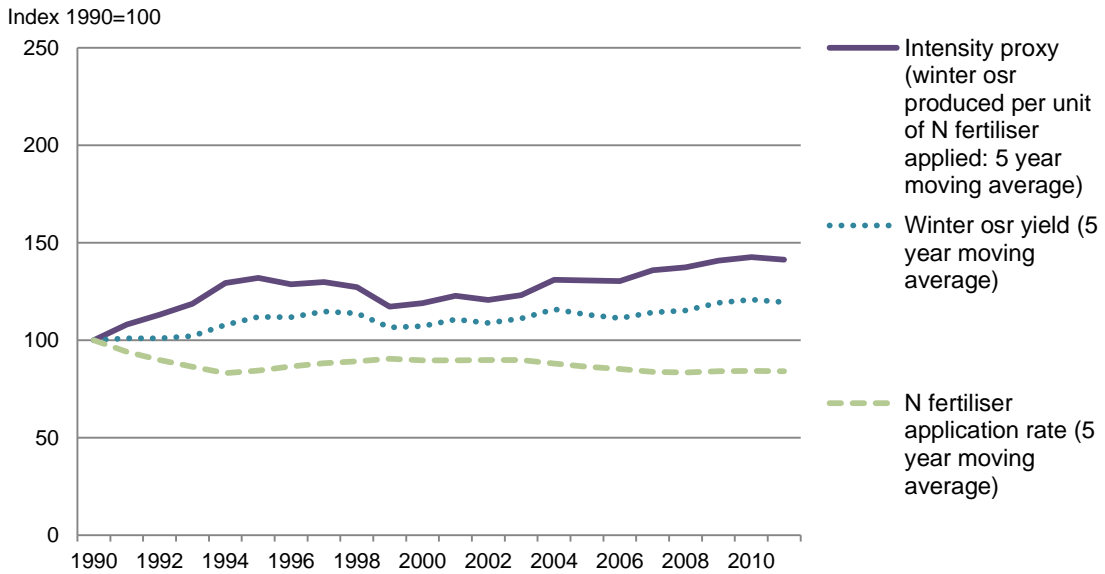
⁴⁴ This measure does not include organic nitrogen from manure or slurry.

⁴⁵ The ten GHG indicators cover farmer attitudes and knowledge, uptake of mitigation methods and the GHG emission intensity of production across key agricultural sectors.

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

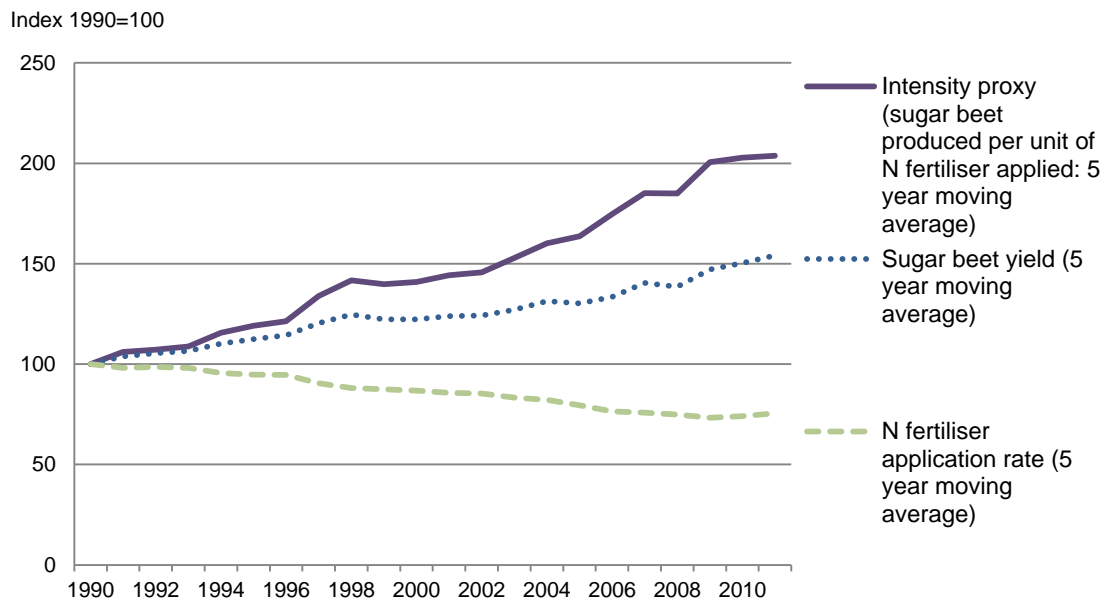


Winter oilseed rape produced per unit of manufactured N fertiliser applied, England



Source: British Survey of Fertiliser Practice, Defra Cereal and Oilseed Rape Production Survey

Sugar beet produced per unit of manufactured N fertiliser applied, England



Source: British Survey of Fertiliser Practice, Defra Agricultural 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 less wheat being produced per unit of nitrogen applied.

The trends for the intensity measures for winter and spring barley are similar to those for wheat although the weather in 2012 affected barley yields to a much lesser extent. 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 2010⁴⁶) aimed to redistribute contract tonnage from low yielding producers (particularly those furthest from factories) to those achieving higher average yields.

Latest position

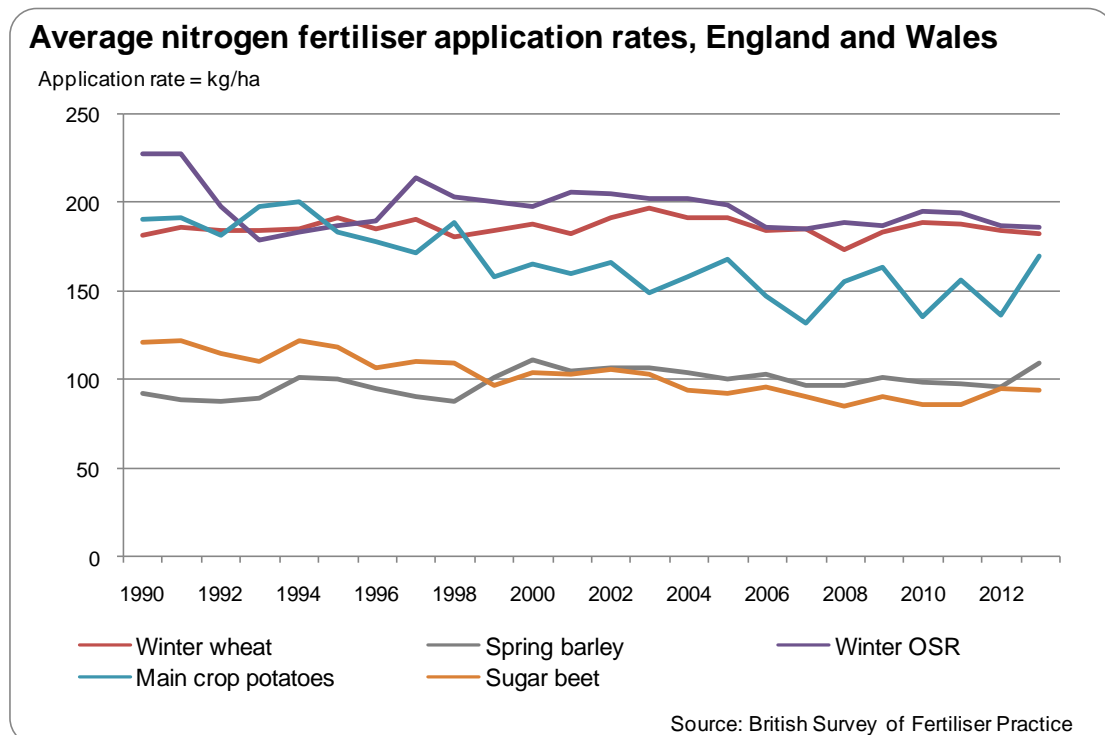
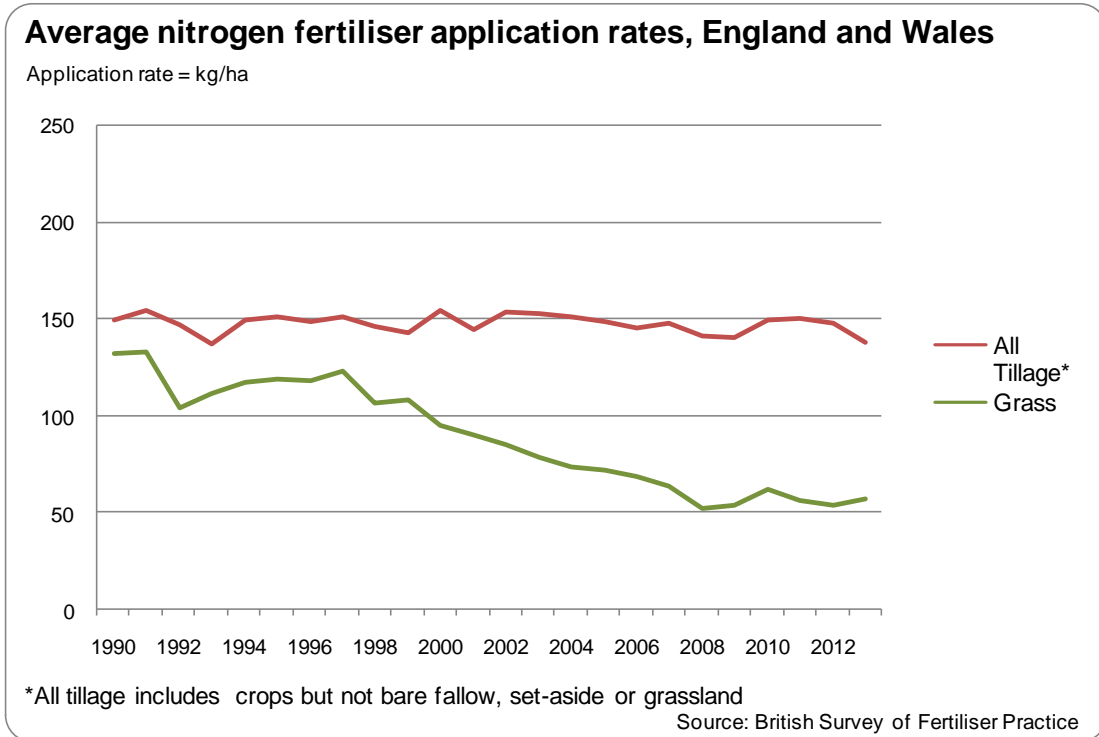
There is variability in production from year to year due to weather, disease, and pest pressure affecting yields. Early indications for 2014 show that crops have benefited from the better planting conditions in autumn / winter 2013, when most planting took place before the heavy rain arrived. For wheat the planted area is expected to be around 19% higher than 2013 with the largest increases seen in those regions that experienced the worst of last year’s weather i.e. West Midlands and Scotland. Most winter wheat is in good condition although the presence of black grass is expected to reduce yields to some degree. There has been a re-balancing of the areas of winter and spring barley with the winter barley area forecast to increase by 27% compared to 2013 and 2% higher than 2012. By contrast the area of spring barley is expected to decrease by around 29% compared to 2013 when farmers planted spring barley to offset failed winter sown crops. The oat area is forecast to be 20% lower than 2013 but still 15% higher than 2012 as some farmers revert back to wheat and barley. Total oilseed rape is forecast to be 8% higher than 2013 due to a 17% increase in the area of winter oilseed rape which was favoured by the mild autumn and good winter survival offsetting a large reduction in the area of spring oilseed rape of 50% compared to 2013.

⁴⁶ http://www.britishsugar.co.uk/Media/2010/new_beet_deal.aspx

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).



Trends

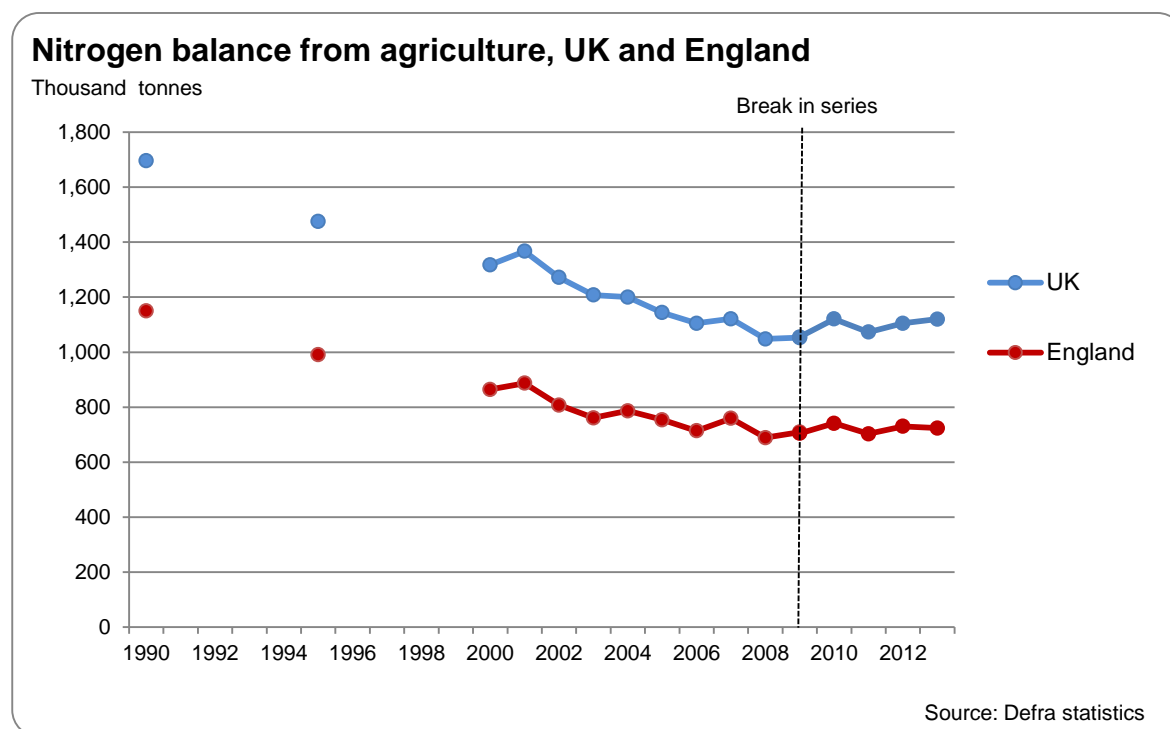
Short term measure of change: the overall application rate for manufactured nitrogen fertilisers has fallen substantially over the last 20 years. Whilst arable application rates have remained relatively stable, grassland application rates have reduced; explaining the majority of the fall in recorded 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 nitrogen⁴⁷ 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 farms⁴⁸ 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.

⁴⁷ 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).

⁴⁸ 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.

Provisional estimates for 2013⁴⁹ suggest that the nitrogen balance for England was a surplus of 724 thousand tonnes. This is a decrease of 6 thousand tonnes (1%) compared to 2012 and a reduction of 140 thousand tonnes compared to 2000. The decrease between 2012 and 2013 has been driven by small reductions to inputs from inorganic (manufactured) nitrogen fertiliser, partially offset by reductions in offtake (particularly harvested crops and crop residue).

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 1,360 farms in the 2013 BSFP around 68% (922) 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 2013.

Table 7: Percentage (%) of farms using each type of manure, GB 2006 to 2013

	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
2013	35	51	17	2	1	3	2	5	4

Source: British Survey of Fertiliser Practice

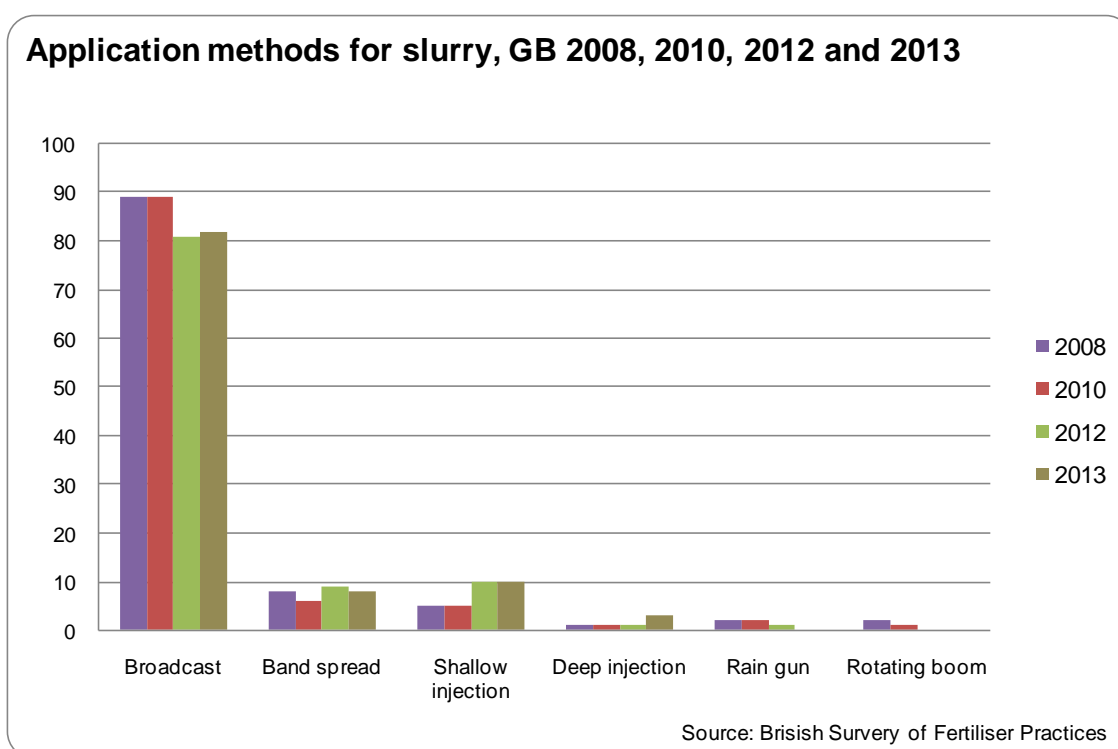
Manure from beef and dairy farms is by far the largest volume of manure type generated in Great Britain. The percentage of farms using cattle FYM has declined by 8% since 2006, whereas the use of cattle slurry has remained more consistent over the period and was used on 17% of farms in 2013. Not all 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.

⁴⁹ 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>

Application methods for slurry

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).

The following chart compares the percentage of farms using each type of slurry application method in Great Britain in 2008, 2010, 2012 and 2013. 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 environmental 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 2013 (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. In 2013 however, the percentage of pig slurry applied as a top dressing to winter sown crops in the spring (43%) is the highest proportion recorded in the Survey to date with the atypical weather conditions across 2012/13 the most likely reason for this.

Table 8: Percentage (%) of fields receiving each organic manure type by sowing season and timing, GB 2013

	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	1	0	0	6	18	14	0	0	15	10
September	4	0	20	10	24	27	8	1	29	22
October	3	0	7	0	2	9	2	0	6	0
Winter (Nov-Jan)	0	0	1	0	0	0	1	0	1	4
Spring (Feb-Apr)	0	1	5	43	2	2	3	0	5	5
Summer (May - Jul)	0	0	0	2	0	1	0	0	0	1
Spring sown										
August	0	0	0	1	3	0	0	0	2	2
September	1	0	6	0	15	2	3	0	1	3
October	1	0	4	5	0	12	6	0	3	1
Winter (Nov-Jan)	2	0	15	1	0	2	0	0	2	4
Spring (Feb-Apr)	14	4	35	14	13	25	7	1	22	32
Summer (May - Jul)	1	0	0	0	5	2	0	0	2	0
Grass										
August	3	3	0	0	0	0	6	9	0	0
September	4	3	0	0	0	0	7	0	0	0
October	5	2	0	0	0	0	11	0	0	0
Winter (Nov-Jan)	8	10	0	0	0	0	2	27	1	0
Spring (Feb-Apr)	40	49	5	10	16	4	32	46	7	13
Summer (May - Jul)	10	26	0	8	2	1	12	16	3	2

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 9⁵⁰). 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 and 2013.

⁵⁰ 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 - 2013

		2008	2009	2010	2011	2012	2013
Winter wheat	with manure	161	180	187	179	170	175
	without manure	183	192	197	198	190	187
Spring barley	with manure	88	89	91	97	95	96
	without manure	101	107	108	107	105	113
Winter barley	with manure	122	138	138	137	140	141
	without manure	137	142	146	144	145	145
Potatoes (maincrop)	with manure	154	155	139	146	133	183
	without manure	156	185	138	178	136	167
Sugar beet	with manure	80	88	87	81	89	87
	without manure	89	101	96	99	99	103
Winter oilseed rape	with manure	159	176	175	174	166	161
	without manure	197	191	204	203	191	187

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

	2011/12			2012/13		
	Low (bottom 25%)	High (top 25%)	All	Low (bottom 25%)	High (top 25%)	All
Average crop area (ha)	15	160	66	17	156	67
Average yield (tonnes/ha)	7	9	8	5	7	7
Average price/tonne(£)	153	157	157	172	180	180
Crops sales	1,032	1,371	1,303	935	1,321	1,237
Straw	66	47	57	89	45	59
Total crops output	1,097	1,419	1,359	1,023	1,366	1,297
Variable costs						
Seed	65	58	60	69	68	69
Fertiliser	189	183	183	228	227	229
Crop protection	151	159	157	191	203	197
Other crop costs	32	37	37	46	38	38
Total variable costs	437	437	436	535	536	532
Gross margin	660	982	923	488	830	764

Source: Farm Business Survey

Economically high performing farms have, on average, about ten times the area of wheat than low performing farms and achieve greater yields driving the better levels of achieved output. In 2011/12 and 2012/13, input costs per hectare were similar on both low and high farms leading to similar levels of variable costs across both groups. In terms of overall gross margins however, the gap between low and high performing farming widened between 2011/12 and 2012/13.

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, at least at the soil surface. 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 due to report later this year.

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 from 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 8% since 2006. The proportion of farms using cattle slurry has remained little changed over the same period. The 2013 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 textures⁵¹.

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. More information on differences between crops will be available when the MinNO LINK project⁵² completes later this year. Cereal crops tend to have the lowest emissions, since modern varieties are adept at making use of the nitrogen applied⁵³. 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.

⁵¹ Defra project AC0101 - An improved inventory of greenhouse gases from agriculture.

⁵²<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>

⁵³ Skiba and Smith (2000) "The control of nitrous oxide emissions from agricultural and natural soils"

- **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.
- **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 other⁵⁴; 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 are 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.

⁵⁴ 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

2.9.7 Land and nutrient use: notes on data collection methodology and uncertainty

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 2013: for winter wheat the GB overall application rate was 177kg/ha and standard error was 2.3kg/ha; for sugar beet the GB overall application rate was 87kg/ha and standard error 3.5kg/ha; for main crop potatoes the overall application rate was 56kg/ha and the standard error was 8.5kg/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 2013, the yield estimate for England was 7.4 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

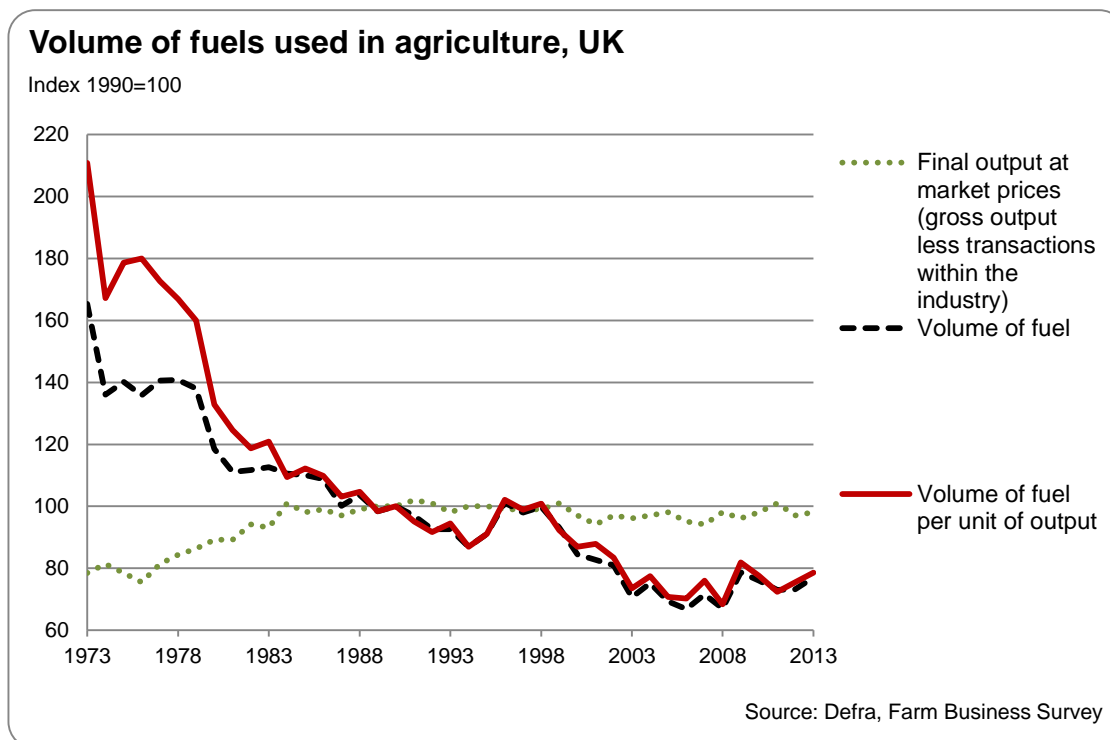
- iv) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

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 7% of the GHG emissions from agriculture).



Trends

Since 1990 there has been an overall decrease in the volume of motor and machinery fuel⁵⁵ 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.

⁵⁵ 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

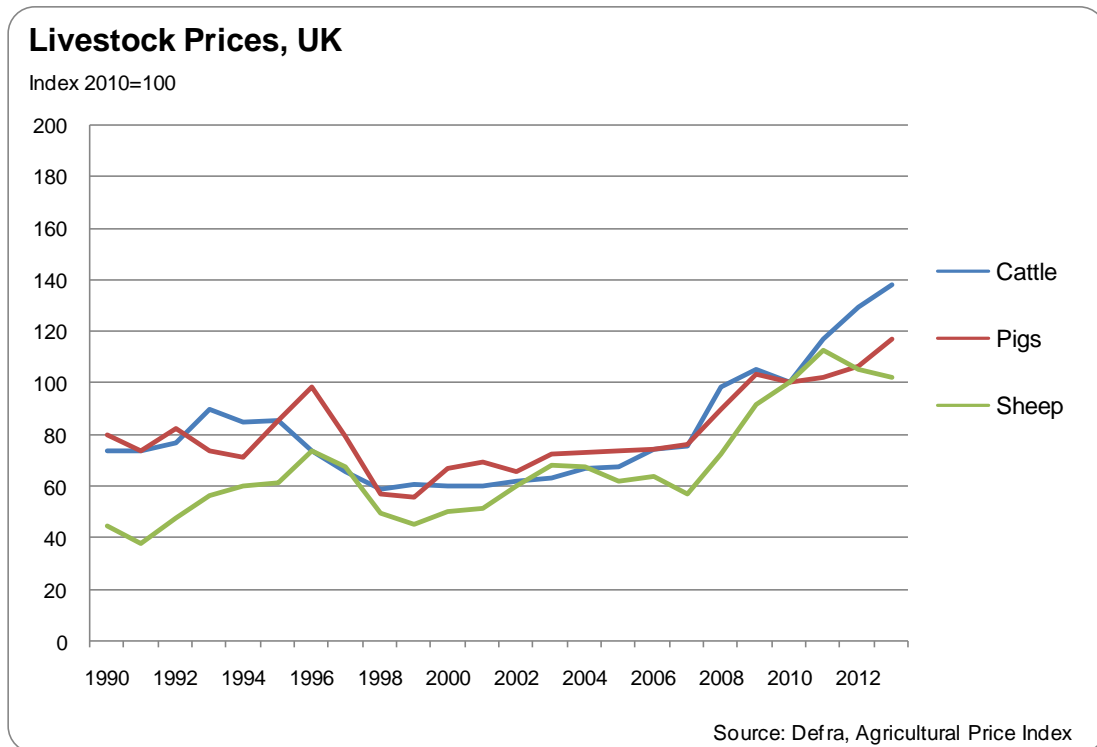
- i) Where the sample size is relatively small, confidence intervals can be quite large, and care needs to be taken with interpretation of the significance of the differences. A link to information on the Farm Business Survey methodology is given in the [Appendix](#).

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.



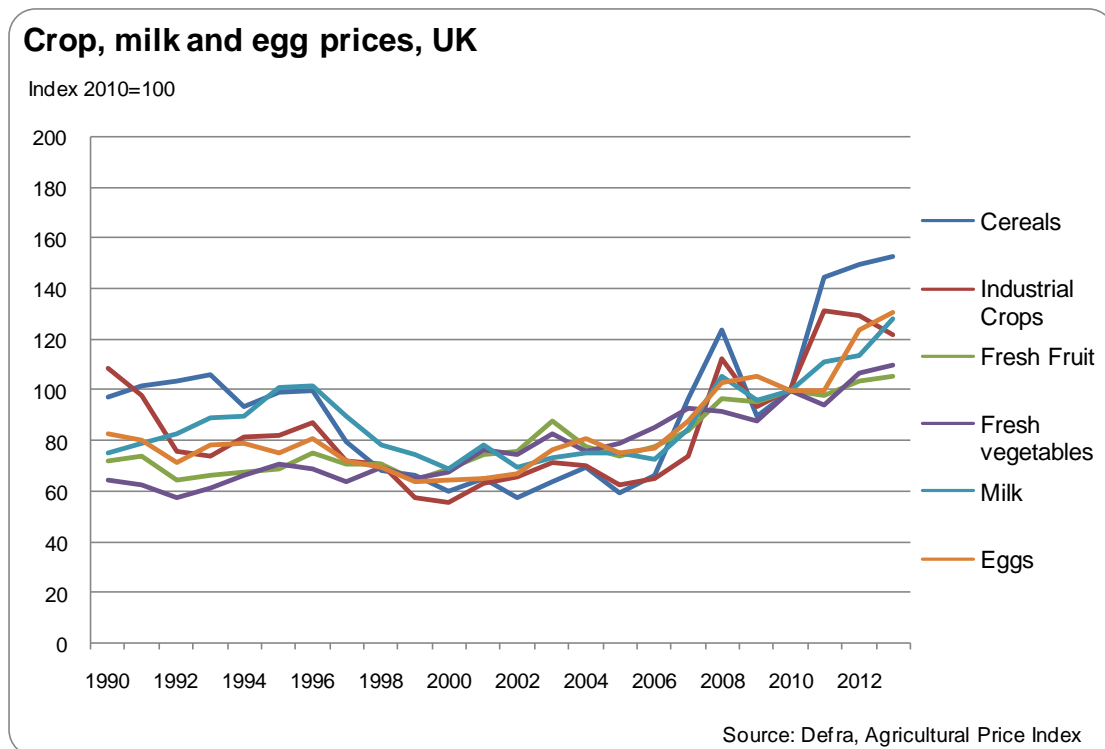
Trends

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). The subsequent reduction in prices in 2010 was the result of increased supplies. More recently, an increase in demand and lack of supply led to increased prices, which have continued through to 2013. The horsemeat revelations also added significant upwards pressure to beef prices during the spring and summer of 2013 as demand for British beef intensified.

Sheep prices increased in 2008, supported by tight domestic supplies and a strong export market. In 2011, strong competition for British lamb (driven by reduced global supplies stemming from a shortage of New Zealand lamb) continued to result in considerably higher prices which reached record levels. During 2012 there was a drop in lamb prices influenced by the bad weather, limiting finishing and tightening supplies. By the end of 2013, whilst sheep and lamb prices were 15% higher than a year earlier, the more usual seasonal uplift was not apparent.

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. Average cereal prices rose in 2011 due to tight global stocks and strong demand. They remained high as a result of weather conditions in 2012 and a tight world market.

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. Price increases continued during 2013 with the annual average price up 3% on 2012.

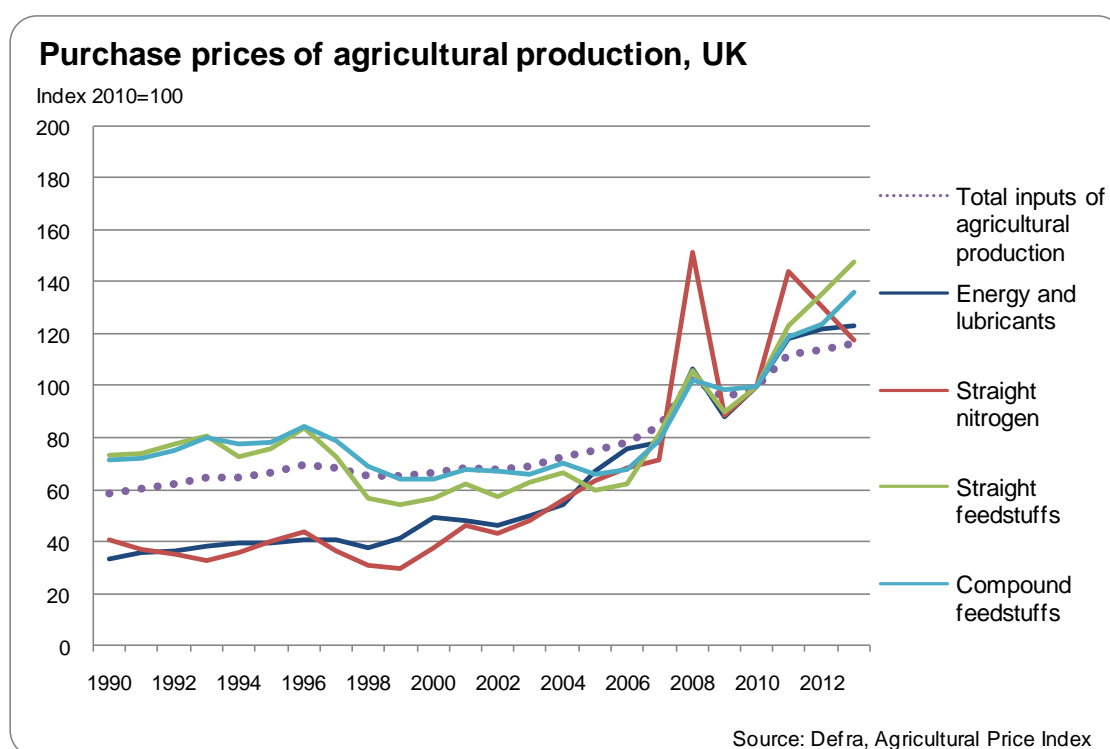
Reduced volumes of milk production in the first half of 2013 were the main drive for the increased milk prices in 2013. Poor weather conditions affected both the quality and quantity of forage in the first half of the year, and led to lower milk yields and production. Prices remained strong through the year, reflecting the competition for supplies between major milk purchasers.

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. Overall, average prices for animal feedingstuffs increased by 10% in 2013. This was largely driven by high prices at the start of the year when supplies were short due to the poor harvest in 2012.

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

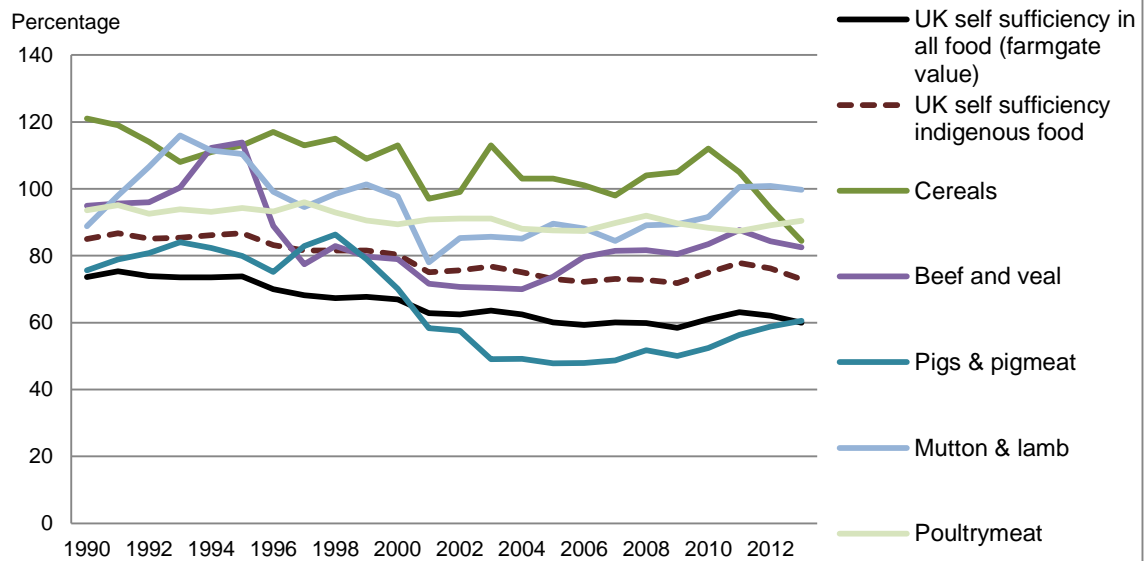


2.12 Contextual factors: trends in UKs ability to meet domestic demand and contribute to the international market

Rationale

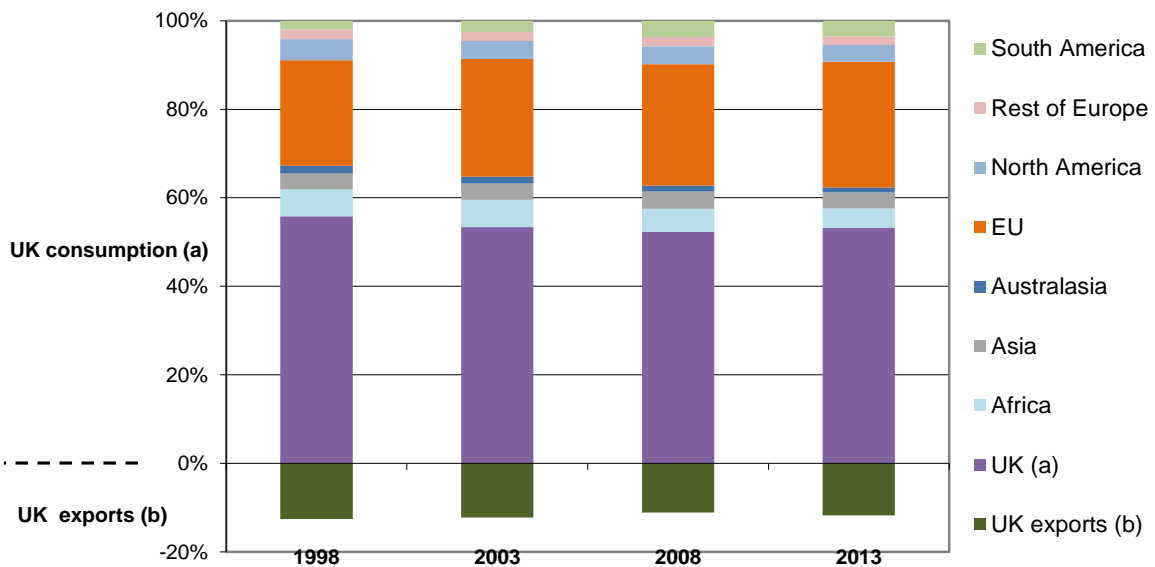
All things being equal greenhouse gas (GHG) emissions associated with UK production would fall if UK production was displaced by produce from international competitors. Measures of UK production as a percentage of UK consumption are shown here to provide an indication of displacement and hence any 'carbon 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: 1998, 2003, 2008, 2013



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. 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 links to 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).

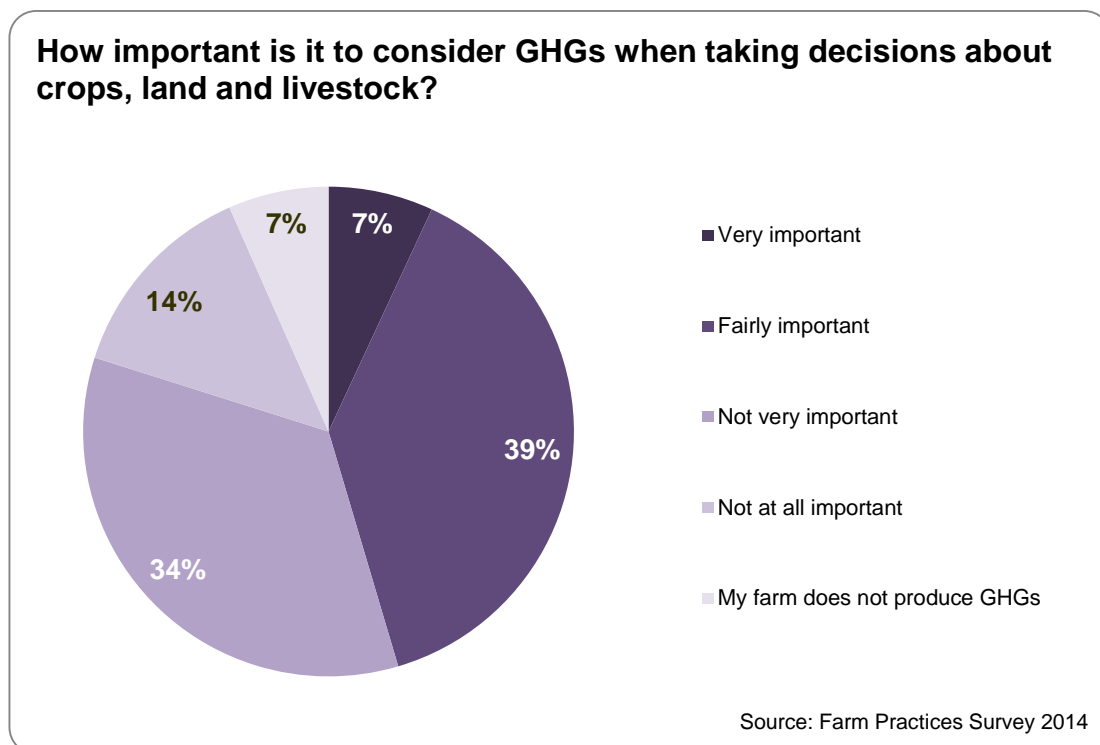
3.1 Farmer understanding, awareness and uptake of actions towards reducing GHGs

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.

Attitudes to, and knowledge of GHGs is one of the GHG indicators, it covers all farming sectors. More details of the indicator can be found in the [Summary](#) earlier in the publication and in the full indicator text at: <https://www.gov.uk/government/statistical-data-sets/greenhouse-gas-emissions-from-agriculture-indicators>

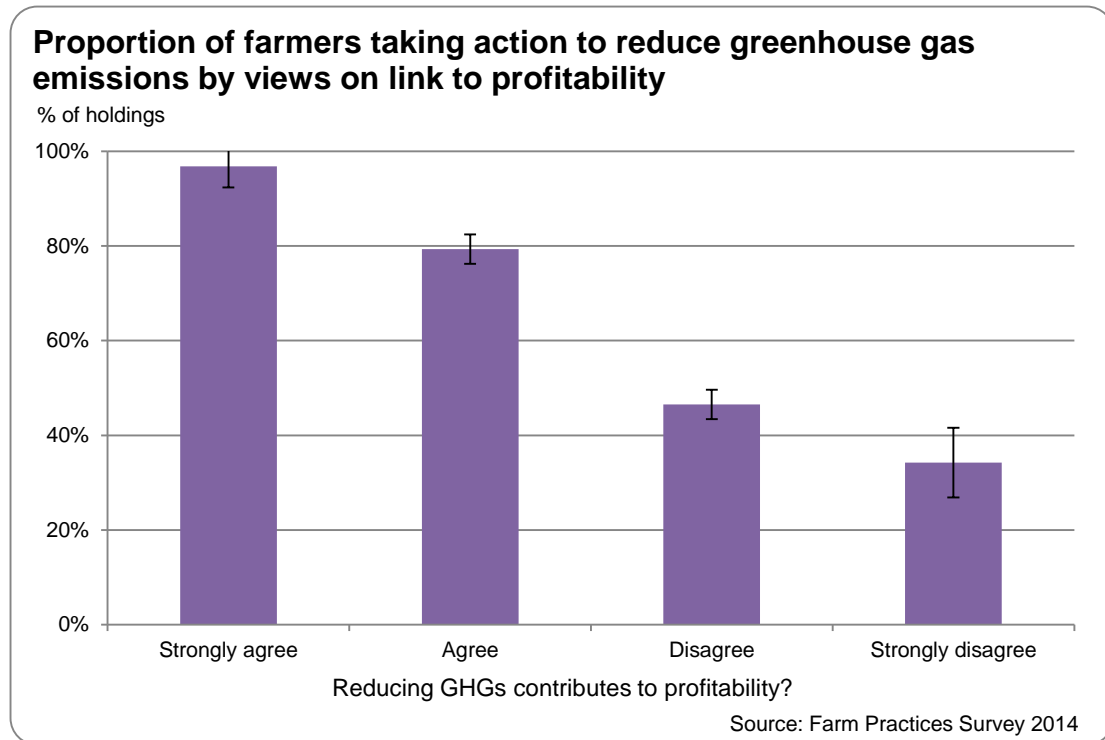
The 2014 postal Farm Practices Survey (FPS) indicated that 45% of farmers thought it important to consider GHGs when making farm business decisions while for 48% it was not important. There was a relatively small number still considering that their farm did not produce GHGs (7%). These tended to be small farms. Cereals, other cropping and specialist pig and poultry farms tended to place greater importance on GHGs than grazing livestock farms. These results are very similar to the 2013 FPS and findings from the 2010 ADAS study (Defra project AC0222⁵⁶).



⁵⁶<http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17110>

The majority of farmers thought that reducing emissions would not improve farm profitability (60%). Dairy and general cropping farms were the most likely to recognise the link to profitability while grazing livestock farmers were less convinced.

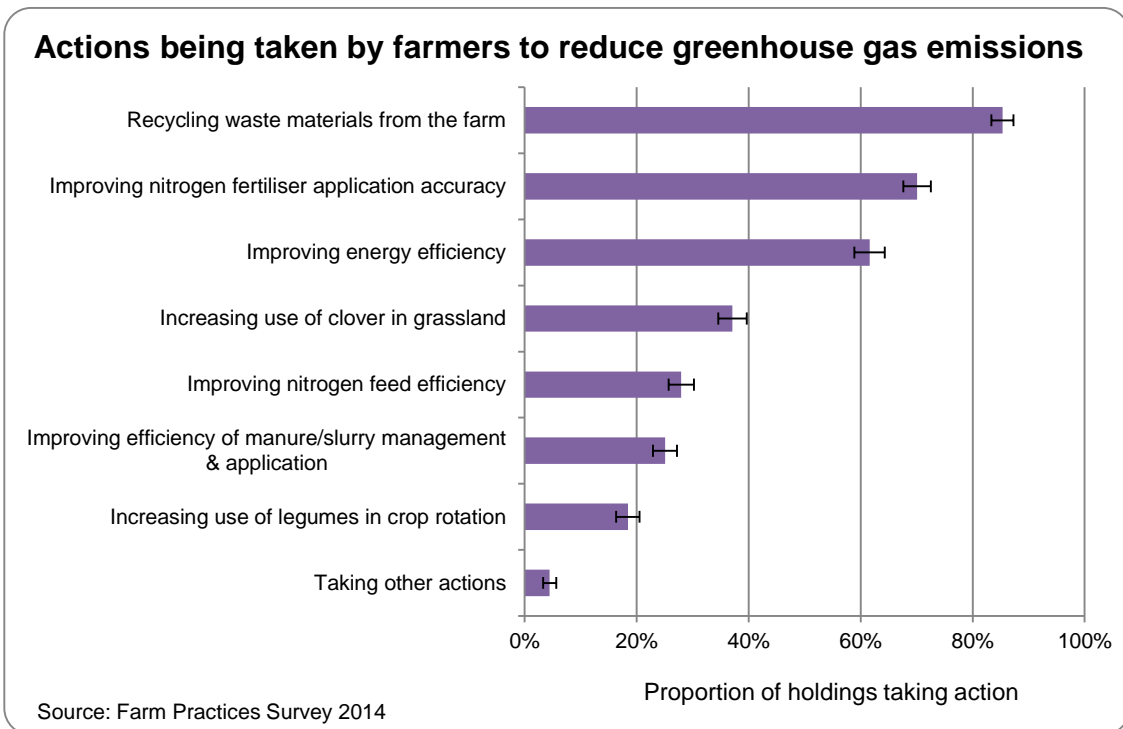
Of those strongly agreeing that reducing GHGs increases profitability 3% were still not taking any actions (compared to 15% in 2013) while 34% of those strongly disagreeing that reducing GHGs would increase profitability nevertheless took action.



What farmers say they do to reduce greenhouse gas emissions

The 2014 FPS indicated that 59% 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 46% respectively) to be taking action than other farm types. These results showed little change on 2013. Unsurprisingly, those who think that reducing emissions is important are more likely to undertake an action to reduce, e.g. 86% of those who thought it was very important, took action.

The most common actions to reduce GHG emissions (cited by more than half of those undertaking actions in 2014) 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.

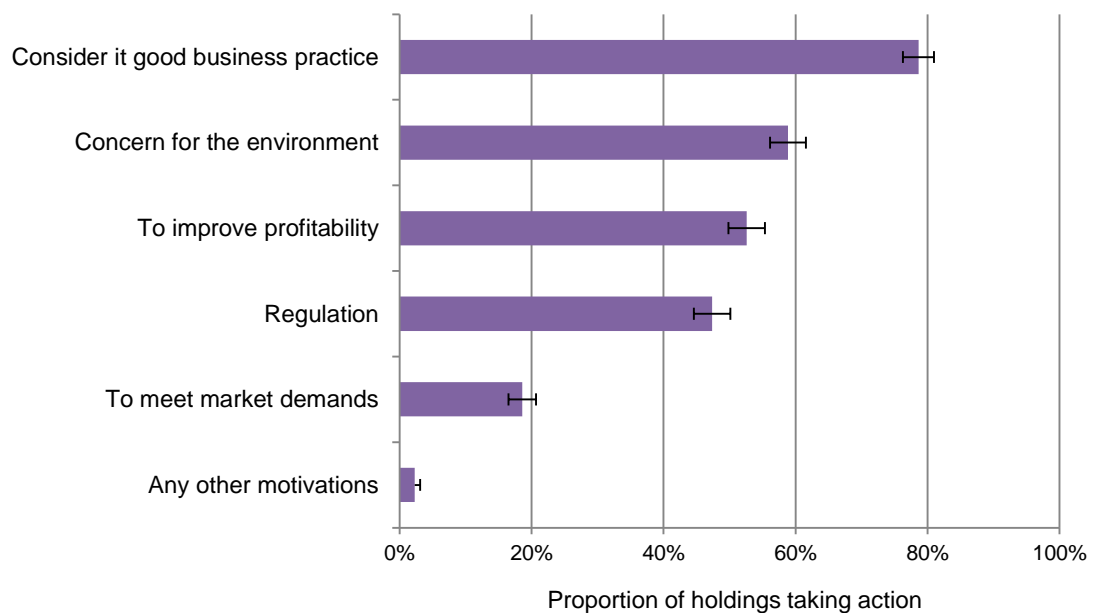


In general, larger farms were more likely to take action, but critically there were some key differences between enterprises which reflected the nature of the business. For example, LFA grazing farms had less focus on energy efficiency (as more extensive, outdoor systems) and less opportunity for planting legumes as part of rotation. Grazing livestock, dairy and mixed farm types had the highest uptake of clover in grassland (as fits the nature of management). However, grazing livestock and mixed enterprises were less likely to take action when compared to dairy farms in relation to manure / slurry management 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 71% of dairy farms. Figures for grazing livestock farms are lower (43% of lowland farms and just 32% 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 quarter of grazing livestock farms are improving slurry / manure management and less than a third improving nitrogen feed efficiency compared to over 60% and 64% for dairy enterprises, respectively.

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

Most farmers (79%) consider it to be good practice to undertake action to reduce GHGs and there is also a strong positive motivator towards the environment (59%). However, perhaps reflecting past messaging (which focussed on environmental issues rather than efficiency), just 53% undertake the actions to improve profitability and 19% to fit with market demands. Just under half of farmers (47%) recognise the regulatory reasons for the actions e.g. around nutrient management.

Main motivations for taking action to reduce greenhouse gas emissions

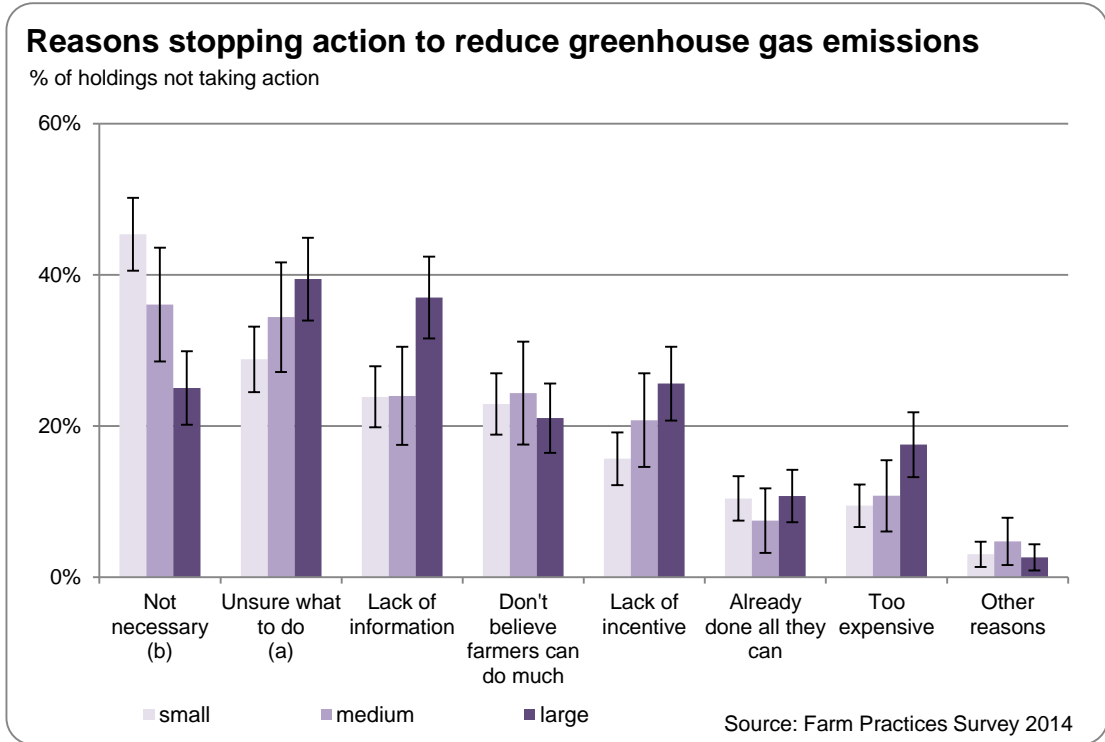


Source: Farm Practices Survey 2014

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 (26%) and lack of clarity on what to do (31%) 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 41% not believing any action is necessary, 23% believing there is not much they can do and 10% believing they have done enough. These findings show little variation from those of the 2013 FPS. Actual financial barriers are relatively small in comparison, with 18% saying not enough incentive and 11% too expensive. Smaller farms suggested they did not produce enough emissions (45% thought action was not necessary for this reason compared to 25% of larger farms). The recognition that action was necessary also varied by farm type with only 21% of dairy farms thinking they did not need to take action compared to 49% of LFA grazing livestock farms.

For those already undertaking actions, financial barriers are stronger (31% saying too expensive). Information barriers are still important i.e. the lack of information (22%) and lack of clarity on what to do (25%). However, the need to take action was reflected in only 17% believing that action is not necessary and 9% believing that there is not much they can do. Over a third (35%) of those taking action believe that they have already done enough. Larger farms were most likely to highlight financial barriers (41% too expensive), while for smaller farms 40% believed they had already done everything they could. The recognition of the need for action varied by farm type with only 6% of dairy farms thinking they did not need to take action compared to 32% of LFA grazing farms.



(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

Details of uptake rates for a wide range of on-farm mitigation measures can be found in the results of the February 2014 Farm Practices Survey at: <https://www.gov.uk/government/collections/farm-practices-survey>

The survey focused on practices relating to greenhouse gas mitigation with topics including nutrient and manure management, manure and slurry storage, farm health plans, cattle and sheep breeding and feeding regimes and anaerobic digestion.

Uptake of on-farm mitigation measures is one of the GHG indicators, it covers all farming sectors. More details of the indicator can be found in the [Summary](#) earlier in the publication and in the full indicator text at: <https://www.gov.uk/government/statistical-data-sets/greenhouse-gas-emissions-from-agriculture-indicators>

Section 4: Emerging evidence

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

4.1 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 \(v\)](#).

4.2 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 regionally-specific emission factors to reflect current and changing specific practices and production systems within agriculture. This will enable better forecasting and monitoring of performance against the wider UK target emission reductions set by the UK Climate Change Act (2008) as well as targets set in the legislation and policies of Devolved Administrations. The project will also help the agricultural industry track uptake of mitigation measures included within the greenhouse gas reduction plans and sector-specific roadmaps.

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 (ResearCH₄) project: AC0115 – developing new CH₄ emission factors from different ruminant species, breeds and genotypes (and their manures) under a range of typical farming systems.
- 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.

Outputs from the three projects are being closely coordinated with Defra project SCf0102, which will actually deliver the UK agricultural greenhouse gas and ammonia inventories (and projections) for submission to the United Nations Framework Convention on Climate Change (UNFCCC), the UK's component administrations, and the United Nations Convention on Long-range Transboundary Air Pollution, respectively.

Considerable progress has been made across the Platform projects. In project AC0115, a range of experiments were carried out using SF₆ and chamber measurement methodologies to examine methane emissions by dairy and beef cattle of varying breeds, ages and physiological states, offered a range of diets (indoors and at grazing) representative of UK cattle farming systems. Experiments were also carried out to measure methane emissions from sheep of different breeds (and therefore body sizes), using growing lambs and mature ewes (dry and with lambs). On-farm measurements of methane production by dairy cows were carried out to assess the potential for automated verification of emissions at a herd level. All the experiments in AC0115 measuring enteric emissions are complete, with initial synthesis reinforcing the important relationship between feed intake and methane emissions, and highlighting the relatively minor role that livestock breed has on methane output beyond that driven by feed intake. Sampling of the methane producing potential of manures is continuing with final results expected in late 2014. The outputs from this project will provide a valuable repository of improved emission factors for use by the agricultural GHG inventory.

In AC0116 measurements of direct and indirect N₂O emissions have continued at a range of sites throughout the UK following applications of manufactured fertiliser N, livestock manures and dung and urine; with and without a nitrification inhibitor. A total of 27 of the 35 plot-scale experiments have now been completed and emissions data are being checked using rigorous quality assurance procedures, prior to reporting. All of the manufactured fertiliser N to arable land experiments (three in total), manure to arable land experiments (six in total) and manure to grassland experiments (six in total) have been completed. The relationships between N₂O fluxes and key factors such as the soil water content, rainfall and temperature are also currently being explored. The quantum cascade laser fast-flux measurement system (developed within the GHG platform) was also applied, showing the importance of 'hotspots' to total N₂O emissions: in one sheep grazed field visible 'hotspots' accounted for <2% of the field area, but were responsible for 55% of estimated N₂O emissions. The University of East Anglia have also completed the main experimental work on quantifying dissolved N₂O concentrations in surface waters from the three Defra Demonstration Test Catchments (DTCs): the Eden, Hampshire Avon and Wensum.

In AC0114, official and industry datasets were analysed for their suitability in supporting the new GHG inventory with activity data that will be more spatially disaggregated, and responsive in tracking change both within a year and between years. This included classifications of climate, soil and grass sward types. Animal housing types, production systems and manure management methods were assessed. These were supported as much as possible by forward-looking electronic identification datasets and the foundation of the June Agricultural Survey-Census. The potential for disaggregating the annual fertiliser surveys were evaluated. Uncertainties in the existing inventory were quantified in a well-structured manner. Structured literature reviews of potential emission factors and mitigation methods were completed.

Annual workshops have been held to present updates on progress within the Platform to representatives of government and industry, and to seek feedback on a range of approaches for reporting uncertainty associated within the revised inventory calculations. Project partners have also represented the UK at Global Research Alliance (GRA) committee meetings and related GRA events. Scientific papers have been published describing the chosen measurement approach for N₂O used by the AC0116 project team and the optimisation of N₂O chamber methods in plot based agricultural experiments.

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.

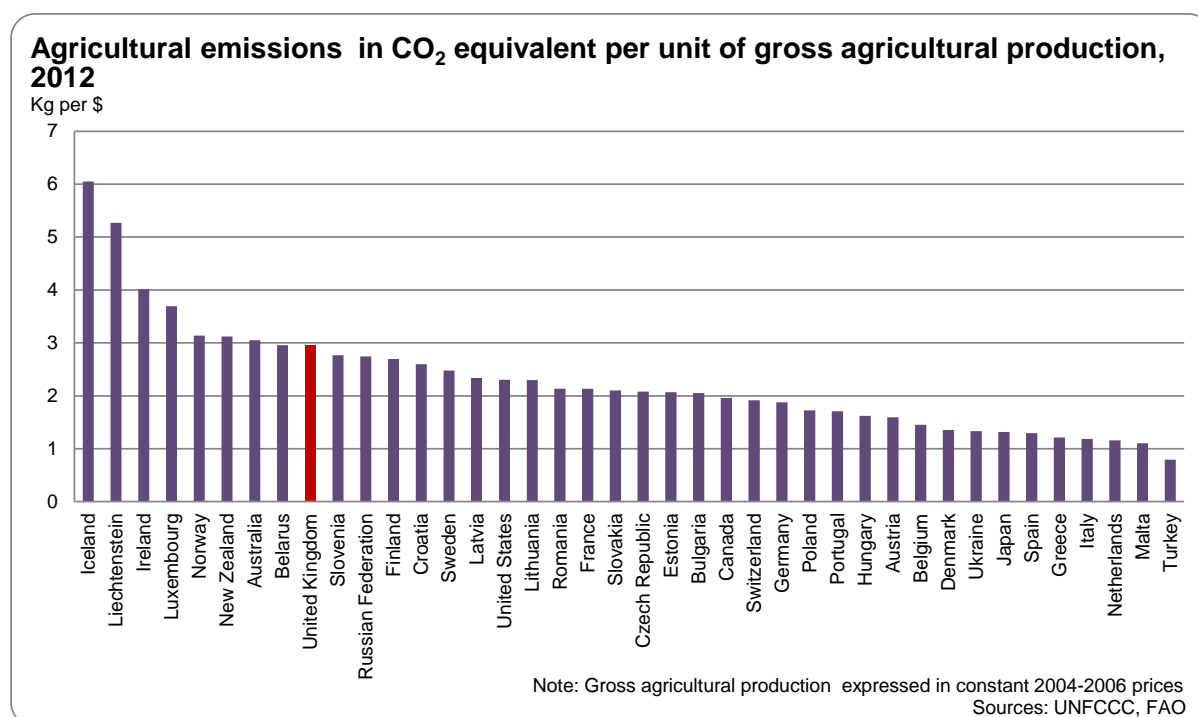
Updates on progress within each of the projects, in addition to newsletters and details of past/future events can be found on the Platform website at: www.ghgplatform.org.uk . More information on the Greenhouse Gas R&D Platform projects can also be obtained by contacting Tom Misselbrook: tom.misselbrook@rothamsted.ac.uk 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)⁵⁷ countries in this way for 2012.



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

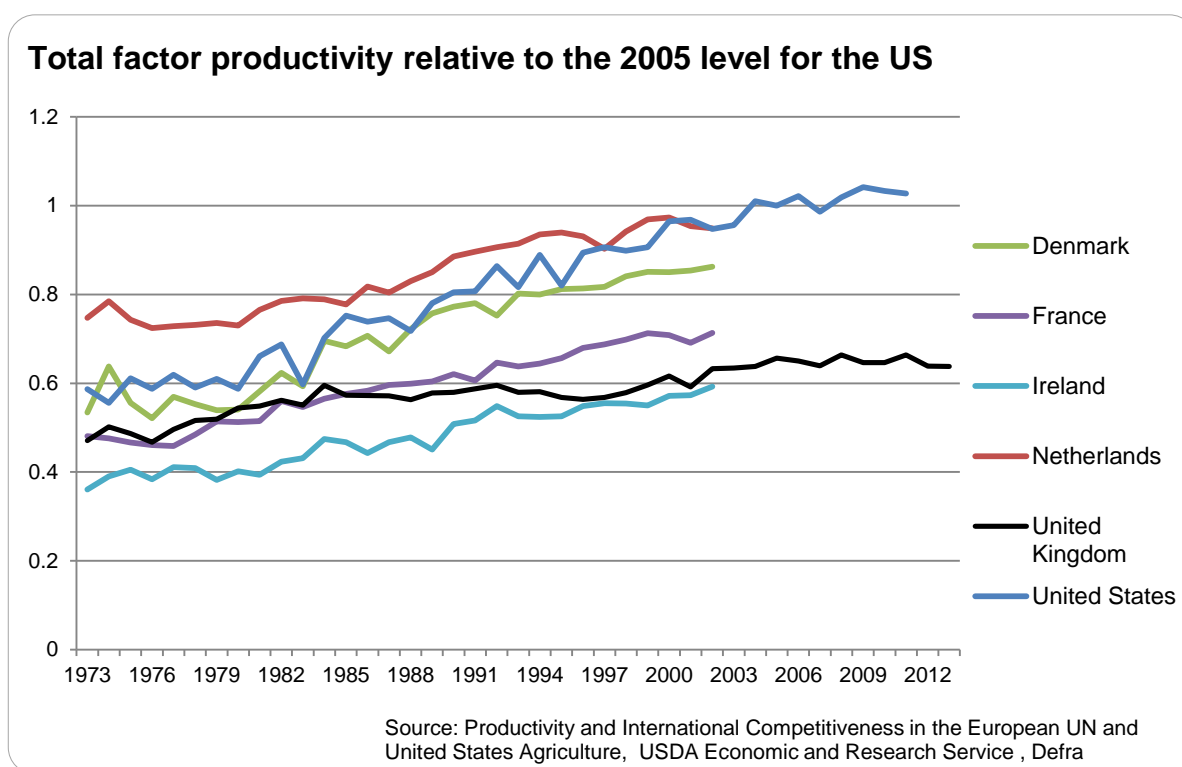
⁵⁷ **Annex I** Parties to the United Nations Framework Convention on Climate Change (UNFCCC) include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the 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:

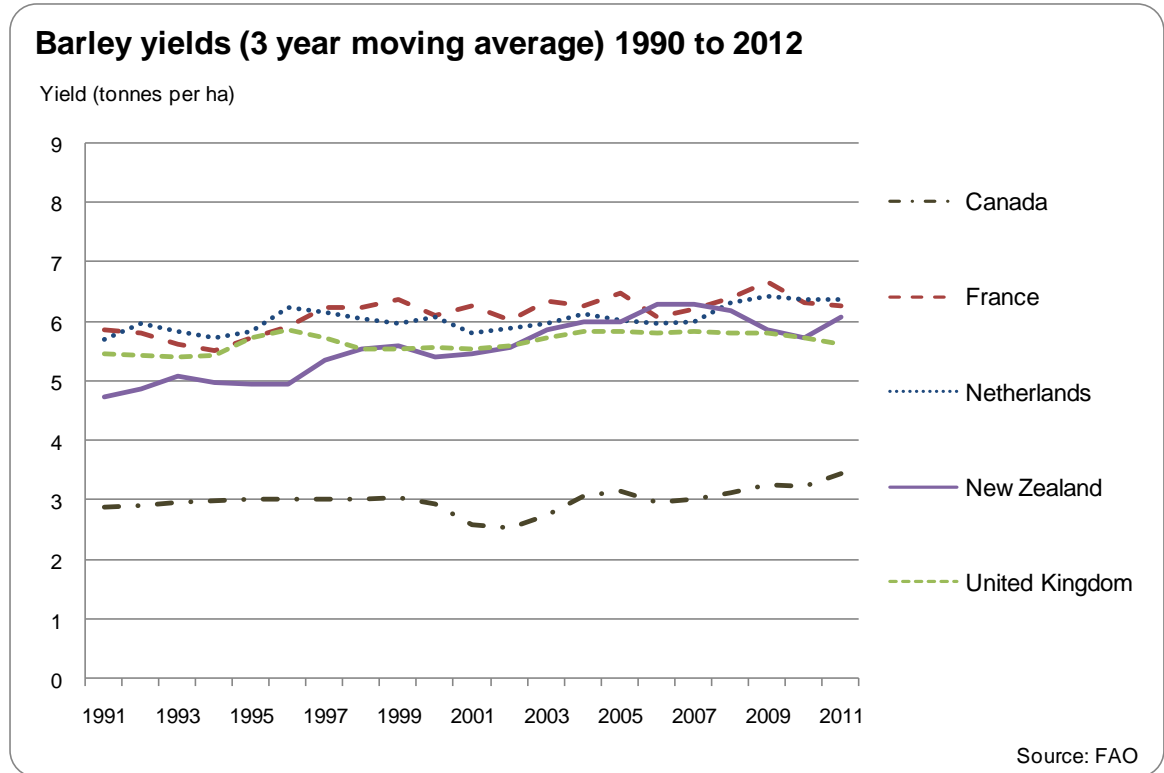
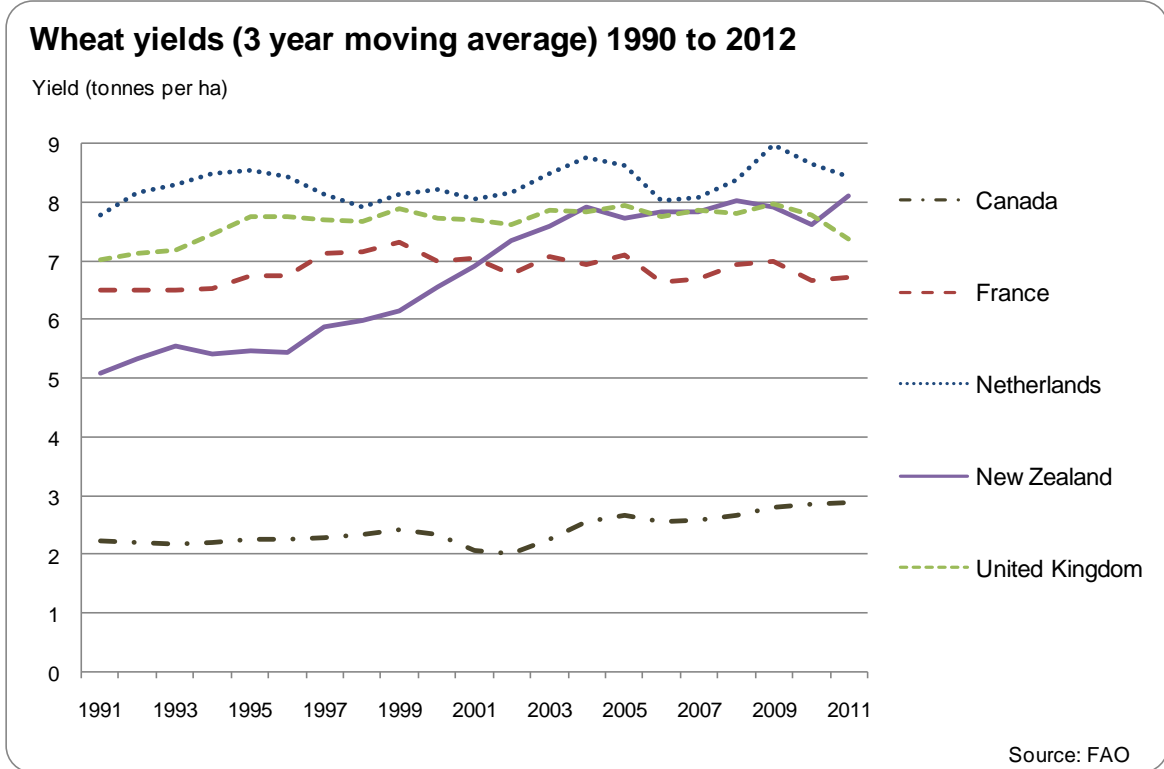
<http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/documents/farrefficiency.pdf>

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 2012, 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.



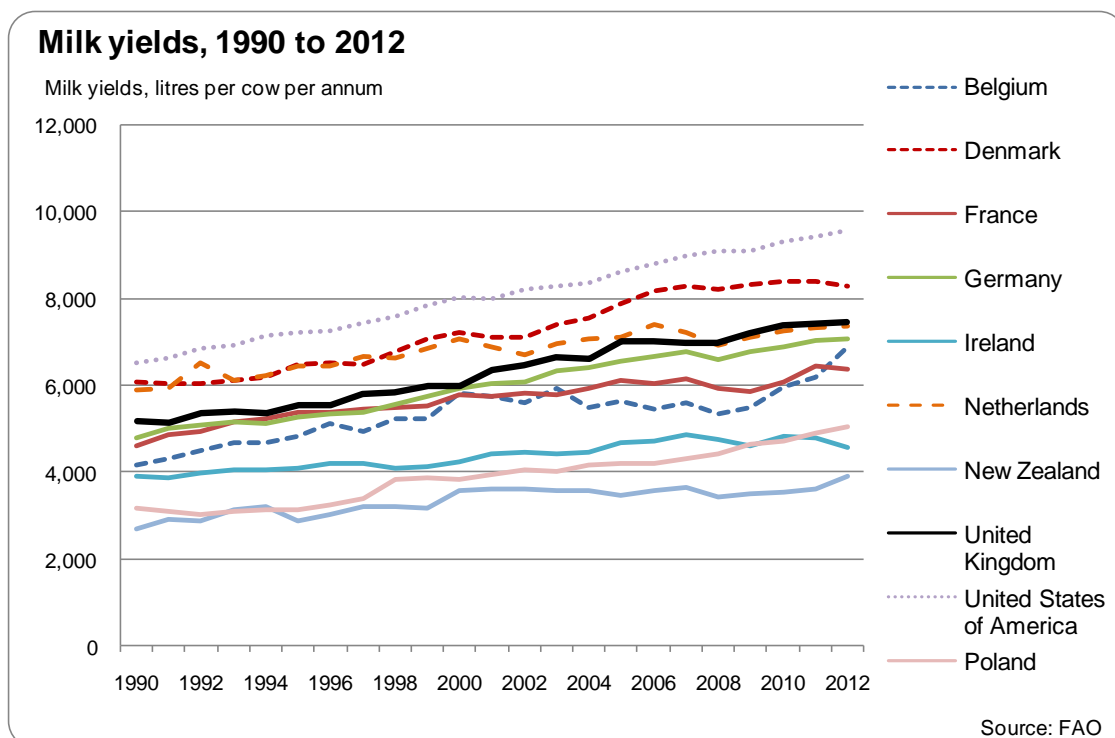
Focussing on cereal yields has its limitations since nitrous oxide emissions are produced from sources other than cereals such as pastures and fodder crops etc. An approach which considers the efficiency of all nitrogen use (the percentage ratio of total nitrogen uptake by crops and forage to the

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 measure 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:

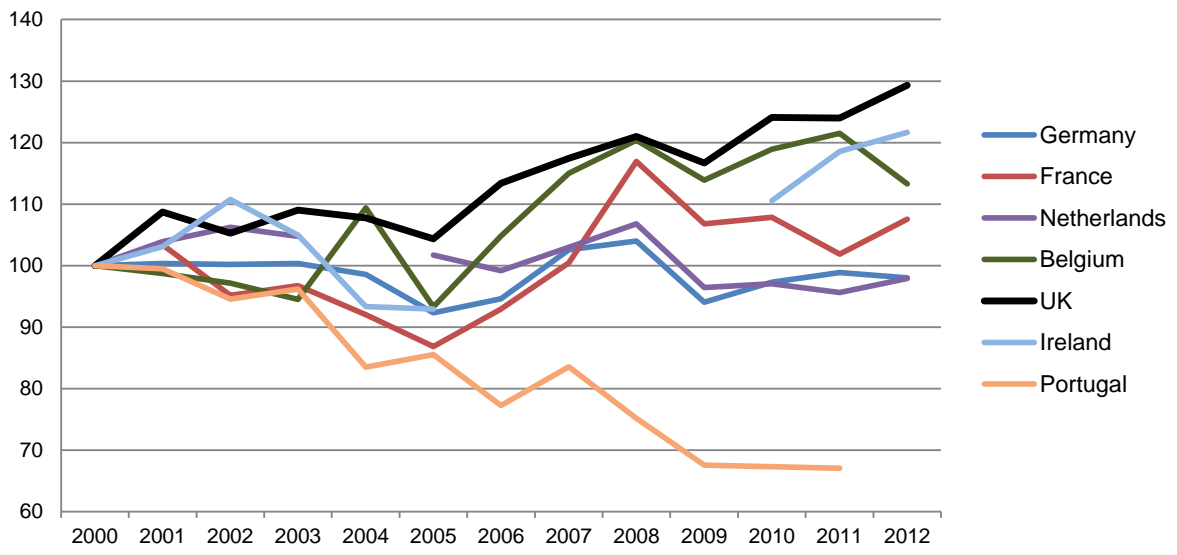
- New Zealand and Ireland's dairy production systems may be defined as low-input/low-output (around 4 thousand litres per cow/ year). Feeding is based mainly on grazing.
- The USA's dairy production systems may be classified as high-input/high-output (around 8,400 litres per cow/year). Feeding is based 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. 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 2000=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-final-crop-areas-yields-livestock-populations-and-agricultural-workforce-at-1-june-2013-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:

<https://www.gov.uk/government/publications/uk-greenhouse-gas-emissions-explanatory-notes>

Farm Business Survey - data collection and methodology:

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

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

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

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

Farm Practices Survey 2014 (Greenhouse gas mitigation measures) - pages 34-35

<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>

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

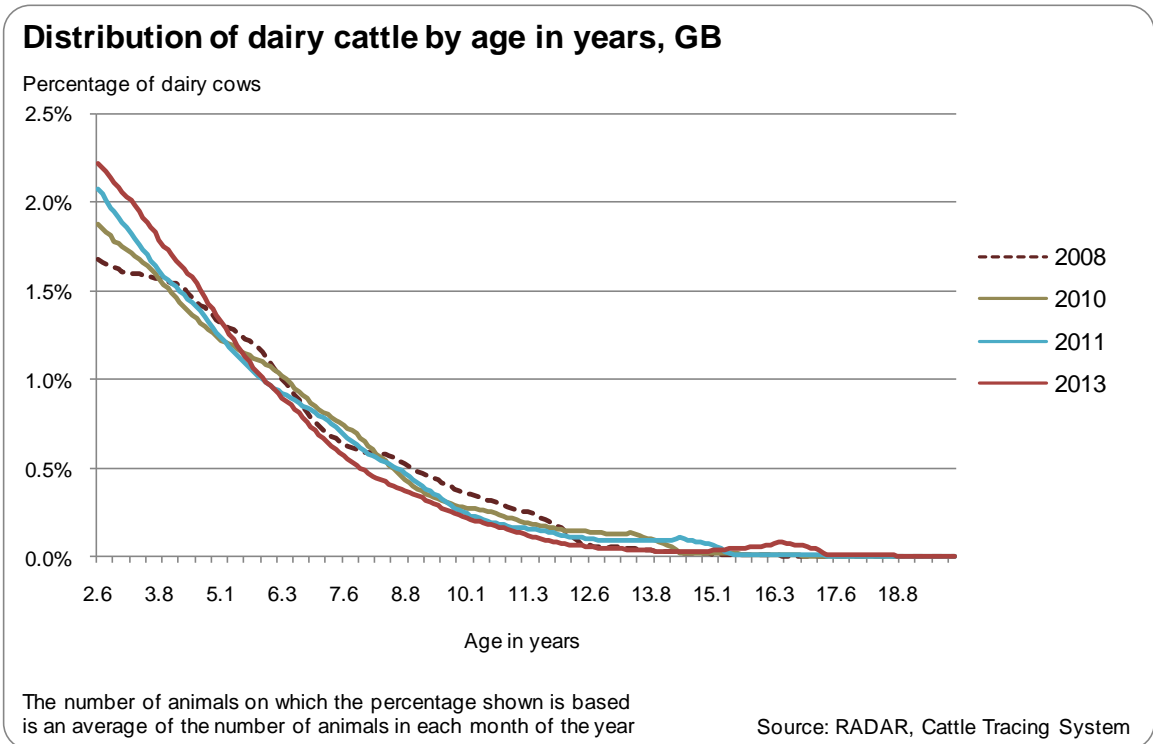
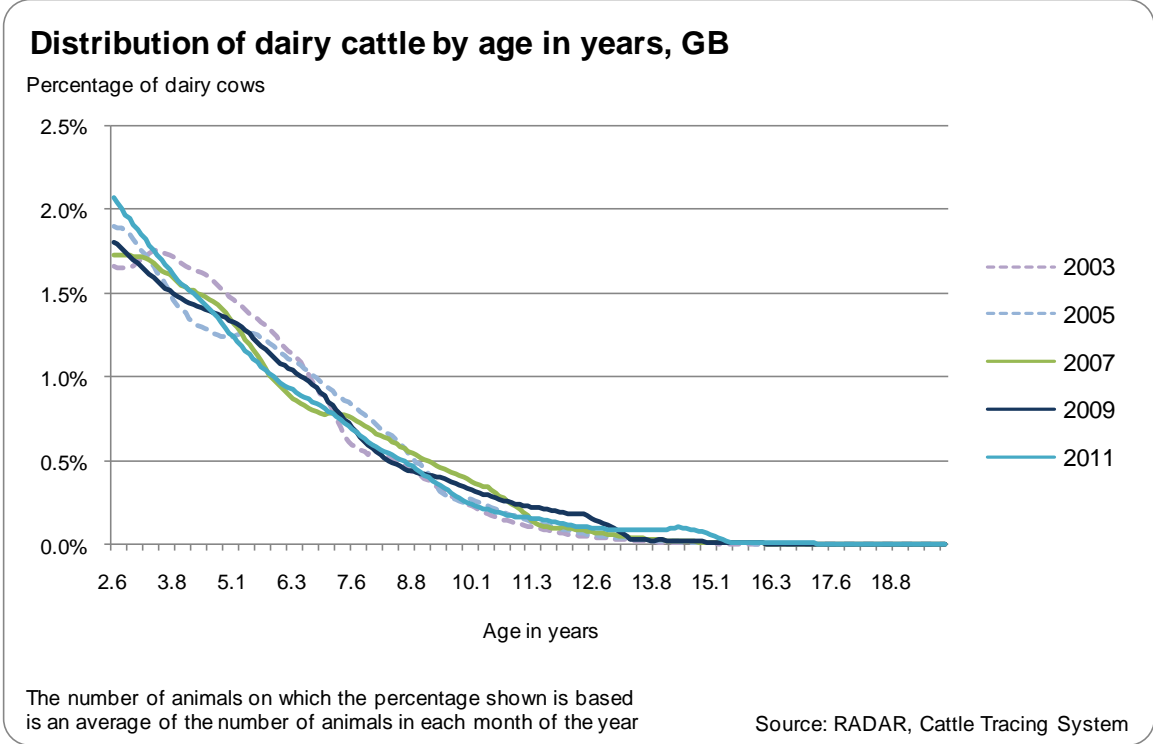
Information on the methodology for deriving Soil Nutrient Balances can be found under "Soils" at:

<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.

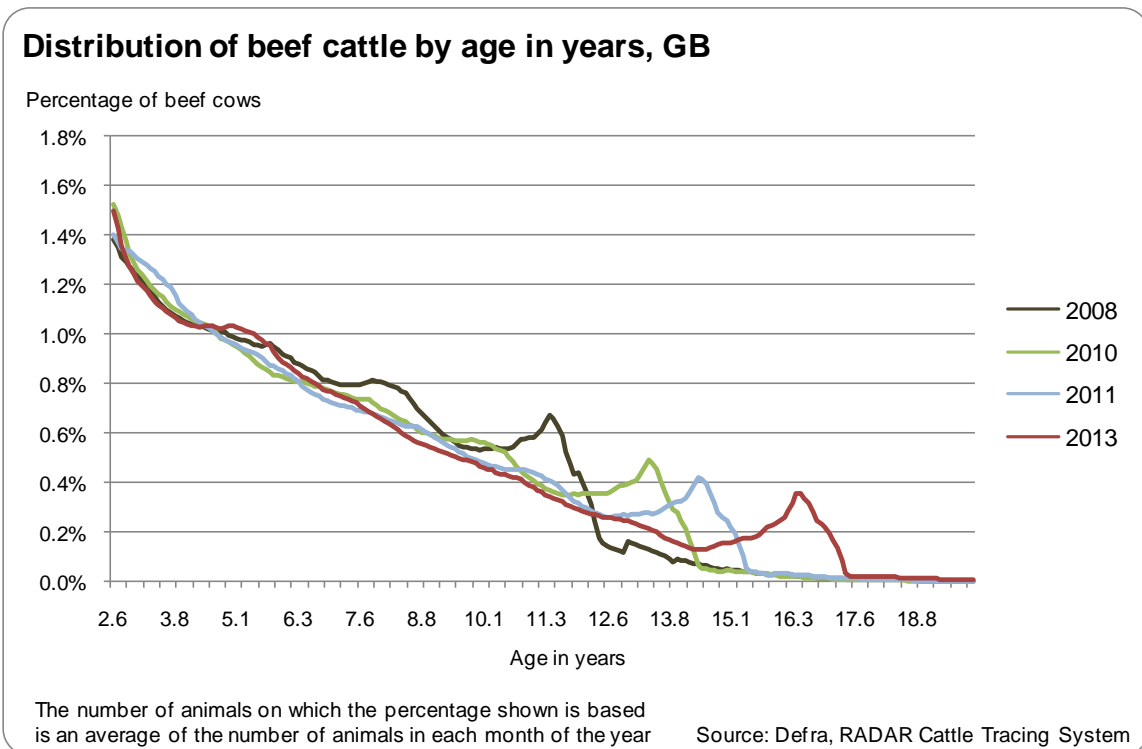
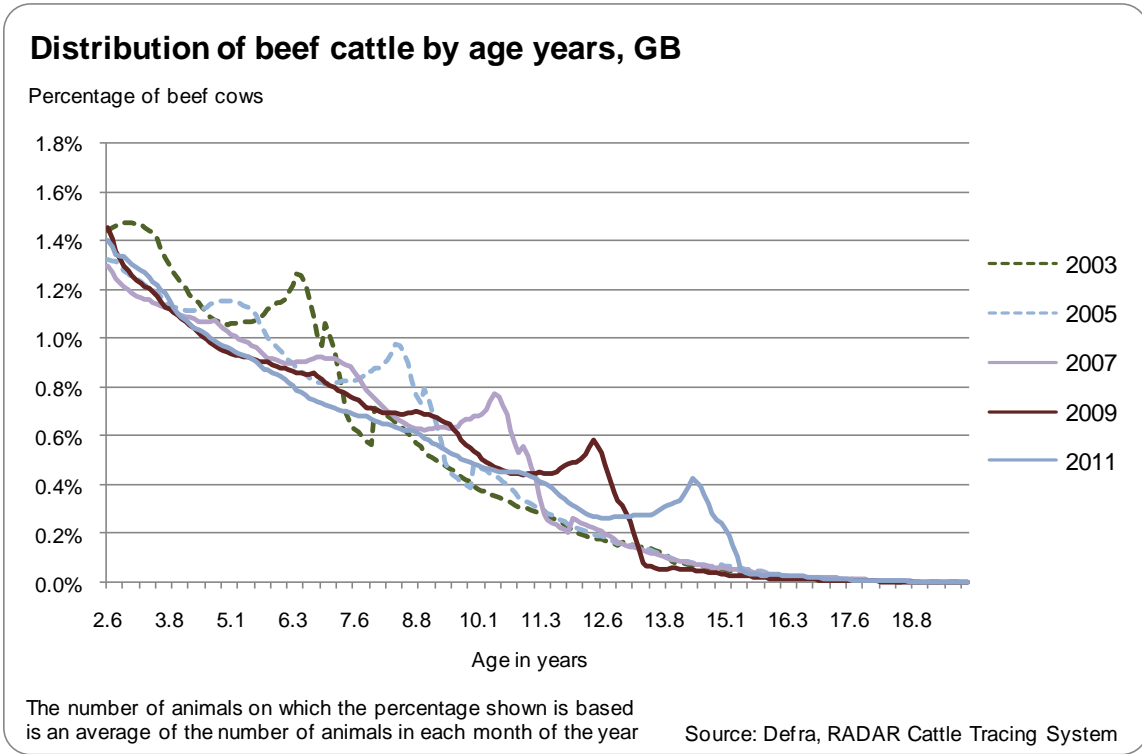
The Countryside Survey:

<http://www.countrysidesurvey.org.uk/about>

(ii) Distribution of dairy cows by age in years

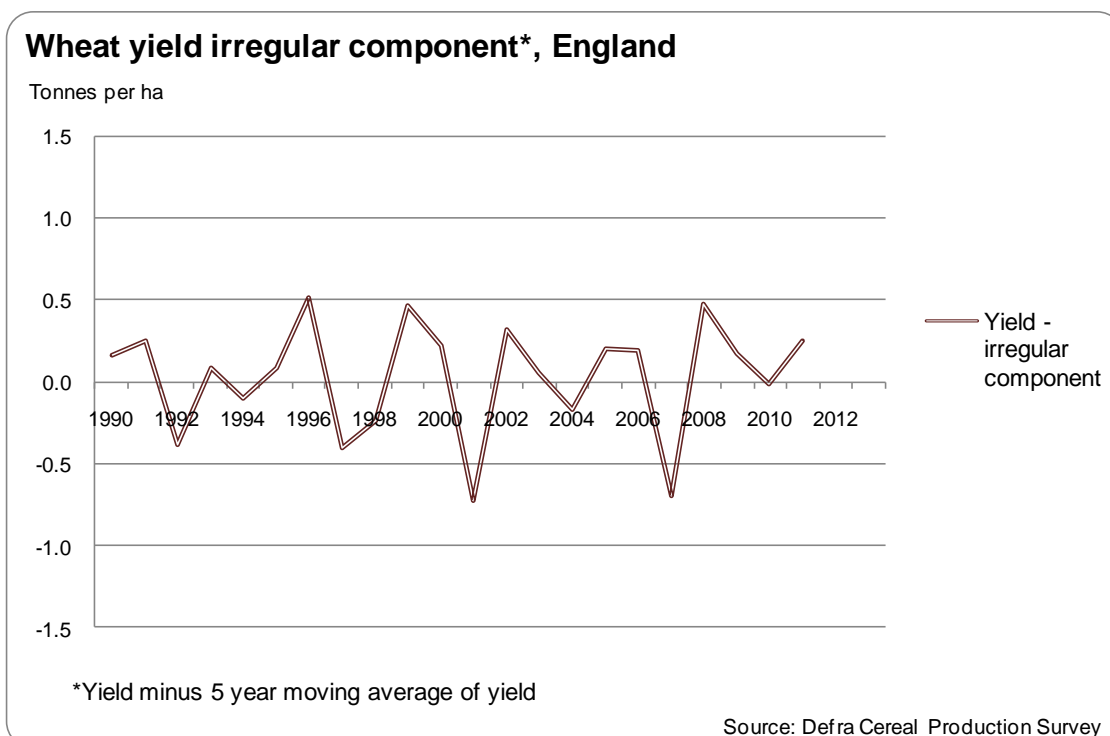
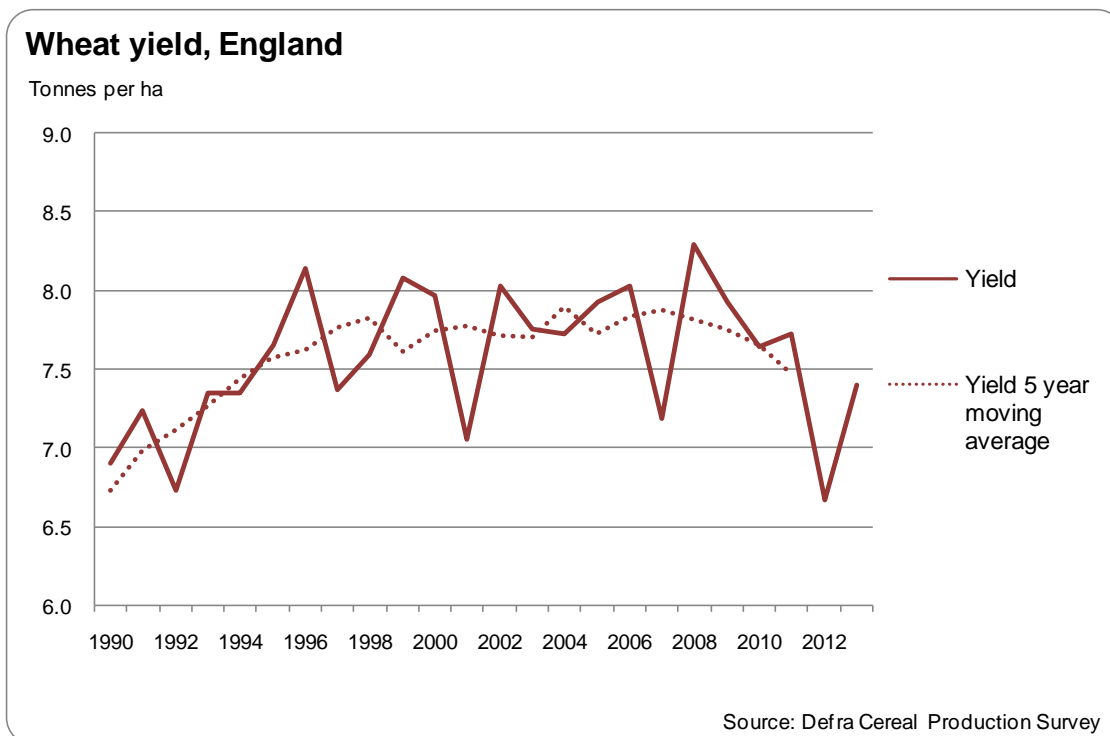


(iii) Distribution of beef cows by age in years

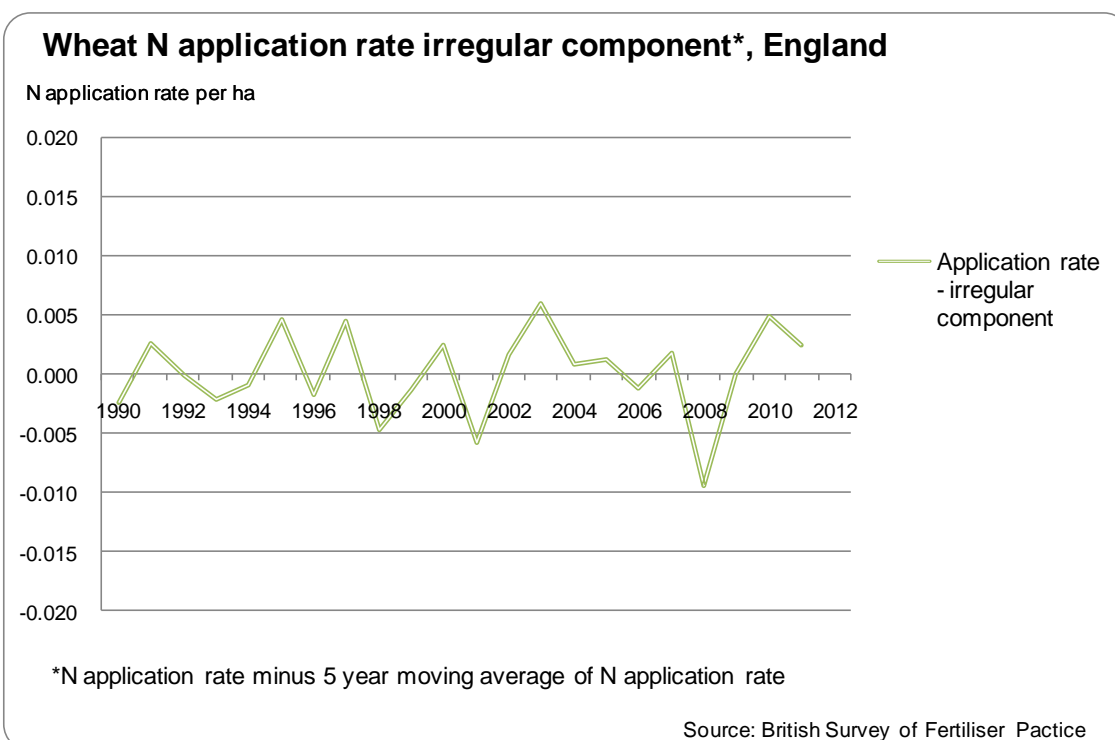
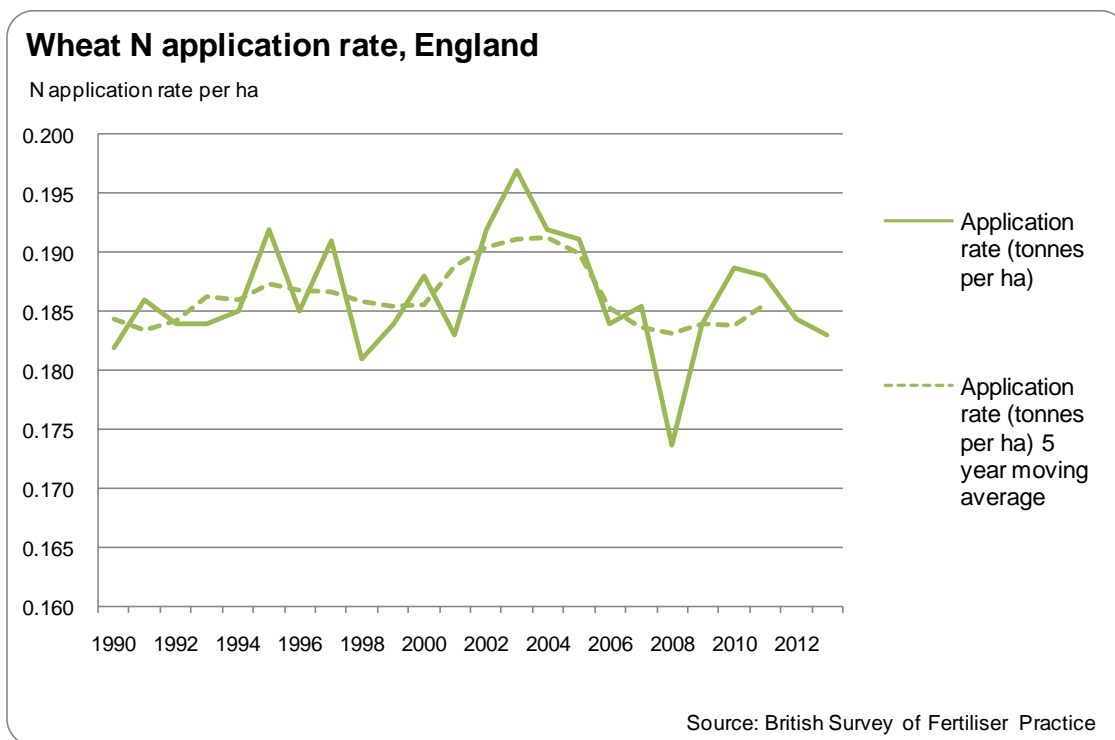


(iv) Wheat production per unit of manufactured N applied

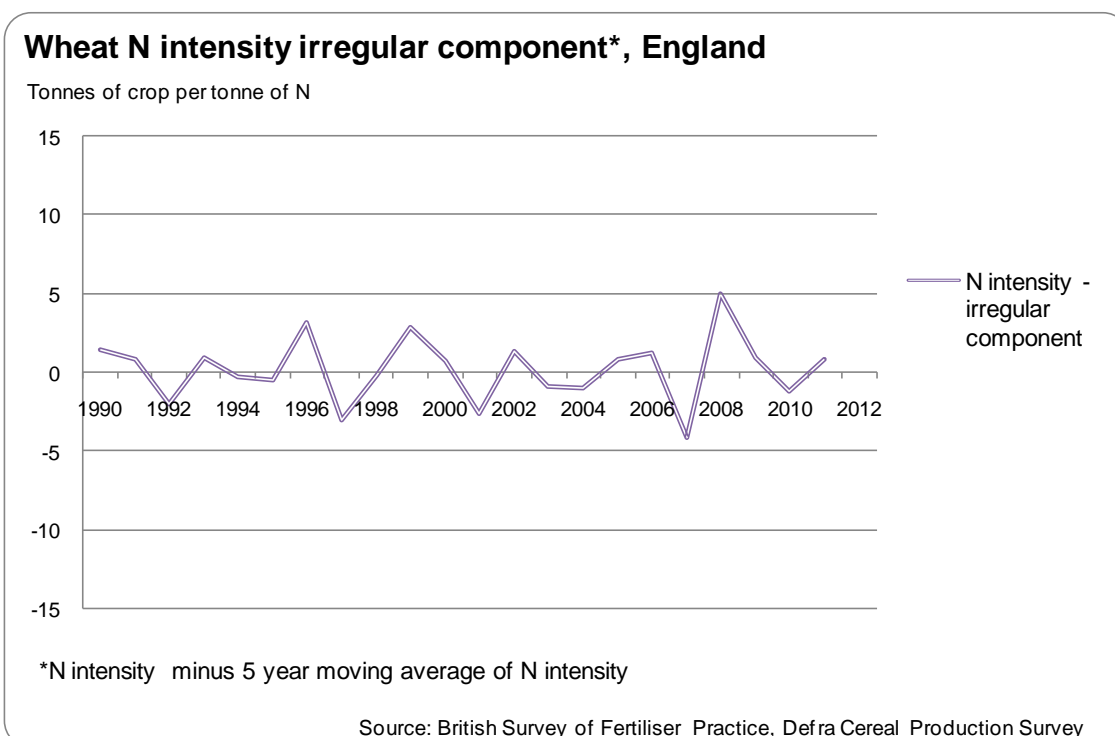
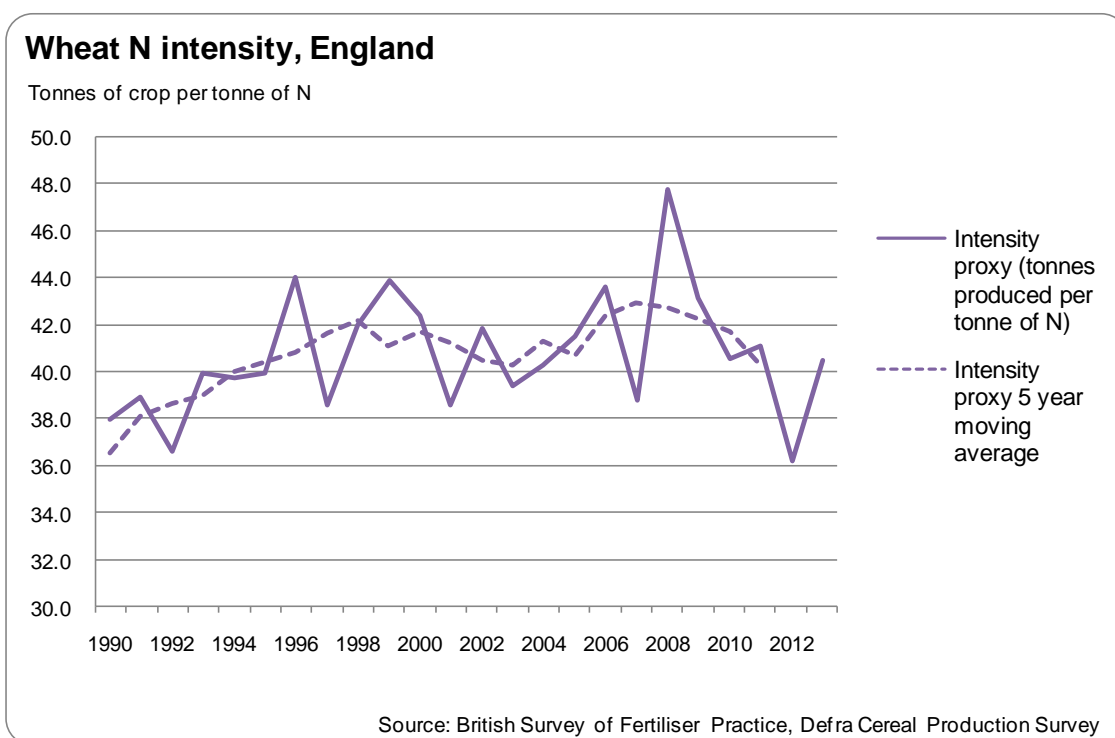
The following charts illustrate the magnitude of the trend and irregular components of the time series given in Section 2.9. The charts show wheat only, similar charts for the other crops shown in Section 2.9 can be obtained by contacting alison.wray@defra.gsi.gov.uk



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



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



(v) Digest of ongoing research projects

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
AC0111	Air quality measurements on cracking clay soils	01/04/2008	To quantify air quality and greenhouse 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
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	Awaiting publication

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
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&Paging=10#Description	31/03/2015
AC0116 (extension)	International DNDC Modelling Network	June 2013	<p>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.</p> <p>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).</p>		31/03/2015
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	30/4/2012 Final report received and being reviewed for publication

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
AC0120	LCA of endemic diseases on GHG emissions intensity	01/10/11	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).	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17791	30/9/2012 Project extended to 31 May 2013 (no-cost) Final draft report under peer review and being revised
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

Project Number	Project Title	Start Date	Aims	Defra weblink	Due to complete
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
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

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
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
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

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
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
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
SCF0105	International collaborative research and knowledge exchange networks	June 2013	Administrative and funding support for international collaborative work under the following contracted projects: <u>Project 1</u> - Secretariat for UK participation in the Global Research Alliance on Agricultural Greenhouse Gases (GRA) and the EU Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) <u>Project 2</u> - Secretariat for the GRA Animal Health and Greenhouse Gas Emissions Intensity Network <u>Project 3</u> - UK Greenhouse Gas Platform Research Expertise Group (REG) Leader	For further information see; http://www.globalresearchalliance.org http://www.faccejpi.com/	Ongoing

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
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.	http://www.wrap.org.uk/content/digestate-compost-agriculture	31/03/2016
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	31/05/2015

Project number	Project title	Start date	Aims	Defra weblink	Due to complete
IF0145	Understanding and dissecting the genetic control of key "environmental impact" traits in forage grasses and legumes	01/04/2008	<p>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:</p> <p>(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.</p> <p>(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.</p> <p>(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).</p>	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
WR1212	Digestate & Compost in Agriculture		To quantify the effects of contrasting digestate and compost applications on soil and crop quality, crop available nitrogen supply and emissions to the air and water environments and to promote the benefits of digestate and compost use to today's and tomorrow's farmers, growers and land managers, via a co-ordinated range of knowledge exchange activities	http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17289&FromSearch=Y&Publisher=1&SearchText=WR1212&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description	
LK0685	Genetic improvement of forage grasses and white clover to improve phosphorus use efficiency and reduce phosphorus losses to water from UK grasslands	01/04/2008	Exploit a range of conventional and molecular breeding strategies to develop new varieties of the two most important forage species associated with UK grasslands: perennial ryegrass (<i>Lolium perenne</i> L.) and white clover (<i>Trifolium repens</i> L.) with higher intrinsic phosphorus use efficiencies (PUE) in terms of P acquisition, utilization and retention. The methods include identification of quantitative trait loci (QTL) and molecular markers for enhanced PUE, direct selection in low P soils and the incorporation of the relevant traits into genetic backgrounds conferring elite agronomic performance. The project also encompasses performance-testing with respect to P utilisation efficiency by livestock.	http://www.greener-grasslands.ibers.aber.ac.uk/projects.htm	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.