









The English Beef and Sheep Production Environmental Roadmap - Phase 2





EBLEX has worked with a number of organisations who have been instrumental in the production of this roadmap. We would like to thank all those who have played a part, including, but not exclusive to:

- Defra
- National Farmers Union (NFU)
- British Meat Processors Association (BMPA)
- Association of Independent Meat Suppliers (AIMS)
- National Sheep Association (NSA)
- National Beef Association (NBA)
- British Retail Consortium (BRC)
- ADAS
- Cranfield University
- Marks & Spencer
- McDonalds
- Kite Consulting
- MLC SL



Chairman's introduction



A lot has happened since the publication of the first phase of our roadmap - but that doesn't mean necessarily that a lot has changed. The beef and sheep industry continues to make great strides on how to lessen its

environmental impact, but whether there is any acknowledgement of that in other quarters is debatable.

We believe we have moved forward since Phase One of our environmental roadmap, Change in the Air, which looked exclusively at mitigating the effects of climate change by reducing greenhouse gas (GHG) emissions and energy use. I take great pride in saying that Roadmap Two breaks new ground again, looking at water use, economic performance versus environmental performance, our value in the landscape, and, significantly, the processing sector. This means there is little direct comparison to the information in Phase One, but doesn't mean it is forgotten or somehow now superseded. It is more a case that change takes time and to re-evaluate exactly where we are now compared to a year ago has little value. Five years down the line, it may be a different story. Change is happening, but change takes time.

The overall objective of this ongoing work is to improve the sustainability of the English beef and sheep industry. This is achieved through identifying areas where beef and sheep producers and processors can take actions that have a positive effect on the environmental impact of their enterprises, reducing the industry's contribution to climate change. The good news is that we can now clearly demonstrate that such changes go hand-inhand with economic performance. The more challenging news, as Roadmap Two demonstrates, is that there are still significant opportunities for more to be done by the industry to cut our carbon footprint.

Roadmap Two takes the analysis of the "environmental hoofprint" into uncharted territory. For the first time, it quantifies where we are in terms of performance on water use and contribution to the landscape and biodiversity, and on energy use in the processing sector. In that sense alone it would be an invaluable resource. However, it goes further, to suggest ways in which changes can be made to improve those figures.

The roadmaps, taken together as they should be, give the most comprehensive view to date of the impact English beef and sheep production has on our environment. As such, I view them as two parts of a unique reference guide of where we are and how we can move forward to help the sustainability, both of our surroundings and our own industry. The next instalment, in 2011, will add to the growing suite of resources.

I hope you will work with me to champion the message that the English livestock production sector is ploughing its own furrow on environmental performance and working to meet the tough emissions targets set by the Government.

John Cross Chairman, EBLEX

"Roadmap 2 goes further. It uses more detailed modelling using data from specific enterprises to quantify links between environmental and economic performance."

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1. Executive Summary

The story so far

The UK's Low Carbon Transition plan calls for greenhouse gas (GHG) reductions of 18% on estimated 2008 levels of 610 million tonnes carbon dioxide equivalent (Mt CO2 eq) per year - a third less than 1990 levels.

As part of this, English farmers are required to continue reducing their annual GHG emissions, with the immediate priority of farming emissions to be at least 11% lower than current predictions by 2020.

The unit of measurement commonly used as a benchmark for performance is CO₂ equivalent (CO₂ eq) emissions per kilogram (kg) of meat.

Life Cycle Analysis (LCA) modelling used in Change in the Air - Phase One of the beef and sheep roadmap - suggested English beef production is currently generating 13.9kg of CO₂ equivalent and consuming just over 31MJ of primary energy per kilogram of meat produced.

On the sheep side, the same LCA modelling revealed 14.6kg of CO₂ equivalent GHG emissions, with energy consumption of 22MJ (Mega Joules) per kilogram of meat produced.

Change in the Air, therefore, looked at how improvements of 11% could be made in these areas by 2020, and concluded that breeding, feeding and management all offered significant opportunities for progress. Roadmap 2 uses more detailed modelling with data from specific enterprises to quantify links between environmental and economic performance. It establishes a reliable water usage footprint for the industry, quantifies beef and sheep meat's contribution to the landscape and biodiversity of England, and takes a snapshot of the energy performance of the processing sector.

To best communicate the findings of this research, the bulk of this document is split into these areas of work accordingly. Each gives full methodology and examination of the results, providing additional detail to the headline findings in this executive summary.

English Beef and Sheep Production - a recap

There are around 2.9 million cattle and 16.7 million sheep slaughtered annually in the UK, supplying more than 1.1 million tonnes of meat to the human food chain, with a farm gate value of nearly ± 3 billion. Around 49% of the beef produced in the UK comes from the beef herd, with 51% from the dairy herd.

It is concentrated on 4.6 million hectares of land, the majority of which is only suited to grazing livestock. Production levels have been declining for the past 10 years. Beef suckler, dairy cow and ewe numbers are forecast to continue to decline over the coming decade due to the decoupling of support payments, competition with more profitable enterprises, labour problems and fewer family successions. The industry has made significant strides in improving its environmental performance in recent years, in no small part through these reductions in stock numbers. But there are also greater efficiencies, for instance 5% fewer prime animals were needed to produce each tonne of meat in 2008 than in 1998.

There are a number of industry-led initiatives, like the GHG Action Plan, pulling together organisations to work together and share good practice, while knowledge transfer initiatives, like EBLEX's Better Returns Programme, are helping to disseminate information on new research and improving environmental performance.

Commercial performance versus environmental performance

Building on the original industry-wide GHG emission benchmarks established by Cranfield University's Life Cycle Assessment model for Roadmap Phase One, a detailed appraisal of the carbon footprints of a selected sample of commercial beef and sheep farms has been undertaken by the E-CO₂ Project.

Conducting these appraisals on enterprises already costed by EBLEX has enabled relationships between financial and environmental performance to be examined, as well as conventional comparisons between the units on the basis of their carbon footprints alone.

Commercial beef production footprints

Across 30 beef units studied, the E-CO₂ carbon calculator shows an average 100year Global Warming Potential (GWP100) of 11.93kg CO₂ eq per kg liveweight, or 23.9kg per kg of carcase weight.

There is a wide range around this average from little more than 3kg CO₂ eq per kg liveweight (6.4 kg/kg carcase weight) to nearly 27kg (53.8 kg/kg carcase weight).

These averages are noticeably higher than the industry-wide benchmarks established by the original Cranfield University modelling in Phase 1. This does not lessen the validity of the figures in the first instalment, but simply reflects the difference between broad theoretical studies and the narrower, but very much more commercial, focus of the E-CO₂ Project assessments we have been able to carry out.

Most importantly, when the most recent assessments are analysed by the main beef production systems, they underline precisely the same trends in GHG emissions shown by the Cranfield estimates (Table 1.1).





Table 1.1: English beef production system footprints

	Environmental Impact (GWP100)	
	kg CO2 eq/kg liveweight Average	kg CO2 eq/kg liveweight Range
Lowland suckler beef	19.22	11.26 - 26.89
Upland suckler beef	15.66	8.83 - 20.60
Dairy beef	11.72	3.19 - 14.19

These results confirm that GHG emissions are notably higher in more extensive systems, based on lower quality forages that support lower growth rates, generating greater levels of methane. Comparing environmental performance and economic performance shows encouraging links, hitherto assumed but which can now be demonstrated. Every 5kg CO₂ eq reduction in GHG emissions per kg of liveweight, is associated with a 50p per kilogram improvement in financial margin (Figure 1.1).

Figure 1.1: Relationship between beef environmental and economic performance



The most significant driver is the efficiency of feed use.

Commercial sheep production footprints

The E-CO₂ sheep enterprise assessments show a similar relationship to the original Phase 1 Cranfield University industry modelling. Overall, the average 100-year Global Warming Potential (GWP100) calculated across 30 monitor units was 11.95 CO₂ eq per kg liveweight or 23.9kg per kg of carcase weight. As with the Cranfield modelling, the average GHG emissions per unit of sheep output are very similar to those per unit of beef production, exceeding the original theoretical industry-wide estimate to a similar degree.

Individual sheep system estimates again show lowland flocks having a distinct environmental advantage over hill enterprises, mainly as a result better quality forages and higher growth rates (Table 1.2).

Table 1.2: English sheep production system footprints

	Environmental I	mpact (GWP100)
	kg CO2 eq/kg liveweight Average	kg CO2 eq/kg liveweight Range
Hill flocks	13.61	8.55 - 19.22
Upland flocks	11.05	9.40 - 13.56
Lowland flocks	11.08	9.57 - 12.87

Again, the range of emissions within each main production system demonstrates the considerable potential for improvement by addressing productive efficiency. This position is underlined by an even more positive association between environmental and financial performance than in the beef industry - every 1kg CO2 eq reduction per kg liveweight in GHG emissions being associated with a 28p improvement in enterprise margin (Figure 1.2).

In the sheep sector "every 1kg CO2 eq reduction per kg liveweight in GHG emissions is associated with a 28p improvement in enterprise margin."







The main drivers are feed efficiency and litter size.

Water usage

Cranfield University has combined the improved Life Cycle Analysis (LCA) model, with which it quantified greenhouse gas emissions in Phase 1 of the roadmap, with the WaSim water simulation model, to establish the first-ever water footprint for English beef and sheep production.

The assessment takes into account all the inputs and outputs of water linked to the production of beef and sheep meat to calculate water use per kilogram of meat.

It uses acknowledged categories of different "types" of water, thus:

Blue water - all abstractions from rivers, lakes and groundwater for irrigation, feed processing, animal drinking, cleaning and other stock-keeping requirements. This is water taken out of the available water supply from the tap. **Green water** - rainfall used by crops (including grass) at the place where it falls. It covers the water which grows the grass and forage crops eaten by the cattle and sheep as they grow. This water is essentially unavailable for other uses.

Grey water - is a notional provision, representing the volume required to dilute pollutants to levels that maintain defined water quality standards. It carries relatively little hydrological impact since it does not physically consume the resource and deny it for other uses.

Beef

Assuming 51% of prime carcase beef is derived from the dairy herd, 30% from hill and upland suckler herds and 19% from lowland suckler enterprises, the modelling establishes the total baseline water footprint of English beef production at 17,657 litres per kilogram of meat produced.

This is considerably higher than both the global average footprint of 15,500 litres per kilogram and the UK average of 7,952 litres per kilogram calculated previously by others.

This is mainly due to the extent to which their methodologies under-estimate the green water footprint derived from the more accurate water balance study basis of the present calculation.

However, if we look simply at blue water ie, that water taken out of the tap that could reasonably have been used for other purposes and the description most commonly used in consumer-facing reports - the figure is just 67 litres per kilogram (Table 1.3).

Table 1.3: Water footprint of English beef production (litres/kg meat)

Blue water	Green water	Grey water	Total
67	14,900	2,690	17,657
0.4%	84.4%	15.2%	

Sheep

Based on the stratification of the sheep industry - with hill, upland and lowland ewes responsible for 39%, 30% and 31% of prime carcase lamb production - the modelling establishes a baseline total water footprint of 57,759 litres per kilogram of meat produced. Reflecting the industry's concentration on less productive land, this is considerably higher than the beef baseline.

The total footprint is again, however, accounted for almost entirely by green and grey water requirements, with the key blue water footprint at just 49 litres per kilogram markedly lower than that of beef (Table 1.4).

Table 1.4: Water footprint of English sheep production (litres/kg meat)

Blue water	Green water	Grey water	Total
49	55,800	1,910	57,759
0.1%	96.6%	3.3%	

The overwhelming dominance of green water in the total figures for both beef and sheep meat production means that, compared to livestock systems that rely on feed produced by irrigation, the actual hydrological impact of English beef and sheep meat production is very small.

Under current UK conditions, therefore, there is clearly little or no sustainability gain to be secured from any reduction in green water requirements. Instead, efforts to improve the overall water footprint of beef and sheep production are best focused on reducing blue and grey water requirements.

Assessing beef and sheep production impacts on the English ecosystem

While beef and sheep production has an important influence on landscape, biodiversity and other significant ecosystem services provided by the English hills and uplands in particular, quantifying the industry's contribution is especially difficult.

ADAS undertook a benchmarking assessment of beef and sheep production's value to the landscape to inform this roadmap.

It follows the United Nations Millennium Ecosystem Assessment, looking at:

- Supporting services, such as soil formation, photosynthesis and other primary production systems and nutrient and water cycling
- Provisioning services, relating to the products actually supplied, including food, fibre, fuel and fresh water

- Regulating services, encompassing the benefits secured from the way ecosystems regulate the climate, air quality, flooding, erosion, diseases, pests and other natural hazards, as well as the purifying of water and enabling pollination
- Cultural services, which cover the nonmaterial value obtained by society through spiritual enrichment, education, reflection, recreation and aesthetic experiences.

The maintenance of many of England's most valuable ecosystems - grasslands, in general, and hill and upland environments, in particular - fundamentally depends on beef and sheep production. Were existing grasslands not maintained by grazing, for instance, some chalk downlands and other upland environments would lose their present value as habitats in supporting some of the country's rarest flora and fauna.

Without a thriving beef and sheep industry, man-made elements of recognised landscape and biodiversity value, like interconnecting hedges, maintenance of ditches and walls, viable rural communities, stewardship schemes that enhance countryside and environmental value for society, could not be delivered.

There are no existing valuation studies specifically investigating the effect of beef or sheep farming on either the landscape or biodiversity. In the absence of other mechanisms, the Environmental Accounts for Agriculture, from Defra, provide the best available basis for assessing the biodiversity value attributed to English beef and sheep farming (Tables 1.5 and 1.6).

Table 1.5: Beef and sheep contribution to landscape value

Area	Basis	Calculation	Value
England	The Accounts	Total benefit from agriculture - £154 million Proportion of land attributable to beef and sheep farming - 41.5%	£64 million
Yorkshire National Parks	Gross Value Added	Total GVA by businesses depending on the environment - £334 million Proportion of land attributable to beef and sheep farming - 56%	£188 million
South West England	Tourist revenue	Total revenue from tourist trips motivated by conserved landscape - £2,354 million Proportion of land attributable to beef and sheep - 15%	£353 million
England National Parks	Tourist revenue	Total revenue from tourists visiting for the scenery - £2,200 million Proportion of land attributable to beef and sheep farming - 41%	£889 million

Through this it is possible to attribute a benefit to landscape value of beef and sheep production in England. Looking purely at the benefit of beef and sheep production on the landscape, based on Defra figures, this would be $\pounds 64$ million.

However, when you take into account other issues like tourist revenue from areas where a proportion of the land is maintained by beef and sheep production, the real figure could be closer to \pounds 1.49 billion

"The overwhelming dominance of green water in the total figures for both beef and sheep meat production means that the actual hydrological impact of English beef and sheep meat production is very small."



Table 1.6: Beef and sheep contribution to biodiversity value

Area	Basis	Calculation	Value
England	The Accounts - area farmed	Total benefit from agriculture - £704 million Proportion of land attributable to beef and sheep farming - 41.5%	£292 million
England	The Accounts - pesticide use	Total benefit from agriculture - £704 million Proportion of pesticides not attributable to beef and sheep farming - 82%	£574 million
England	The Accounts - agri- environment scheme total	Total benefit from agriculture - £704 million Proportion of schemes attributable to beef and sheep farming - 29%	£204 million
England	The Accounts - agri- environment scheme activity	Total benefit from agriculture - £704 million Proportion of schemes relevant to beef and sheep farming - 31%	£218 million

It is therefore possible to extract that the beef and sheep contribution to biodiversity value could be as high as £1.288 billion, based on Defra figures.

The challenge is to ensure that as much of this value as possible is sustained as the industry adapts to cope with economic and environmental pressures.

In meeting the challenge of reducing greenhouse gas emissions, for instance, there would be a compelling logic in moving production away from hill farming were it not for the fact that this could easily lead to immeasurable harm to the sustainability of these environments in a whole host of other important ways.

More industry debate is needed around this emerging important issue.

The meat processing sector

The water and energy consumed, and effluent produced, in beef and sheep processing has been quantified in a 2010 study undertaken for the roadmap project by MLCSL with the British Meat Processors Association (BMPA) and 22 individual abattoirs, cutting and retail packing plants across England.

Derived from reported abattoir output tonnages divided by the number of beasts processed, the average beef carcase currently processed weighs 336kg and the average sheep carcase 20kg.

The meat processing sector is not a heavy water user compared to other parts of the UK food and drink industry, consuming 7.2 million cubic metres per year, less than a quarter the amount of water used by dairies, breweries, distilleries or in soft drinks manufacture, according to the most recent Defra estimates. Of this, the UK beef and lamb industry utilises a total of 4 million cubic metres of water per year in animal slaughtering, cutting and retail packing.

Using the throughput and carcase yield data obtained, this represents an average of 3.6 litres per kilogram of beef and 2.5 litres per kilogram of sheep meat.

Abattoir effluent comprises a mixture of water, blood, faeces, urine and wash water. This can either be discharged directly to foul sewers or pre-treated on site to reduce water company trade effluent charges.

Given the extent to which water usage is driven by cleaning in meat processing, effluent production levels tend to be closely linked to water consumption. Indeed, discharge volumes are typically around 85% of mains water usage. Discharge data, throughput and carcase yields indicate average water and effluent discharges amounting to 3.1 litres per kilogram of beef and 2.1 litres per kilogram of sheep meat produced.

Around 65% of the total energy consumed by beef and sheep abattoirs and cutting plants is in the form of electricity to power operating equipment. The remaining 35% is as thermal energy from the combustion of gas (around 20%) and kerosene or oil (15%) in on-site boilers.

Based on energy usage records, throughputs and carcase yield, the roadmap study estimates abattoirs, cutting and packing plants are together consuming an average of 0.63kWh (kiloWatt hours) of energy per kilogram of beef, and 0.54kWh per kilogram of sheep meat.

Defra greenhouse gas emission conversion factors for 2010 suggest beef processing contributes around 0.27 kg CO₂ equivalent per kg of meat and sheep processing 0.23 kg CO₂ equivalent (Table 1.7).

Table 1.7: Beef and sheep processing greenhouse gas emissions (kg CO2 eq/kg)*

	Average	Range
Beef	0.27	0.11 - 0.53
Sheep	0.23	0.15 - 0.38

* Defra 2010 conversions: kWh electricity x 0.544; kWh gas x 0.20; kWh oil x 0.25

The study shows that there is significant variation in water consumption, effluent production and energy use between different plants, even allowing for differences in size and processes. These all allow for improvements which will inevitably also offer cost savings. Examples of how these savings can be made through reducing water consumption, effluent production, and energy use, as well as improved environmental management systems, are illustrated later in this document (page 43).





Executive summary: key figures at a glance

- 50p per kg improvement in beef producers' financial margin per 5kg CO2 eq reduction in GHG emissions per kg of liveweight
- 28p per kg improvement in sheep producers' financial margin per 1kg CO2 eq reduction in GHG emissions per kg of liveweight
- 67 litres of water (that could reasonably be used for other purposes) to produce 1kg of beef
- 49 litres of water (that could reasonably be used for other purposes) to produce 1kg of sheep meat
- £1.494 billion is the estimated total benefit to the landscape value of beef and sheep production in England
- £1.288 billion is the estimated total beef and sheep contribution to biodiversity value in England.
- 4 million cubic metres of water used each year in beef and sheep meat slaughtering and processing (3.6 litres per kg of beef and 2.5 litres per kg of sheep meat).
- 0.63kWh of energy used per kg of beef produced in abattoirs, cutting and retail plants. The equivalent figure for sheep is 0.54kWh.



2. The Roadmap Project



The English Beef and Sheep Production Roadmap is an industry-wide project led by EBLEX working closely with Defra, NFU, National Beef Association, National Sheep Association, British Meat Processors Association, Association of Independent Meat Suppliers and British Retail Consortium. Valuable inputs have also been received from Marks & Spencer and McDonalds.

The project's fundamental purpose is to improve the overall sustainability of the English beef and sheep industry in pursuit of the critical global need to produce more from less. This will only be achieved through a clear strategy that helps all those involved reduce the negative and promote the positive environmental, as well as economic and societal, impacts of their businesses.

In line with the international Sustainable Agriculture Initiative, sustainable agriculture is defined as the productive, competitive and efficient production of safe agricultural products while protecting and improving the natural environment and social/economic conditions of local communities (Figure 1).

Figure 1: Key Sustainable Agriculture Initiative pillars





3. Objective and Scope



This Phase Two document builds on Phase One - Change in the Air - published in late 2009 which focused on mitigating the effects of climate change by reducing greenhouse gas (GHG) emissions and energy use.

It does so by evaluating the specific relationships between physical and financial performance and GHG emissions on commercial beef and sheep units across the country.

Following on from the establishment of current GHG emission benchmarks from the best available model and an overall strategy to meet the 2020 targets set for agriculture in the UK's Low Carbon Transition Plan, it concentrates on the practical opportunities for linked environmental and economic improvement. Employing the same modelling approach as the original GHG emissions analysis, the document goes on to establish the first ever water footprint for English beef and sheep production as a sound basis for monitoring and managing this environmental impact.

It also attempts to value the landscape and biodiversity contribution of English beef and sheep production as a first step towards quantifying the industry's impact on the ecosystem services that do not figure in traditional valuations, but are vital to overall sustainability.

Finally, it quantifies water consumption, energy use and effluent production in the meat processing sector and identifies ways in which these environmental impacts can best be managed. Recognising the fundamental interconnectedness of environmental, societal and economic goals in ensuring sustainability, the roadmaps together chart the way ahead for the English beef and sheep industries against the background of the following key considerations:

- Fully 40% of agricultural land in England - 60% in the UK as a whole - is only suitable for grass rather than arable, vegetable or fruit crop production
- Beef and sheep producers constitute the bulk of UK farmers and their viability is essential to the sustainability of many rural communities
- Grazing livestock are important in preserving the landscape, biodiversity and recreational value of the hills and uplands
- Managed grasslands are increasingly valued for the range of other desirable ecosystem services they provide including carbon storage, water quality, flood prevention and tranquillity
- Red meat is a valuable source of energy, protein, vitamins and minerals in a balanced human diet, making a reliable and affordable supply important for consumer health and well-being

- Measures to enhance the biodiversity and habitat value of open and enclosed grazing land are highly desirable even though they may conflict with the need to reduce reducing GHG emissions
- As well as being vital for the management of some of the country's most valuable landscapes, grazed beef and sheep production systems are valued by the general public for their perceived animal health and welfare benefits.

The value of both phases of this roadmap in promoting UK beef and sheep production sustainability will be greatly enhanced by co-operative development with appropriate organisations in Scotland, Wales and Northern Ireland.

Information exchange with similar sustainability-driven studies in New Zealand, France, Ireland and the USA will further add to the project's value.

"Defra greenhouse gas emission conversion factors for 2010 suggest beef processing contributes around 0.27 kg CO₂ equivalent per kg of meat and sheep processing 0.23 kg CO₂ equivalent."





4. Assessing Commercial Farm GHG Performance



Building on the original industry-wide GHG emission benchmarks established by Cranfield University's Life Cycle Analysis model, a detailed appraisal of the carbon footprints of a selected sample of commercial beef and sheep farms has been undertaken by E-C02 Project.

Conducting these appraisals on enterprises already costed by EBLEX has enabled relationships between financial and environmental performance to be examined as well as conventional comparisons between the units on the basis of their carbon footprints alone.

The Appraisal Process

A total of 30 beef and 30 sheep production businesses were visited by trained carbon and energy assessors to collect key information which was processed through a bespoke carbon calculator, accredited by the Carbon Trust, to establish reliable enterprise-specific GHG emission measurements. The sophisticated software employs information commonly available on commercial farms to calculate the carbon dioxide, methane and nitrous oxide emissions arising from all aspects of the production system, including the feeds, fertilisers, agrochemicals, manures, bedding, fuel and electricity used.

It utilises a LCA from birth to the farm gate, agreed carbon dioxide equivalent conversion factors and economic allocation to establish annual GHG emissions per kilogram of live and deadweight for each enterprise.

Where beef and sheep production form part of mixed farming businesses, the inputs and outputs from other enterprises are specifically excluded and overheads allocated according to overall business share.

Rigorous training of assessors and grading of every farm to reflect the availability and accuracy of the data collected ensures the overall carbon footprint calculations are as statistically robust as they can be.

Commercial Beef Production Footprints

Across all 30 beef units studied, the E-CO2 carbon calculator shows an average 100year Global Warming Potential (GWP100) of 11.93kg CO2 eq per kilogram liveweight or 23.9kg per kilogram of carcase weight (Table 1). As might be expected with the variety of different production systems involved, there is a wide range around this average - from little more than 3kg CO₂ eq per kg liveweight (6.4kg/kg carcase weight) to nearly 27kg (53.8kg/kg carcase weight).

Table 1: Overall English beef production footprint

	Environmental Impact (GWP100)	
	kg CO2 eq/kg liveweight	kg CO2 eq/kg deadweight
Average	11.93	23.86
Lowest	3.20	6.40
Highest	26.89	53.78

These levels are noticeably higher than the industry-wide benchmarks established by the original Cranfield University modelling in the Phase 1 roadmap, reflecting the difference between broad theoretical studies and the narrower but very much more commercial focus of the E-CO2 Project assessments. Most importantly though, when the most recent assessments are analysed by the main beef production systems, they underline precisely the same trends in GHG emissions shown by the Cranfield estimates (Table 2).

Table 2: English beef production system footprints

	Environmental Impact (GWP100)	
	kg CO2 eq/kg Average	kg CO2 eq/kg Range
Lowland suckler beef	19.22	11.26 - 26.89
Upland suckler beef	15.66	8.83 - 20.60
Dairy beef	11.72	3.19 - 14.19

As in the Change in the Air work, dairy beef emissions are only around 60% of those of lowland suckler beef enterprises.

Similar differences are apparent in the results of a further 67 McDonalds suppliers assessed to the same protocols in parallel E-CO2 Project work.

These results confirm that GHG emissions are, in practice, notably higher in more extensive systems based on lower quality forages that support lower growth rates, generating greater levels of methane production per unit of output.

It also illustrates the considerable apparent environmental advantage enjoyed by dairy beef systems as a result of the fact thats the vast majority of breeding herd emissions are attributed to milk production. Meat is effectively a by-product of the milk production process. The considerable ranges of environmental performance within each main beef production system clearly suggests substantial opportunities for improvement, even within a sample generally considered to represent more progressive producers.

Assessing the environmental performance of the enterprises alongside their financial efficiency confirms this potential by revealing an encouragingly positive relationship between the two.

Every 5kg reduction in GHG emissions per kilogram of liveweight, indeed, appears to be associated with a 50p per kilogram improvement in financial margin (Figure 2).





The most significant driver is the efficiency of feed use.

Commercial Sheep Production Footprints

The E-CO2 sheep enterprise assessments show a similar relationship to the original Phase 1 Cranfield University industry modelling. Overall, the average 100-year Global Warming Potential (GWP100) calculated across all 30 units was 11.95 CO2 eq per kilogram liveweight or 23.9kg per kilogram of carcase weight (Table 3).

Table 3: Overall English sheep production footprint

	Environmental Impact (GWP100)	
	kg CO2 eq/kg liveweight	kg CO2 eq/kg deadweight
Average	11.95	23.90
Lowest	8.55	17.09
Highest	19.22	38.43

As with the Cranfield modelling, the average GHG emissions per unit of sheep output are very similar to those per unit of beef production, exceeding the original theoretical industry-wide estimate to a similar degree.

While the range around this average was also considerable, in common with the Cranfield estimates, it was nowhere near as great as that around the beef average. This perhaps reflects the fact that the English sheep industry has no equivalent of dairy beef in which the meat is essentially a by-product.

Individual sheep system estimates again show lowland flocks having a distinct environmental advantage over hill enterprises, mainly as a result better quality forages and higher growth rates (Table 4).

Table 4: English sheep production system footprints

	Environmental Impact (GWP100)	
	kg CO2 eq/kg Average	kg CO2 eq/kg Range
Hill flocks	13.61	8.55 - 19.22
Upland flocks	11.05	9.40 - 13.56
Lowland flocks	11.08	9.57 - 12.87

Again, the range of emissions within each main production system demonstrates the considerable potential for improvement by increasing productive efficiency. This position is underlined by an even more positive association between environmental and financial performance than in the beef industry - every 1kg CO2 eq reduction per kg liveweight in GHG emissions being associated with a 28p improvement in enterprise margin (Figure 3).

Figure 3: Relationship between sheep producers environmental and economic performance



The main drivers are feed efficiency and litter size.



Conclusion

There is a good correlation between economic performance and CO2 eq cost of production for both beef and sheep producers. While not too surprising in itself, it is valuable to have concrete survey data to confirm that those managers who are the most efficient at managing their farm and animal resources for profit are also the most effective at keeping GHG emissions low.



These findings support the three key sustainable pillars of agriculture referred to in Section 2: pursuing economic improvement goals improves the GHG position and supports the overall sustainability of the business which in turn stabilises the position of farming in society.



5. Making the most of water



Cranfield University has combined the improved Life Cycle Analysis (LCA) model, with which it quantified GHG emissions in Phase One of the roadmap, with the WaSim water simulation model to establish the first-ever water footprint for English beef and sheep production.

The assessment takes into account all the inputs and outputs of the different systems linked to the production of beef and sheep meat to calculate water use per kilogram of meat for individual production systems, as well as the industry as a whole.

The analysis covers production through to despatch from the farm and is expressed in terms of litres per kilogram of carcase weight. Slaughter and processing water is not taken into account (see chapter 7).

Water footprint basis

Following the water footprint concept developed by Hoekstra & Hung (2002), the assessment establishes total water usage from calculations of its three main components - blue, green and grey water. Dividing the footprint into these components also enables a more realistic evaluation of the actual hydrological impact of production activities.

Blue water includes all abstractions from rivers, lakes and groundwater for irrigation, feed processing, animal drinking, cleaning and other stock-keeping requirements.

This has a significant impact on society since its utilisation in beef and sheep production renders it unavailable for other consumption or environmental uses, including domestic and industry supply, maintenance of river flows and preservation of wetland and other valuable habitats.

Even in England's relatively wet climate, rising demand from many sectors and growing seasonal variability is placing increasing pressure on such water resources, especially in the south and east.

Green water, on the other hand, is the rainfall used by crops (including grass) at the place where it falls. This water is essentially unavailable for other uses. In the absence of grassland or crops, it would be consumed to almost exactly the same extent by other vegetation. Indeed, deeper-rooted tree and scrub cover would lead to even higher levels of water use than crops or grassland. And the alternative of leaving the land bare is neither feasible without considerable input to restrict natural regeneration, nor desirable in terms of soil erosion and run-off.

Since it cannot be used elsewhere and levels of usage are not increased by its role in crop production, green water consumption carries little or no hydrological impact.

Grey water is a notional provision, representing the volume required to dilute pollutants to levels that maintain defined water quality standards.

It also carries relatively little hydrological impact since it does not physically consume the resource and deny it for other uses.

After all, water notionally required to reduce the biological oxygen demand of accidental slurry or silage effluent leaks, or counter higher than acceptable nitrate or phosphate concentrations from soil leaching, is, at the same time, also available to meet human consumption or environmental maintenance needs.

Grey water as a concept is, arguably, of most value to water companies as a measure of the 'cost' of countering any negative water quality impacts from farming. Within the total water footprint, therefore, blue water stands out as the most important focus for improving the sustainability of beef and sheep production, with both the grey and green water components being far less significant.

The LCA footprint calculations take account of all the main areas of blue, green and grey water input in current production systems, namely that used for drinking, washing and cleaning, that 'embedded' in the diet, and that required to balance nitrate leaching.

Drinking, washing and cleaning water

The drinking water requirements for beef and sheep production are calculated from overall stock water needs on the basis of dry matter intake and ambient temperatures from a recent Defra study (Thomson et al; 2007).

For each production system (Table 5) the drinking water used is taken to be the difference between the total water requirements of the stock and the water provided in the feed.

Table 5: Main production systems included in the LCA

Lowland sucker herds (autumn calving)
Upland suckler herds (spring calving)
Upland suckler herds (autumn calving)
Hill suckler herds
Intensive dairy beef
Extensive dairy beef
Hill flocks
Upland flocks
Lowland flocks
Early lambing flocks

The entire drinking-related footprint is clearly classified as blue water.

Also entirely blue water in the model is the very small component of the footprint calculated for cleaning trailers and equipment, and for use in dipping sheep.

Water in the feed

The water 'embedded' in all the main feeds used in English beef and sheep production is calculated from detailed evaluations of UK-grown grass, grass silage, wheat, barley, oilseed rape and sugar beet production using average crop yields and local rainfall and evapotranspiration data.

Although the animal feed industry only uses by-products of oilseed rape and sugar beet production (in the form of rapeseed meal and sugar beet feed), the whole water consumption associated with growing the crop is included in the calculation. This undoubtedly results in some over-estimation. The water footprint also includes estimates for imported soya from Argentina and Brazil in line with Defra import statistics.

The overall animal feeding contribution to the water footprint is then calculated from the typical inclusion rates of the various feeds in beef and sheep diets, and intake levels under the different production systems.

Since all home-produced feeds - with the exception of a tiny minority (6%) of the sugarbeet crop - and soya beans imported from our primary trading partners, are produced without irrigation, the overwhelming majority of the feed-related footprint is green water. Forty-five litres of water per tonne is used in the feed processing industry for stem raising, and to replace water evaporated during heat processing to ensure a constant feed concentration.

Water for nitrate leaching

Having assessed every possible element of grey water that could be required to dilute pollution caused by beef and sheep production, all but nitrate leaching are considered too small or unquantifiable to be reliably included within the footprint calculation.

Slurry and manure pollution balancing requirements are omitted, given the impossibility of attributing recorded incidence levels to beef rather than dairy units. At the same time, the virtually nonexistent housing requirement for sheep and the fact that the vast majority of housed beef are kept on solid farmyard manure systems - in contrast to slurry-based dairy systems means they are only likely to be associated with a tiny minority of such incidents.

The impossibility of attributing silage effluent pollution incidents between enterprises, and the fact that both beef and sheep production tend to utilise higher dry matter big bale silage with its far lower point source polluting risk, means water requirements for this purpose are excluded too.

Also excluded are pesticide pollution balancing needs, on the basis that these too are minute. What is more, the only specific risk - from sheep dip - can effectively be discounted because failure to dispose of it properly would result in quite unacceptable pollution (of which no incidents are reported). While phosphate leaching from fertiliser application could generate a significant grey water requirement in some cases, the relative importance of nitrate use and leaching means this will be the key driver of water needs. The water requirement for this purpose will, at the same time, more than meet any leached phosphate balancing need.

Grey water footprint calculations for nitrate leaching are made according to the recommendations of the Water Footprint Manual, with adjustments for the extent to which surplus rainfall (beyond that used by the crops) is available to naturally dilute any nitrates leached into freshwater bodies.

Beef production water footprint

Assuming 51% of prime carcase beef is derived from the dairy herd, 30% from hill and upland suckler herds and 19% from lowland suckler enterprises, the modelling establishes the total baseline water footprint of English beef production at 17,657 litres per kilogram of meat produced.

This is considerably higher than both the global average footprint of 15,500 litres per kilogram and the UK average of 7,952 litres per kilogram calculated previously by others. This is mainly due to the extent to which their methodologies under-estimate the green water footprint derived from the more accurate water balance study basis of the present calculation.

Such differences underline the great danger of comparisons with other footprint calculations made on a different basis. Many Australian beef production estimates, for instance, owe their very low footprints around 210 litres per kilogram - to an exclusive focus on blue water from surface and groundwater storage. Interestingly, a far lower reliance on irrigated crop production means that the key blue water footprint for English beef is only 67 litres per kilogram, the overwhelming majority of the footprint - 84% and 15% respectively - being accounted for by green and grey water (Table 6). This is around a third the level of the comparable Australian footprint.

Table 6: Water footprint of English beef production (litres/kg meat)

Blue water	Green water	Grey water	Total
67	14,900	2,690	17,657
0.4%	84.4%	15.2%	

Blue water similarly accounts for barely 0.5% of the footprints of all the main production systems making up the English industry (Table 7).

Table 7: Water footprint of English beef production systems (litres/kg meat)

Component system	Blue water	Green water	Grey water	Total
Lowland suckler beef	78	15,600	3,490	19,168
Upland suckler beef	81	12,800	3,300	16,181
Hill suckler beef	103	44,200	3,080	47,383
Dairy beef	45	8,150	1,980	10,175

Dairy beef has a noticeably lower blue water and total water footprint than suckler systems because it excludes the water requirements of adult cows, which are assumed to be allocated to their primary product - milk.

Equally, the far lower yields of grass from less productive land means very much more rainfall per unit of forage produced. This means a vastly higher green water component for hill sucklers and, as a result, a considerably higher total footprint than other systems.

Sheep production water footprint

Based on the stratification of the sheep industry - with hill, upland and lowland ewes responsible for 39%, 30% and 31% of prime carcase lamb production - the modelling establishes a baseline total water footprint of 57,759 litres per kilogram of meat produced.

Reflecting the industry's concentration on less productive land, this is considerably higher than the beef baseline.

The total footprint is again, however, accounted for almost entirely by green and grey water requirements, with the key blue water footprint at just 49 litres per kilogram, markedly lower than that of beef (Table 8).

Blue water	Green water	Grey water	Total
49	55,800	1,910	57,759
0.1%	96.6%	3.3%	

Table 8: Water footprint of English sheep production (litres/kg meat)

In just the same way as with beef, the far lower productivity of hill land, in particular, means a very much higher water footprint for hill production systems (Table 9). Again, however, the key blue water footprint shows how little actual water any of the systems consume.

Table 9: Water footprint of English sheep production systems (litres/kg meat)

Component system	Blue water	Green water	Grey water	Total
Lowland flocks	31	21,800	2,550	24,381
Upland flocks	40	24,700	2,600	27,340
Hill flocks	85	135,000	205	135,290

Overall water footprint assessment

Despite differences in methodology, the study demonstrates a total water footprint for English beef and sheep production of a similar order to many estimates from other countries.

The overwhelming dominance of green water in the total figures, however, means that compared to livestock systems that rely on feed produced by irrigation, the actual hydrological impact of English meat production is very small.

Hill beef and sheep production clearly has a very much higher green water footprint than other systems. However, since these systems primarily involve grass-fed stock in areas of much higher than average rainfall, the natural water surplus is calculated to be noticeably greater than other parts of the country (Figure 4).

"Blue water similarly accounts for barely 0.5% of the footprints of all the main production systems making up the English industry."



Figure 4: Average surplus rainfall, mm per tonne DM (dry matter) grass yield for each site class



Under these circumstances, higher green water consumption for grass and forage production in the hills and upland areas is clearly not reducing water flow to rivers and streams to any greater extent than other areas, so it has no greater hydrological impact.

The fact that upland and hill areas are generally unsuitable for other forms of food production is a further consideration here.

Improving the water footprint

Analysis of annual rainfall and evapotranspiration data across the country show that even the driest parts of England have a useful excess of rainfall over that required for grass production (Figure 4).

This suggests green water consumption in grass and forage production is having no significant impact on surface and groundwater availability for other purposes. Indeed, were pastures and other land used for animal feed production to be left uncropped, natural vegetation would consume at least as much green water. And were such areas to be forested, even greater amounts of water would be absorbed, reducing flow to surface and groundwater reserves within the catchments.

Under current UK conditions, therefore, there is clearly little or no sustainability gain to be secured from any reduction in green water requirements.

Instead, efforts to improve the overall water footprint of beef and sheep production are best focused on reducing blue and grey water requirements.

Reducing days to slaughter and increasing growth rates will help reduce lifetime drinking water requirements of cattle and sheep. However, many farms have considerable potential to reduce their blue water footprints through:

- Good management and lagging of pipes and drinkers to minimise leakages
- Using bowsers with small side troughs or drinkers instead of large field troughs to reduce wastage from leaking pipe runs and trough cleaning
- Using livestock nose pumps to access local surface and ground water supplies to similarly reduce wastage
- Collecting rainwater from housing roofs to replace tap supplies.

Most, if not all, of these options offer the opportunity for both equipment as well as metered water cost savings.

More precision in grassland management and fertilisation will be valuable in reducing nitrate leaching and, as a result, the main element of the grey water footprint. In particular:

- Maintaining soil pH at the correct level for optimum grassland productivity
- Monitoring soil P & K regularly to maintain the right status
- Making the greatest possible use of clover and organic manures

- Adjusting fertilisation to take account of clover and manure contributions
- Matching N fertiliser amounts and timing to sward needs over the season
- Maintaining the optimum nitrogen to sulphur ratio.

Better grassland management and fertilisation is likely to be extremely valuable economically in most cases at current fertiliser prices.

It will also deliver valuable environmental benefits; especially for those farming in Nitrate Vulnerable Zones (NVZs) too.







6. Assessing other ecosystem impacts

While beef and sheep production is recognised as having an important influence on landscape, biodiversity and other significant ecosystem services provided by the English hills and uplands in particular, quantifying the industry's contribution in these key respects is especially difficult.

As part of determined sustainabilityimproving, a benchmarking assessment of beef and sheep production's value to landscape and biodiversity has been undertaken by ADAS to inform this roadmap.

Valuing ecosystem services

The most comprehensive evaluation of the state of the global environment to date - the United Nations Millennium Ecosystem Assessment - classifies the many and varied services provided by the ecosystems on which society relies for its health and wellbeing into four distinct groups:

- Supporting services, such as soil formation, photosynthesis and other primary production systems and nutrient and water cycling which underpin the production of all other ecosystem services
- Provisioning services, relating to the products actually supplied, including food, fibre, fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals and fresh water

- Regulating services, encompassing the benefits secured from the way ecosystems regulate the climate, air quality, flooding, erosion, diseases, pests and other natural hazards, as well as the purifying of water and enabling pollination
- Cultural services which cover the nonmaterial value obtained by society through spiritual enrichment, education, reflection, recreation and aesthetic experiences.

These are illustrated in Figure 5.

Figure 5: Ecosystem services for the UK (Haygarth & Ritz 2009)



The provisioning services provided by beef and sheep production as part of the ecosystem are relatively easy to value, given current market mechanisms that put a price on products like meat, offal, wool and hides. Far more difficult to value are the cultural services represented by the landscape and key elements of supporting and regulating services enabled by biodiversity, let alone the proportion of their value attributable to beef and sheep farming.

These services are considered to be public goods - goods that provide clear, although less immediately quantifiable, benefits to society which are not specifically valued by standard market economics.

The value of these so-called non-market goods is primarily derived from people's use of ecosystems for recreation, reliance upon them for fresh air, flood control and the like, and pleasure in knowing they exist whether or not they are actively utilised.

For the purposes of this report landscape is defined as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and human factors'.

Biodiversity, in turn, is defined as 'the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part'. This definition includes diversity within species, between species and amongst ecosystems.

These definitions underline the critical contribution of both natural and human activities to landscape and biodiversity.

The maintenance of many of England's most valuable ecosystems - grasslands in general and hill and upland environments in particular - fundamentally depends on beef and sheep production.

Were existing grasslands not maintained by grazing, for instance, they would quite rapidly revert to scrub and tree cover which would seriously compromise their present landscape value for enjoyment and recreation. Similarly, lack of grazing would lead chalk downlands and other upland environments to lose their present value as habitats in supporting some of the country's rarest flora and fauna.

Without a thriving beef and sheep industry, man-made elements of recognised landscape and biodiversity value, like mosaics of interconnecting and enhancing hedges, ditches and walls would cease to be maintained, viable rural communities, and stewardship schemes that enhance countryside and environmental value for society, could not be delivered.

There are no existing valuation studies specifically investigating the effect of beef or sheep farming on either the landscape or biodiversity, certainly not within the United Kingdom.

Although far from perfect, the valuation evidence presented here brings the best available modern methodologies and information to bear on establishing a range of possible values for the contribution made by today's industry.

It does so in the full recognition of the very real limitations of the exercise within its present scope, as well as the fact that it fails to account for important ecosystem services like climate, flood and disease regulation.

Even so, the exercise will enable more informed benchmarking of the industry's less tangible contributions to the environment as the basis for ensuring the best possible balance is maintained in sustainability improvement efforts.

Landscape valuation

Two separate approaches are taken to valuing the contribution of beef and sheep farming to the English landscape.

The first is based on the Environmental Accounts for Agriculture (known as the Accounts) published by Defra to provide a framework for measuring and valuing the positive and negative impacts of agriculture on the environment.

Employing data from the 2007 Countryside Surveys, the Accounts use a model bringing together information from many different valuation studies to attribute values to key habitats and linear features like hedges, ditches and stonewalls.

They employ a number of techniques that are open to challenge as far as accuracy is concerned. For instance, they assume the benefits of a feature in one part of the country can be directly transferred to another. In addition, they apportion 100% of the value of landscapes to agriculture. Importantly, they also take no account of the so-called non-use (or feel-good) values those that derive from knowledge the landscape is present, available for others to enjoy and can be passed on to future generations.

In line with valuation studies in general, the Accounts accept the general consensus that there are significant positive flows from current agricultural landscapes which are for the most part under-estimated.

For 2008, the Accounts value English agriculture's landscape contribution to society at around £154 million per annum.

As approximately 41.5% of the farmed area of the country is accounted for by beef and sheep production, this suggests the industry delivers an annual landscape value of around $\pounds 64$ million (Table 10).

With latest Defra information showing 96% of beef and sheep farmers undertake countryside maintenance and management work it is not unreasonable to assume such a significant landscape value contribution.

Indeed, the fact that beef and sheep production tends to be concentrated on the hill and upland landscapes, arguably makes it more valuable in the ecosystem services they provide than many other farmed areas. This implies that they should be credited with an even greater contribution than a simple linear apportionment of the whole.

Alongside the Accounts approach, the ADAS study also considers the value of beef and sheep farming in the wider economy and examines Gross Value Added (GVA) data from Yorkshire's National Parks, and tourist expenditure information for the South West and National Parks more widely as separate case studies.

GVA gives a market value for the landscape's direct use by businesses in an area calculated from their turnover and the extent to which they depend directly or indirectly on the environment.

Tourist expenditure is also a direct-use valuation tool. It includes only the money spent by visitors within an area not the cost of getting to it.

Again there are a number of clear limitations to both GVA and tourist spend valuations. Not least the fact that the former includes all agricultural outputs and the latter only accounts for visitors and not those who live there or those who consider the area to have value without visiting. Based on the proportions of land within each area devoted to beef and sheep farming, the separate case studies suggest the industry delivers a landscape value of £188 million to Yorkshire National Parks, £353 million to the South West and £889 million to English National Parks as a whole (Table 10).

Because they involve regions of particular appeal for their scenery and recreation, it is clearly inappropriate to use these figures to estimate a national value.

They do, however, indicate that English beef and sheep production is likely to be making a considerably higher contribution to the economy on the basis of their management of the landscape than suggested by the Accounts approach.

Biodiversity valuation

In the absence of other mechanisms, the Environmental Accounts for Agriculture provides the best available basis for assessing the biodiversity value attributed to English beef and sheep farming.

Tourist revenues are considered inappropriate given the extent to which biodiversity underpins ecosystem services as a whole rather than being a definable service itself.

As well as valuing key aspects of agriculture's contribution to the landscape, the Accounts assess the biodiversity value it delivers through both the maintenance and management of habitats, primarily Sites of Special Scientific Interest (SSSIs) and farm woodland, and individual species, primarily farmland birds.

The Accounts caution that their biodiversity valuations come with a high degree of uncertainty, not least because they are based on so few elements of the whole biodiversity equation. However, as for the value of landscape, the clear view is that resolving these uncertainties would cause the figures to be revised upwards rather than downwards.

As with the landscape valuation, the most straight-forward way of attributing the £704 million of total biodiversity benefits in the Accounts for English farming to beef and sheep production is on the basis of its share of the farmed area.

This gives an industry value of around \pounds 292 million (Table 11).

The multi-faceted nature of biodiversity, however, means that this method of apportionment may be inappropriate. The biodiversity value of hill and upland farming areas is, for instance, widely regarded as very much higher than that of most areas of arable monoculture.

Under these circumstances, pesticide usage figures could provide a better way of apportioning value. They are, after all, alleged to be one of the major contributors to biodiversity loss. Equally, they almost certainly represent a good indicator of the intensity of agriculture which is generally considered to be inversely proportional to its biodiversity.

The latest Pesticide Usage Survey (2006) shows a total of 21 million kg of product applied to agricultural land in England, of which 0.55 million kg (less than 3%) is applied to grassland.

On this basis of the extent to which it uses the products that intensify agriculture and reduce biodiversity, it could be assumed that approximately 97% of agriculture's total biodiversity value comes from grassland farming. Adjusting this for the 84% of the grazing area used by beef and sheep farming and assuming these enterprises use as much pesticide as dairying - which is unlikely gives an Accounts biodiversity value of around £574 million (Table 11).

As one of their main aims is to protect and enhance farm-based wildlife, the uptake of agri-environment schemes provides another way of apportioning the £704 million total Accounts biodiversity value. This can be done either on the basis of the proportion of farms undertaking such schemes or the proportion of boundary, buffer, tree and woodland schemes being undertaken.

Depending on the basis employed, the biodiversity value attributed to beef and sheep farming of between $\pounds 204$ and $\pounds 218$ million (Table 11).

Area	Basis	Calculation	Value
England	The Accounts	Total benefit from agriculture - £154 million Proportion of land attributable to beef and sheep farming - 41.5%	£64 million
Yorkshire National Parks	Gross Value Added	Total GVA by businesses depending on the environment - £334 million Proportion of land attributable to beef and sheep farming - 56%	£188 million
South West England	Tourist revenue	Total revenue from tourist trips motivated by conserved landscape - £2,354 million Proportion of land attributable to beef and sheep - 15%	£353 million
England National Parks	Tourist revenue	Total revenue from tourists visiting for the scenery - £2,200 million Proportion of land attributable to beef and sheep farming - 41%	£889 million

Table 10: Beef and sheep contribution to landscape value

Table 11: Beef and sheep contribution to biodiversity value

Area	Basis	Calculation	Value
England	The Accounts - area farmed	Total benefit from agriculture - £704 million Proportion of land attributable to beef and sheep farming - 41.5%	£292 million
England	The Accounts - pesticide use	Total benefit from agriculture - £704 million Proportion of pesticides not attributable to beef and sheep farming - 82%	£574 million
England	The Accounts - agri- environment scheme total	Total benefit from agriculture - £704 million Proportion of schemes attributable to beef and sheep farming - 29%	£204 million
England	The Accounts - agri- environment scheme activity	Total benefit from agriculture - £704 million Proportion of schemes relevant to beef and sheep farming - 31%	£218 million

Overall industry value

English beef and sheep production clearly provides a far greater value to the countryside than simple farm gate revenue calculations indicate.

Valuing the landscape and biodiversity, let alone attributing such valuations to beef and sheep production, is a highly complex business. It is also a process very much in its infancy.

There are a whole host of ways in which such valuations can be made, none of which are without their limitations or issues. This makes the precision calculation of the less tangible (but no less important) contributions of farming in general and beef and sheep production in particular almost impossible.

Nevertheless, it is obvious from the considerations discussed that the landscapes and biodiversity maintained by beef and sheep production make a significant contribution to the overall sustainability of many of the country's most cherished environments, as well as supporting a large number of vital rural communities.

As is so often the case, the true value of something only really becomes apparent once it has been lost.

The challenge with beef and sheep production is to ensure that as much of the value it contributes to the vital life support systems on which our economy depends is sustained as the industry adapts to cope with the economic and environmental pressure it faces.

In meeting the challenge of reducing greenhouse gas emissions, for instance, there would be a compelling logic in moving production away from hill and upland beef and sheep were it not for the fact that this could easily lead to immeasurable harm in the sustainability of these environments in a whole host of other important ways.



7. The Meat Processing Sector

The water and energy consumed, and effluent produced, in beef and sheep processing have been quantified in a 2010 study undertaken by MLCSL with the British Meat Processors Association (BMPA) and individual abattoirs, cutting and retail packing plants across England.

Alongside valuable guidance from the Government-backed Waste & Resources Action Programme (WRAP), this study also explores ways in which such environmental impacts can best be minimised through carefully planned and targeted improvements in plant operation and management.

Benchmarking the industry

Data on annual throughputs, carcase yields, water and energy consumption and effluent production was collected from a total of 22

abattoirs, cutting and retail packing plants concentrated in England.

Although these were some of the larger and more efficient plants in the business, the fact that they represent a major proportion of national processing volumes means they provide a reasonable quantification of the water and energy inputs and effluent output per kilogram of meat produced in the country.

Carcase yield

Derived from reported abattoir output tonnages divided by the number of beasts processed, the average cattle carcase currently processed weighs 336kg and the average sheep carcase 20kg (Table 12).

Table 12 : Beef and sheep carcase yields (kg/head)

	Average	Range
Beef	336	377 - 310
Sheep	20	18 - 23

Considerable variation is evident around these averages due to variations in the mix of beef and sheep animal types processed and a range of other commercial factors, including geography, condemnations and degree of offal harvesting.

Water consumption

The meat processing sector is not a heavy water user compared to other parts of the UK food and drink industry, consuming less than a quarter the amount of water used by dairies, breweries, distilleries or soft drinks manufacture, according to the most recent Defra estimates (Table 13).

Dairies	39.0
Breweries	35.2
Soft Drinks	27.5
Distilleries	25.9
Meat Processing	7.2

Table 13: Annual UK food and drink sector water consumption (million cubic metres/yr)

However, legal meat hygiene standards necessitate the use of considerable quantities of potable (blue) water for almost all washing and rinsing operations.

All process floor areas need to be washed clean at least once a day. In addition, water is used for watering and washing livestock in lairages, washing carcases, cleaning lairages, process equipment and work areas and, in many cases also, the hygiene of transport vehicles on site entry and exit. The majority of processing plants obtain their water from the public supply with some utilising bore-hole water for functions like yard and vehicle washing.

Altogether, the present study estimates the UK beef and lamb industry utilises a total of 4 million cubic metres of water per year in animal slaughtering, cutting and retail packing.

Using the throughput and carcase yield data obtained, this represents an average of 3.6 litres per kilogram of beef and 2.5 litres per kilogram of sheep meat (Table 14).

	Average	Range
Beef	3.6	1.8 - 4.0
Sheep	2.5	1.5 - 3.9

Table 14: Beef and sheep processing plant water consumption (litres/kg)

With water consumption highly dependent on plant layout and floor area, as well as the precise processing systems and management practices employed however, there is considerable variation around these averages.

Effluent production

Abattoir effluent comprises a mixture of water, blood, faeces, urine and wash water. This can either be discharged directly to foul sewers or pre-treated on-site to reduce water company trade effluent charges.

The high organic matter loading of much of this effluent means abattoirs generate waste with some of the highest pollution potential - as measured by Chemical Oxygen Demand (COD) or Biological Oxygen Demand (BOD) in the food and drinks sector.

The study shows that around half the plants have no on-site treatment facilities.

This means they either discharge their effluent direct or, in some cases, have to get their effluent tankered away at considerable extra expense.

Given the extent to which water usage is driven by cleaning in meat processing, effluent production levels tend to be closely linked to water consumption. Indeed, discharge volumes are typically around 85% of mains water usage.

Discharge data, throughput and carcase yields indicate average water and effluent discharges amounting to 3.1 litres/kg of beef and 2.1 litres/kg of sheep meat produced (Table 15).

Table 15: Beef and sheep slaughtering plant effluent discharges (litres/kg)

	Average	Range
Beef	3.1	1.7 - 5.4
Sheep	2.1	0.8 - 3.4

As with water consumption, big differences are evident between plants in the average water and effluent discharges.

While some of these differences arise from variations in data collection and specific plant processes and management, good primary and secondary treatment facilities allow a number of processors to reduce volumes by recycling lightly soiled waste water for less sensitive tasks such as lairage and yard cleaning.

Equally, higher discharge than water consumption levels in some cases show plants are failing to effectively exclude rainwater from foul drains and, as a result, significantly increasing effluent levels and disposal costs.

Energy consumption

Around 65% of the total energy consumed by beef and sheep abattoirs and cutting plants is in the form of electricity. This is used to power operating equipment in the slaughter and boning areas, process byproducts, and run refrigeration and air compressor units.

The remaining 35% is as thermal energy from the combustion of gas (around 20%) and kerosene or oil (15%) in on-site boilers to heat water for cleaning, knife sterilisation, tripe washing, space heating and blood drying. The extent to which many plants out-source their meat transport and the general unavailability of company car fuel usage records has necessitated excluding these elements of energy consumption from the present evaluation.

Energy use in these respects is, however, almost certainly very minor compared to the main plant operating requirements. Based on energy usage records, throughputs and carcase yield, the study estimates abattoirs, cutting and packing plants are together consuming an average of around 0.63kWh (kilowatt hours) of energy per kilogram of beef and 0.54kWh per kilogram of sheep meat (Table 16).

Table 16: Beef and sheep processing plant energy consumption (kWh/kg)

	Average	Range
Beef	0.63	0.25 - 1.22
Sheep	0.54	0.35 - 0.89

Again, the study shows considerable variation in energy consumption between different plants resulting, amongst other things, from different levels of on and offsite chilling, different availabilities of mains gas, different data collection periods, different efficiencies of boilers, refrigeration and other equipment, and different processes.

Assuming 65% of this energy comes from electricity, 20% from gas and 15% from oil, Defra greenhouse gas emission conversion factors for 2010 suggest beef processing contributes around 0.27 kg CO2 eq per kg of meat, and sheep processing 0.23 kg CO2 equivalent (Table 17).

Table 17: Beef and sheep processing greenhouse gas emissions (kg CO2 eq/kg)*

	Average	Range
Beef	0.27	0.11 - 0.53
Sheep	0.23	0.15 - 0.38

* Defra 2010 conversions: kWh electricity x 0.544; kWh gas x 0.20; kWh oil x 0.25

Improvement opportunities

As well as highlighting inevitable plant type, system and operating differences, the considerable variation in water consumption, effluent production and energy use between different plants revealed by the study suggests considerable opportunities for improvement in environmental impact - improvements which offer significant cost savings alongside sustainability gains.

As in most cases of resource use improvement, better management almost invariably results from better monitoring.

Reducing water consumption

Notwithstanding the critical importance of maintaining first class hygiene standards throughout meat processing plants, there appears to be considerable scope for reducing water consumption by improving the efficiency with which it is used in most abattoirs, cutting and retail packing plants.

While only a handful of those participating in the study practised any form of water sub-metering within their plants, all the companies managing water consumption weekly by quantity have been able to demonstrate considerable cost savings in recent years. One company, indeed, quoted savings of more than £10,000 per annum through sub-metering and weekly investigation of anomalies.

A number of general and specific recommendations on action to reduce water consumption have been developed by WRAP as a foundation for improvement. These include improving particular aspects of:

- General site maintenance and operation
- Carcase washing
- Hand and apron washing

- Equipment sterilisers
- Machine and tray washing
- Site cleaning procedures
- Vehicle washing
- Lairage and gutroom practices
- Tripery practices.

Rainwater harvesting from roofs for vehicle cleaning, lairage and yard washing, and toilet flushing, can also play a valuable role in saving mains water.

Reducing effluent production

The close relationship between effluent volume and water use means the simplest way to reduce abattoir, cutting and packing plant effluent production is to use less water.

In addition, there is much that can be done to reduce the potency (BOD) of the effluent produced by on site treatment ahead of discharge. Reducing the amount of solids that go down the drain in the first place is an opportunity open to all sites that will make a major contribution to this through a whole host of good management practices.

Essentially, these involve doing everything possible to keep as much of the solid waste as possible - blood, gut contents and manure - away from the wash water, collecting and adding them either to the Category 1 waste skip for rendering or the Category 2 skip for composting.

Other practices that can help include leaving sufficient bleed-time, trapping and adequately containing all blood and scraps with drip pans and collection trays, cleaning spilt blood and debris from the plant floor thoroughly before washing down, utilising good blood collection, storage and processing systems, and manure collection and dry brushing before hosing out lairages. On-site biological treatment plants that convert soluble and colloidal materials into bio-solids in a variety of ways offer even greater opportunities for reducing both the volume and potency of plant effluent.

While such systems can be costly to put in place, they - and associated dewatering or anaerobic digestion units - have the potential to make considerable savings by transforming effluent into material that can be spread on land as a soil conditioner rather than disposed of to the sewers.

Reducing energy consumption

Energy is an area where substantial savings can be made in most businesses with no capital investment. Indeed, the Carbon Trust estimates immediate savings of up to 20% should be possible through simple management or system improvements.

Most obvious amongst these in meat processing plants are:

- Implementing switch-off programmes and installing sensors to turn off or power-down lights and equipment when not in use
- Improving insulation on heating and cooling equipment and pipework
- Insulating and covering scald tanks to minimise heat loss
- Recovering waste heat from effluent streams, vents, exhausts and compressors
- Maintaining leak-free compressed air systems
- Favouring more efficient equipment
- Maintaining equipment as well as possible
- Maintaining optimal combustion of boilers

- Eliminating system leaks
- Using external air for cooling when ambient temperatures are low enough.

With chillers accounting for up to 70% of electricity consumption in abattoirs, energysaving measures should clearly be focused on refrigeration in the first instance for maximum benefit.

Boilers and hot water systems should also be a major focus for energy efficiency improvement efforts.

Environmental Management Systems

A globally recognised Environmental Management System (EMS) such as ISO14001 provides an excellent basis for managing environmental activities in a comprehensive, systematic and welldocumented way.

EMS plans set a framework for more effective management of airborne pollutants (smells and noise), as well as energy, water and effluent, establish procedures for consistently monitoring key indicators and ways of improving performance against set targets.

As such they can be invaluable in reducing environmental impacts, cutting costs and providing evidence of compliance with environmental legislation and demonstrating commitment to investors, employees and the general public.



8. Action Plan Update

The tables below are updated from those included in Phase One of the roadmap, Change in the Air. Initially published in November 2009, this information was updated in November 2010. The aim is to ensure continuous monitoring of the benchmarks set out in the first roadmap.

Component	Action	Output	2008	2009	2020 target		
Performance Monitoring							
Beef efficiency	Undertaking an annual assessment of the weight of carcase produced per day of age across GB beef production bringing together BCMS age at slaughter data and carcase weights from EBLEX carcase classification reports.	An annual benchmark for the efficiency of beef output that can be tracked forward (and back) to provide the industry and producers with information on progress and targets against which to assess individual performance.	0.471 kg/d carcase wt (326 kg 692.51 days)	0.476 kg/d carcase wt (329 kg 691.4 days)	0.5 kg/d carcase wt		
Beef fertility	Undertaking an annual assessment of calves produced per cow per year from BCMS and/or Defra census data, broken down at least by dairy or beef herd origin.	An annual benchmark for beef fertility that can be tracked forward (and back) to provide the industry and producers with information on progress and targets against which to assess individual performance.	Calving interval 413.5 days (88.27 calves per 100 cows)	Data unavailable at time of print	Calving interval 392.4 days (95 calves per 100 cows)		
Lamb efficiency	Undertaking an annual assessment of the weight of lamb carcase produced per ewe per year from Defra census data and AHDBS carcase classification reports.	An annual benchmark for lamb production efficiency that can be tracked forward (and back) to provide the industry and producers with information on progress and targets against which to assess individual performance.	17.31 kg lamb carcase per ewe (270335 tonnes 1,5616 K ewes)	16.66 kg lamb carcase per ewe (248,423 t 1,491,200 ewes	18.00 kg lamb carcase per ewe		

Component	Action	Output	2008	2009	2020 target		
Performance Monitoring							
Ewe fertility	Undertake an annual assessment of ewe litter size from Defra census data.	An annual benchmark for lamb fertility that can be tracked forward (and back) to provide the industry and producers with information on progress and targets against which to assess individual performance.	117.8%	120.4%	125.7% (plus 7.5 lambs per 100 ewes)		
Beef and sheep unit performance	Extend the current costings scheme to include more herds and flocks for each production system to secure more accurate data on key aspects of physical performance.	Better benchmarks of more detailed performance measures across the range of production systems to track industry progress and provide targets for individual business performance assessment	284 beef 205 sheep	297 beef 188 sheep	310 beef 260 sheep		
Beef and sheep breeding progress	Undertake an annual evaluation of Signet Beefbreeder, ABRI breeds and Sheepbreeder genetic progress in key sire and maternal Estimated Breeding Values by breed.	An annual benchmark of the progress being made by beef and sheep breeders to track progress and highlight the potential for performance improvement currently available by using the best in breed.	5 year average to 2008 Suffolk 0.082 pts/yr Texel 6.81 I pts/yr Limousin 0.742 BV/ yr	5 year average to 2009 Suffolk 0.96 Texel 5.39 Limousin 0.710	5 year average to 2020 Suffolk 0.12 pts/yr Texel 10.0 pts/yr Limousin 1.1 BV/ yr		
National beef and sheep productivity	Establish an annual survey of the current productivity of beef and sheep systems, if feasible, involving a stratified sample representative of industries and utilising the sort of readily-available data pioneered in the EBLEX Snapshot tools.	An annual benchmark to anchor the detailed performance measures secured from the Beef and Sheep Costings scheme, allowing better assessments to be made of the productive efficiency of the national herd/flock and its components.	In progress	In progress	Annually update		

List of abbreviations

- BOD Biological Oxygen Demand
- CO2 eq Carbon Dioxide Equivalents
- COD Chemical Oxygen Demand
- DW Dead Weight
- EBV Estimated Breeding Value
- GHGs Greenhouse Gases
- GVA Gross Value Added
- GWP Global Warming Potential
- GWP100 Global Warming Potential, over 100 years
- KWh KiloWatt Hours
- LCA Life Cycle Analysis
- LW Live Weight
- MJ Mega Joules
- MLCSL Meat and Livestock Commission Commercial Services Ltd
- MT Mega Tonnes
- NVZ Nitrate Vulnerable Zone
- SSSI Site of Special Scientific Interest
- WRAP Waste & Resources Action Programme



EBLEX is the organisation for beef and sheep producers in England. It exists to enhance the profitability of the sector by helping the beef and sheep supply chain to be more efficient and adding value to the industry.



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