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Greenhouse Gas Emissions on Northern Ireland Dairy Farms

- A carbon footprint time series study

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Executive Summary

1. The UK Climate Change Act commits the UK to an 80% reduction in GHG emissions by 2050 from 1990 baseline levels. The UK GHG inventory charts annual emission levels from 1990 at the UK, regional, and sectoral levels. The inventory shows that by 2014, Northern Ireland reduced its emissions by 17.4% from 1990 levels whereas its agriculture sector achieved a 5.2% reduction.

2. In addition to the inventory, carbon footprints can be considered as a supplementary approach that typically present emissions per unit of product and thereby allow assessments at that level. These carbon footprints add to the knowledge on emissions and assist in developing appropriate reduction strategies for the associated sector.

3. A carbon footprint time series study for Northern Ireland's dairy farm sector was undertaken. Within this study, the BovIS Dairy Greenhouse Gas (GHG) calculator developed by the Agri-Food and Biosciences Institute (AFBI) was used to determine individual carbon footprints for those dairy farms within the Farm Business Survey (FBS). Following this, annual average carbon footprints for the NI dairy farm sector were determined for the years between 1990 and 2014.

4. Results from the carbon foot printing study show that while the agriculture sector has made relatively modest progress in reducing total Greenhouse Gas emissions (i.e. a reduction of 5.2% since 1990), dairy farming has made substantial progress in reducing its emissions on a per unit of production basis (i.e. a 30.7% reduction since 1990). The reason for this improvement is that Northern Ireland has experienced continual growth in its total milk production over the period (i.e. a 67% increase since 1990) which was driven primarily through increases in milk yield per cow. Therefore, this growth has spread the emissions burden associated with each dairy cow over a greater volume of production.

5. In terms of inter-farm variability, the emissions intensity of production for 2014 (i.e. the final year in the series) was found to vary between 0.91 and 2.06 kilograms of CO_{2e}/kg ECM (excluding sequestration.) with an average of 1.32. Furthermore, it was identified that the main factor causing variation in carbon footprint between the individual dairy farms was milk yield per cow. This factor was found to have an inverse relationship with carbon footprint levels.

6. Another factor identified as causing variation in carbon footprint levels between individual dairy farms was the proportion of their total stock that were lactating dairy cows. This factor was also found to have an inverse relationship with carbon footprint levels. The reasoning for this is that as the number of dairy replacements increases, both their associated costs and emissions have to be spread over the milk produced. This highlights the importance of minimising replacement rates and meeting target calving ages.

7. Finally, there will be factors unmeasured in this study that will influence carbon footprint levels via their impact on milk yields and herd replacement rates. These factors will include land quality, management capabilities and genetic potential of the herd.

1 Introduction

1.1 Background

In response to concerns about climate change there has been action by government to reduce greenhouse gas (GHG) emissions. In particular, the UK Climate Change Act commits the UK to an 80% reduction in GHG emissions by 2050 from the 1990 baseline levels. To assess progress against this target and allow effectiveness of mitigation strategies to be evaluated it is crucial that greenhouse gas emissions are accurately measured. In the main this requirement is fulfilled by the UK GHG Inventory which contains a single consistent time series on emissions going back to 1990. From the inventory, trends in overall emissions at the UK, regional, and sectoral levels can be assessed. In addition to the inventory, carbon footprints can be considered as a supplementary approach that typically present emissions per unit of product and thereby allow assessments at that level.

The latest results from the UK GHG inventory show that Northern Ireland's total GHG emissions were estimated to be 20.3 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in 2014, which accounts for 4% of total UK GHG emissions. Additionally, it showed that in 2014 agriculture was the largest GHG emitting sector in Northern Ireland and accounted for 28% of its total emissions. In comparing 2014 against the base year, Northern Ireland's agriculture sector had a 5.2% reduction in emissions whereas there was a 17.4% reduction across all its sectors. There are three main agricultural GHGs which are as follows; Nitrous Oxide (N_2O), Carbon Dioxide (CO_2) and Methane (CH_4).

Within the remainder of this report, a carbon footprint time series study for Northern Ireland's dairy farms is reported. It is hoped that this study will add to the knowledge on emissions from the agriculture sector and assist in developing appropriate reduction strategies for GHG emissions on dairy farms.

1.2 Objectives

The objectives of this carbon foot printing study were to:

- Estimate the average carbon footprints on Northern Ireland dairy farms for the years between 1990 and 2014.
- Identify the key physical and financial factors that influence carbon footprint levels on dairy farms.
- Allow benchmarking by presenting the average farm level characteristics of those farms in the 'top 25%', 'average' and 'bottom 25%' carbon footprint groups.

In fulfilling the above objectives, progress in terms of reducing GHG emissions per kilogram of milk is determined for the equivalent period as covered by the latest GHG inventory (i.e. 1990 to 2014). Additionally, the identification of key relationships between farm characteristics and carbon footprint levels will hopefully provide direction towards suitable strategies to reduce GHG emissions on dairy farms in Northern Ireland. Whereas, the provision of benchmarking results will allow individual farms to compare and contrast their own results.

1.3 Methodology

For the purposes of this carbon footprint time-series study, the BovIS Dairy Greenhouse Gas (GHG) calculator developed by the Agri-Food and Biosciences Institute (AFBI) was applied to determine carbon footprints for those dairy farms that participated in the Farm Business Survey (FBS). This involved the calculation of annual carbon footprints for all dairy farms in the FBS datasets between 1990 and 2014.

The BovIS Dairy GHG calculator developed by AFBI uses a life cycle assessment approach to determine carbon footprints for each dairy farm. The calculator takes account of all major on-farm emissions and a number of significant off-farm emissions that can be attributed to the dairy enterprise. Total emissions determined by the calculator are presented in terms of carbon dioxide equivalent per kilogram of energy corrected milk (CO_{2e}/kg ECM). The calculator has been assessed as meeting international standards (PAS 2050) and is available to producers through DAERA's online service.

The Farm Business Survey (FBS) is an annual survey that monitors the physical and financial performance of farms in Northern Ireland. It is conducted by CAP Policy, Economics and Statistics Division of the Department of Agriculture, Environment and Rural Affairs (DAERA). The FBS sample of farms is considered representative of the main types and sizes of farms in Northern Ireland. Farms are initially selected at random to join the survey and generally participate for many years. To determine individual carbon footprints for dairy farms that participated in the FBS, the associated farm data were run through the Dairy Systems GHG calculator.

Following the calculation of carbon footprints for the individual FBS farms, the data was weighted to estimate an average carbon footprint for all Northern Ireland dairy farms. The outcome of this exercise is an average carbon footprint value for each year between 1990 and 2014. In terms of the weighting a number of approaches were investigated. These involved stratifying the FBS sample results by either herd size (cows), milk sales per cow, or stocking density and then applying the associated population weights. From this it was identified that weighting by stocking density had almost no impact on the sample average and therefore was given no further consideration. Weighting by milk sales per cow or herd size resulted in annual average values that although different from the unweighted average were very similar to each other. Given this finding, and the fact that population numbers by herd size were more readily available, weighting by herd size (cows) was selected based on four strata (<40, 40-<70, 70-<100, 100+).

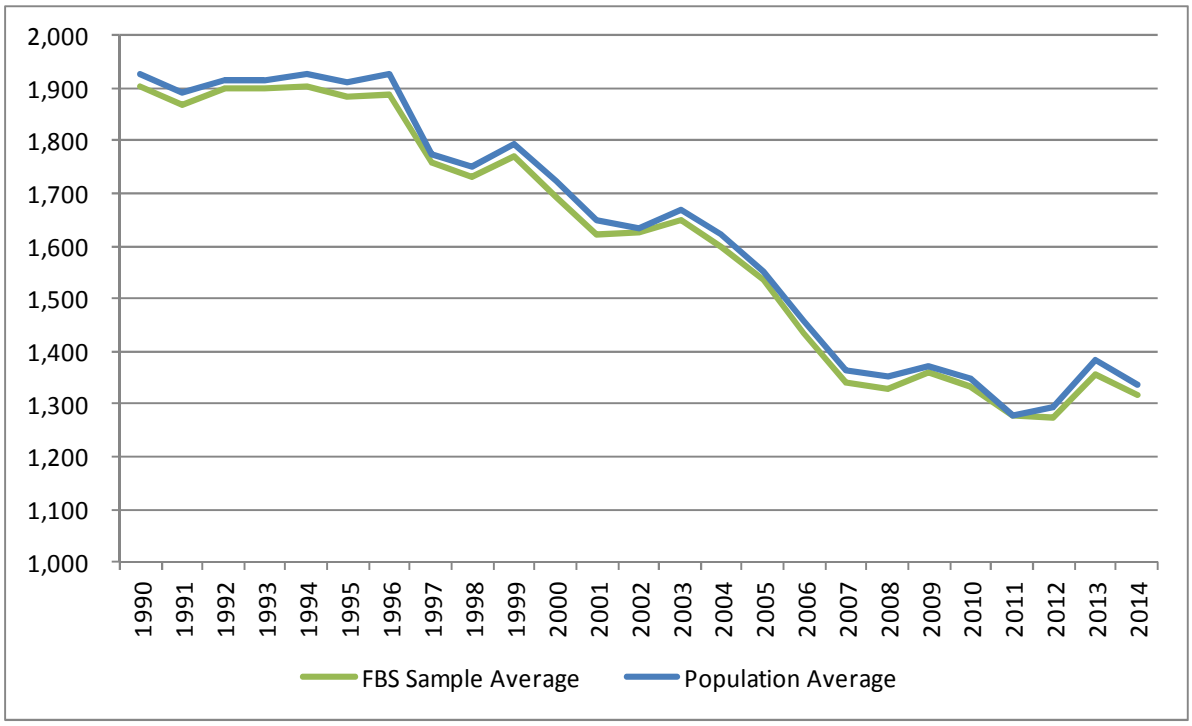
Finally, in addition to calculating Northern Ireland annual average carbon footprints a number of statistical analyses were completed. Firstly, linear regressions were undertaken to investigate the relationships between carbon footprint levels and various characteristics of the associated dairy farms. To check for consistency over time, the regression analyses were repeated on the FBS results for the final five years (2010-2014) in the series. Secondly, the FBS dairy farms were ranked on the basis of their carbon footprint with average farm level characteristics subsequently calculated for those in the 'top 25%', 'average' and 'bottom 25%' carbon footprint groups.

2 Results

2.1 Average greenhouse gas emissions on Northern Ireland dairy farms

Within Figure 1, the unweighted (i.e. FBS Sample Average) and weighted (i.e. Population Average) carbon footprints for the years between 1990 and 2014 are shown. In both cases the carbon footprints refer to the total emissions (excluding sequestration) related to milk production as measured by grams of carbon dioxide equivalent per kilogram of energy corrected milk (CO_{2e}/kg ECM). As can be seen the weighted carbon footprints are very similar to the unweighted carbon footprints. Nevertheless, to account for any potential sampling issues it was considered necessary to apply weighting in this study. From this point onwards, reference will only be made to the weighted carbon footprints.

Figure 1: Emissions intensity of milk production (g CO_{2e}/kg ECM (excl. Seq.))



As shown by figure 1, the average carbon footprint (excluding sequestration) in 2014 was 1,336 grams of carbon dioxide equivalent per kilogram of energy corrected milk (CO_{2e}/kg ECM). This represents a 30.7% decrease from the average carbon footprint of 1990 and compares favourably with the 5.2% decrease in emissions over a similar period as reported for the Northern Ireland agriculture sector by the UK Greenhouse Gas Inventory. Overall, this illustrates that while modest progress has been made in reducing emissions within the agricultural sector, substantial progress has been made within the dairying sector in reducing emissions on a per kilogram ECM basis. This partly reflects the fact that while milk production in the dairy sector has expanded by 67% since 1990, the total number of dairy cows over this period has remained relatively static (see figure 2). This increase in milk production can therefore be attributed to substantial increases in milk yield per cow. This is supported by the Farm Business Survey results in figure 3 which shows increases of 42% in milk yield and 157% in concentrate usage between 1990 and 2014.

Figure 2: Dairy cows and milk production in Northern Ireland, 1990-2014

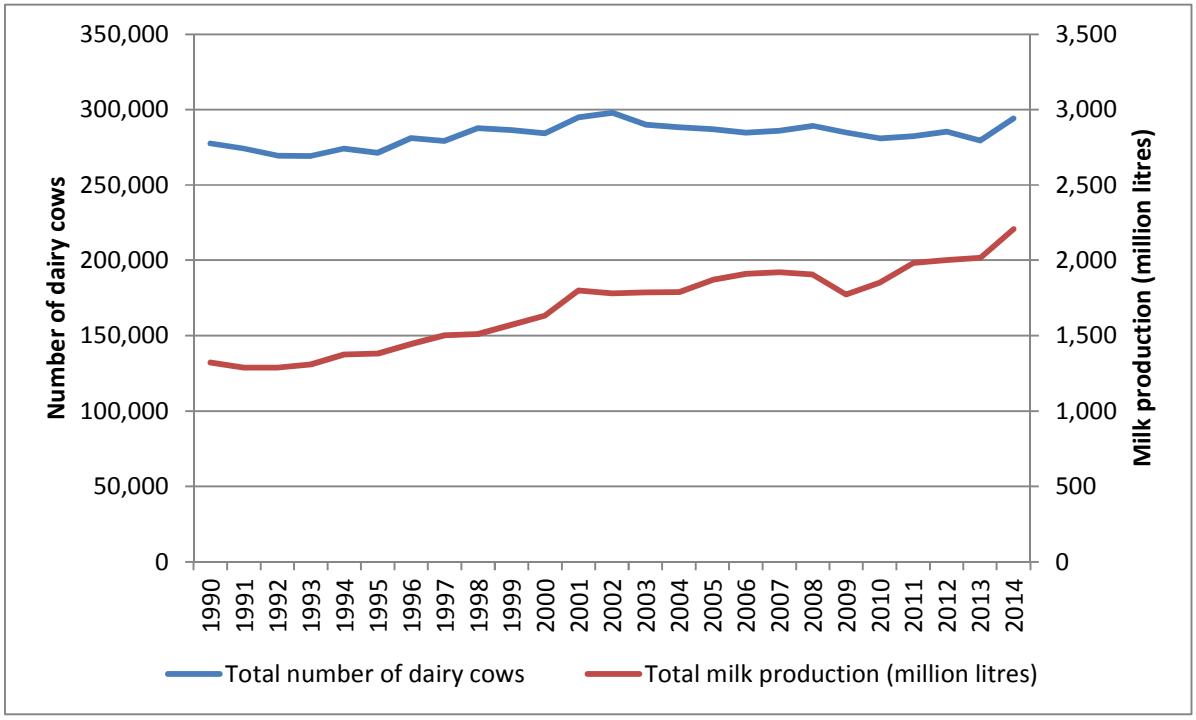
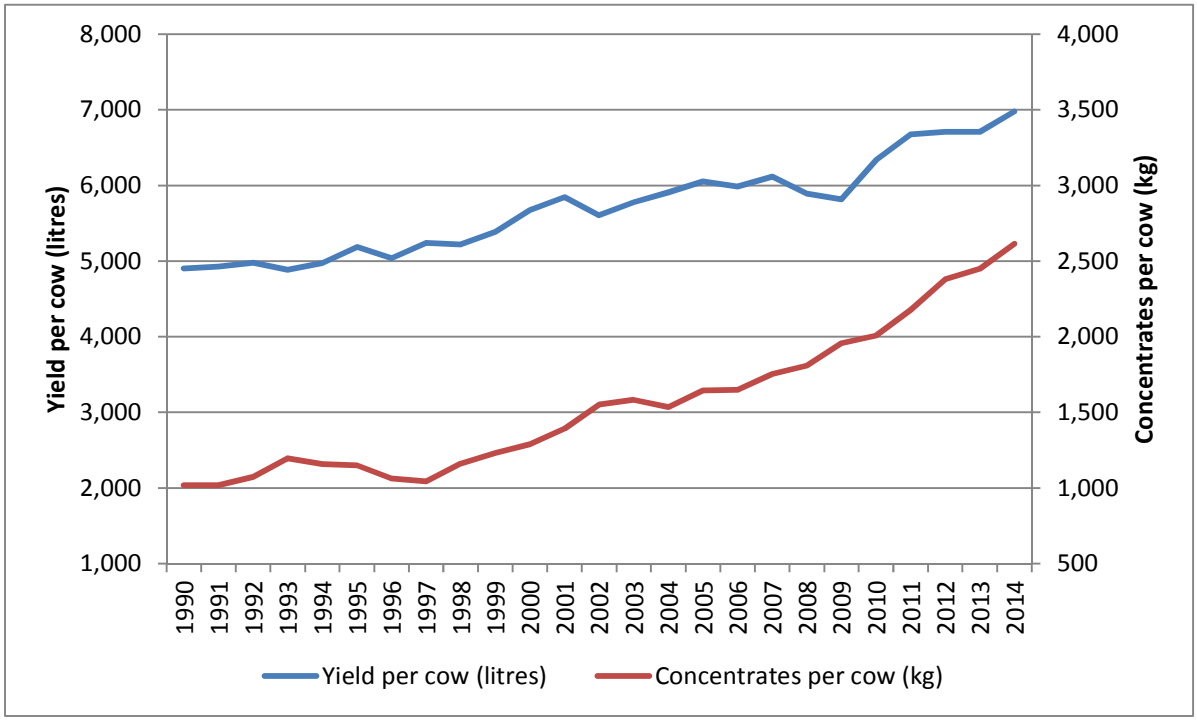


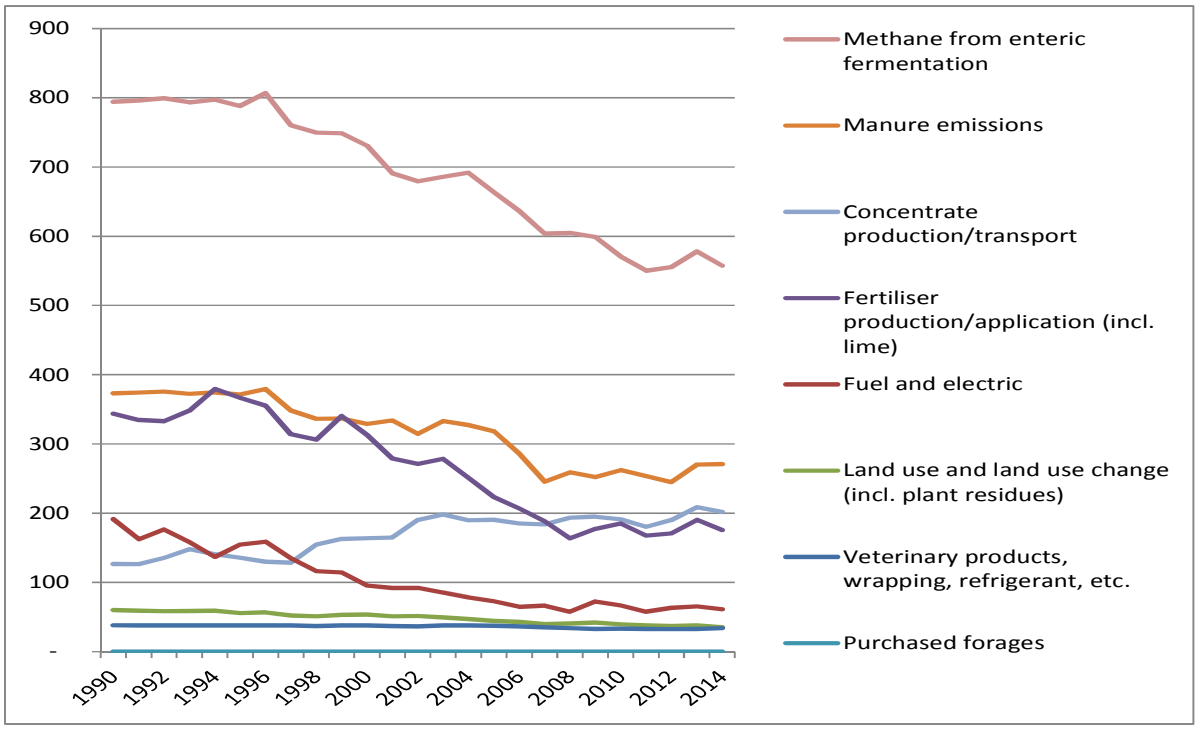
Figure 3: Average milk yield and concentrate usage per cow on Farm Business Survey farms, 1990-2014



2.2 Sources of greenhouse gas emissions on Northern Ireland dairy farms

Figure 4 shows the contributions that each source of emissions makes to the overall weighted average carbon footprints (excluding sequestration) that were calculated for the years between 1990 and 2014. This shows that for each source of emissions with the exception of 'concentrate production/transport' there have been a gradual reduction in their emission contributions over the period. The increase in emissions contributed by concentrate production/transport can be attributed to the increased concentrate usage over the period as was shown in figure 3. When expressed on a per litre basis, results from the Farm Business Survey show that concentrate usage increased from 0.21 kilograms in 1990 to 0.37 kilograms in 2014.

Figure 4: Emissions intensity of milk production broken down by source (g CO_{2e}/kg ECM (excl. Seq.))



As shown in figure 4, the main changes in emissions by source between 1990 and 2014 are as follows:

Reductions:

- Methane from enteric fermentation emissions decreased from 794 grams in 1990 to 557 grams in 2014 (i.e. a reduction of 237 grams or 30%)
- Fertiliser production/application (incl. lime) emissions decreased from 344 grams in 1990 to 176 grams in 2014 (i.e. a reduction of 168 grams or 49%)
- Fuel & electric emissions decreased from 191 grams in 1990 to 61 grams in 2014 (i.e. a reduction of 130 grams or 68%)
- Manure emissions decreased from 373 grams in 1990 to 271 grams in 2014 (i.e. a reduction of 102 grams or 27%)

Increases:

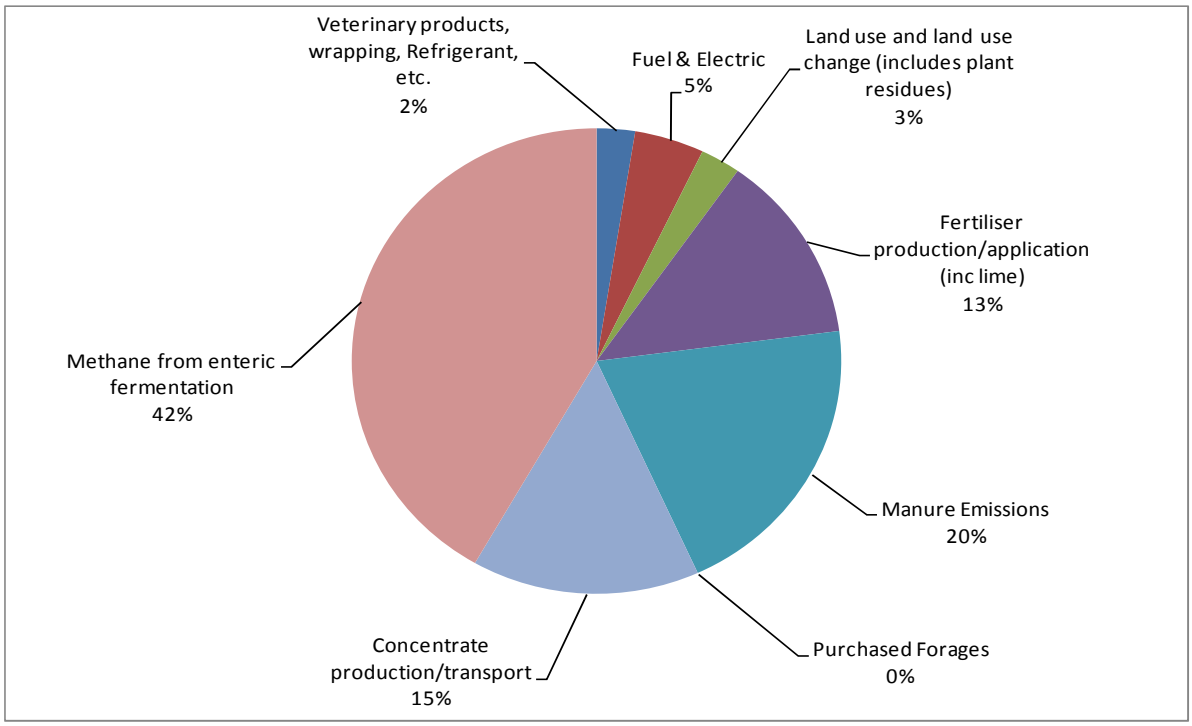
- Concentrate production / transport emissions increased from 127 grams in 1990 to 202 grams in 2014 (i.e. an increase of 75 grams or 59%)

Figure 5 shows the percentage contributions that each source of emissions makes to the overall weighted average carbon footprint (excluding sequestration) that was calculated for 2014. The three largest contributing sources account for 79% of total emissions and their individual contributions are as follows:

- Methane from enteric fermentation emissions (42% of total emissions)
- Manure emissions (20% of total emissions)
- Concentrates production / transport emissions (15% of total emissions)

In comparison, the three largest contributing sources back in 1990 were methane from enteric fermentation emissions (41% of total emissions), manure emissions (19% of total emissions) and fertiliser production/application emissions (18% of total emissions). In total these three sources contributed 78% of total emissions in 1990.

Figure 5: Emissions intensity of milk production broken down by source, 2014



Overall, when considering the percentage contributions by each source of emissions there have been three key changes between 1990 and 2014. These are as follows:

- Concentrates production / transport emissions **increased** from 7% of total emissions in 1990 to 15% of total emissions in 2014 (i.e. an increase of 8 percentage points)
- Fertiliser production/application (incl. lime) emissions **decreased** from 18% of total emissions in 1990 to 13% of total emissions in 2014 (i.e. a reduction of 5 percentage points)
- Fuel & electric emissions **decreased** from 10% of total emissions in 1990 to 5% of total emissions in 2014 (i.e. a reduction of 5 percentage points)

2.3 Relationships between carbon footprints and farm characteristics

In this section, results from the linear regressions undertaken are presented. These regressions were undertaken to investigate the relationships between carbon footprint levels and various characteristics of the associated dairy farms. To check for consistency over time, these regression analyses were repeated on the Farm Business Survey results for each of the latest five years (2010-2014). Given that relationships were found to be fairly consistent over time only those results for the most recent year (2014) will be presented.

Within the linear regressions, the R-squared value (coefficient of determination) was estimated. This value indicates the proportion of variation in the dependent variable (i.e. carbon footprint) that is determined by value of the independent variable (e.g. milk yield). The higher the R-squared value, the more that carbon footprint is determined by the other variable involved. R-Squared values vary between 0 (i.e. no relationship) and 1 (i.e. perfect fit).

In addition to considering the R-squared values, the relationships were also tested for statistical significance. Within this, P-values were determined with the 90%, 95% and 99% levels considered for statistical significance.

2.3.1 Relationships between carbon footprints and physical characteristics

Linear regression analyses were undertaken to investigate the relationships between carbon footprint levels (kg CO_{2e}/kg ECM (excl. Seq.)) and the following physical characteristics of the associated 109 dairy farms in the Farm Business Survey sample:

- Fertiliser application rate (kilograms per hectare) - total, nitrogen, phosphorous and phosphate application rates were considered separately.
- Stocking rate (cow equivalents per hectare)
- Average number of dairy cows (head)
- Milk sales (litres)
- Milk yield (litres per cow)
- Concentrate usage (kilograms per litre)
- Concentrate usage (kilograms per cow)
- Dairy cow equivalents (as a proportion of total cow equivalents on the farm)

From the regression analyses undertaken it was deemed that milk yield (litres per cow) and cow equivalents of dairy cow equivalents (as a proportion of total cow equivalents on the farm) were the only physical characteristics from the above list that had any discernible relationship with the carbon footprint. These relationships are shown in figure 6 (milk yield) and figure 7 (cow equivalent of dairy cows).

Figure 6 firstly indicates that 43.2% of the variation in carbon footprint levels can be explained by variations in milk yield (litres per cow) when these factors are considered in isolation. Secondly, it indicates that the relationship is significant at the 99% level. Thirdly, the fitted line clearly indicates an inverse relationship between milk yield per cow and carbon footprint i.e. as milk yield increases, there are more litres to spread the emissions over.

Figure 6 - Carbon footprint and milk yield, 2014

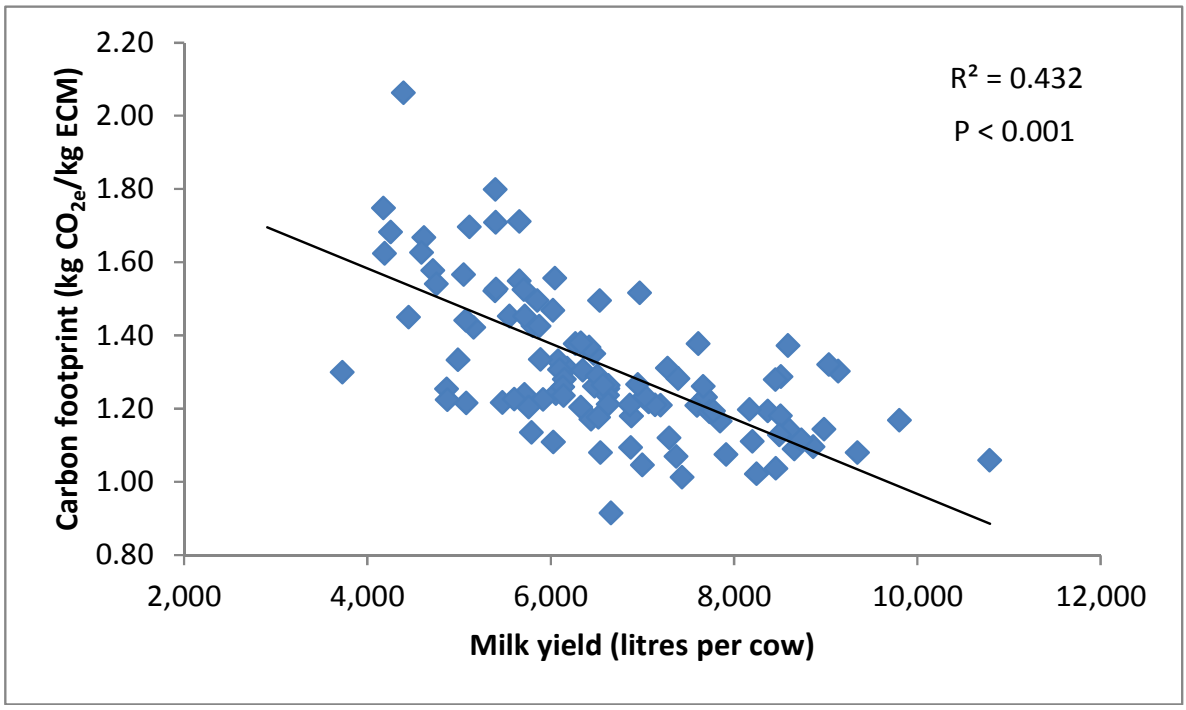
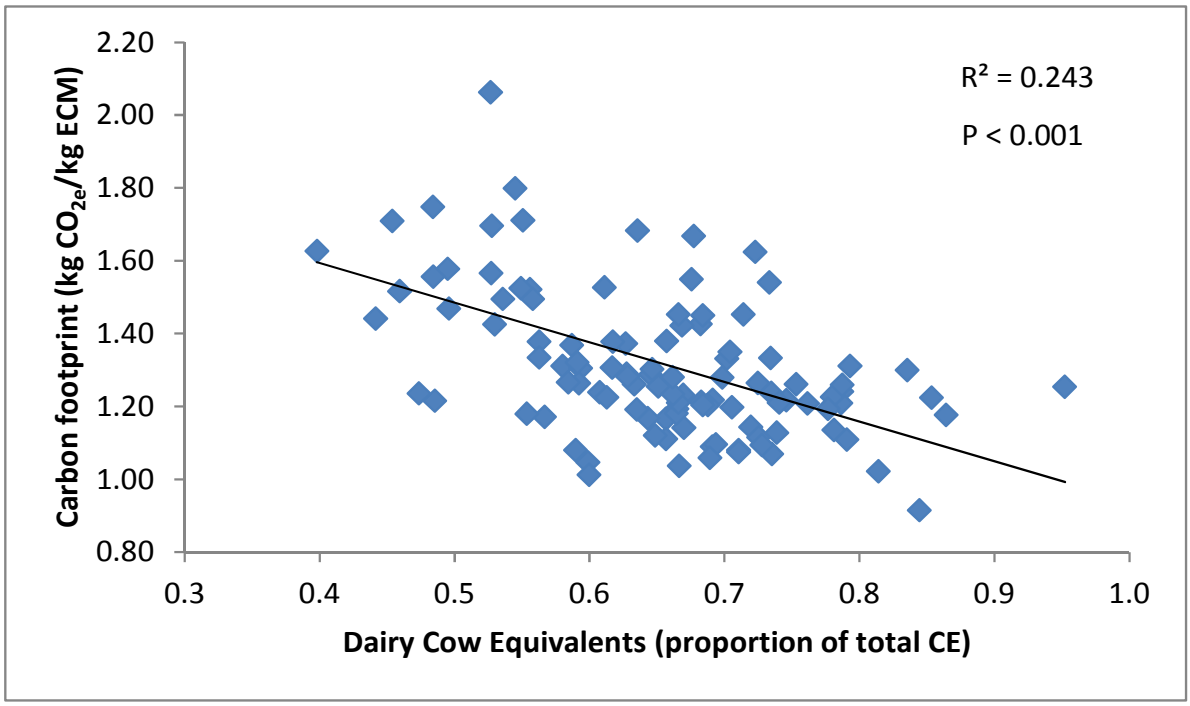


Figure 7 firstly indicates that when considered in isolation, 24.3% of the variation in carbon footprint levels can be explained by variation in the proportion of total cow equivalents that are lactating dairy cows. Secondly, it indicates that the relationship is significant at the 99% level. Thirdly, the fitted line clearly indicates an inverse relationship between proportion of total cow equivalents that are dairy cows and carbon footprint e.g. as the number of dairy replacements increases, their associated emissions also have to be spread over the milk produced.

Figure 7 - Carbon footprint and dairy cow equivalent proportion, 2014



2.3.2 Relationships between carbon footprints and financial characteristics

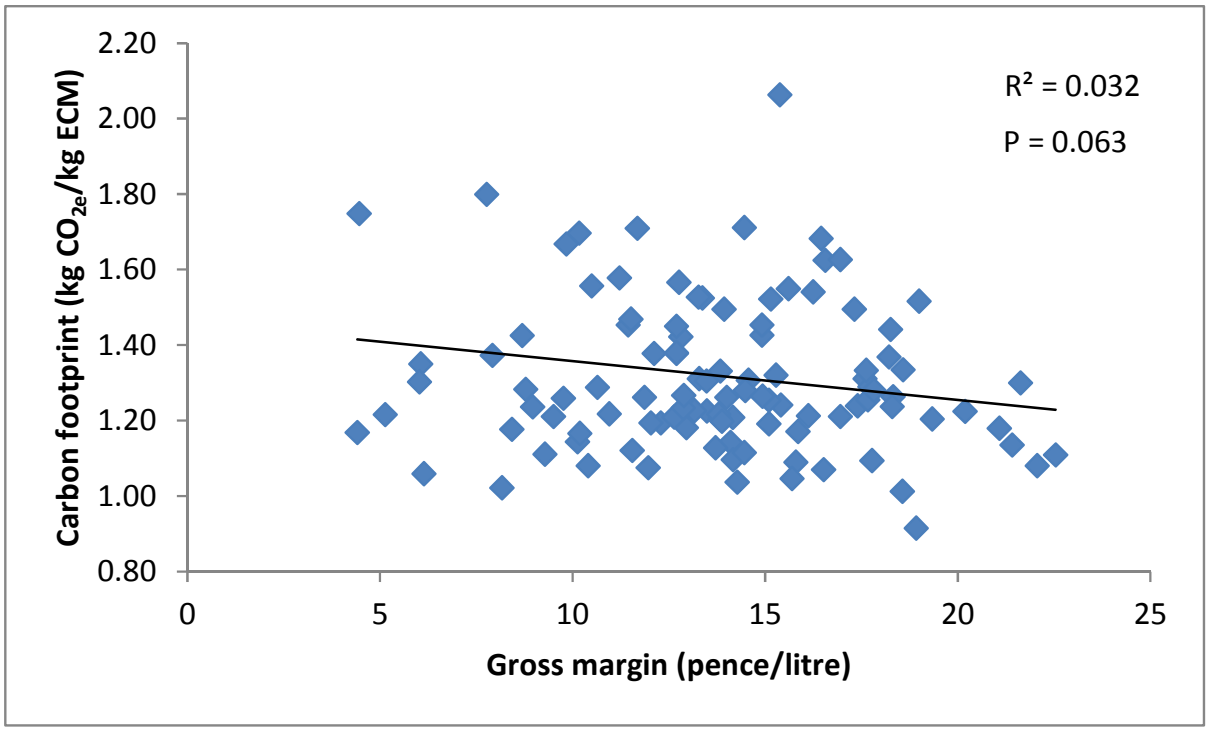
Linear regression analyses were undertaken to investigate the relationships between carbon footprint levels (kg CO_{2e}/kg ECM (excl. Seq.)) and the following financial characteristics of the associated 109 dairy farms in the Farm Business Survey sample:

- Output
- Concentrate costs
- Hay, silage & grazing costs
- Total variable costs
- Gross Margin

(All of the above financial variables are expressed on a pence per litre basis).

From the regression analyses undertaken it was deemed that none of the above financial characteristics have a discernible relationship with the carbon footprint. For example, figure 8 indicates a very poor relationship between carbon footprint and gross margin. The R-squared value indicates that only 3.2% of the variation in carbon footprint levels can be explained by variations in gross margins. Also, the relationship is only significant at the 90% level. In summary, there is almost no relationship between carbon footprint and gross margin.

Figure 8 - Carbon footprint and gross margin, 2014



2.4 Benchmarking carbon footprint levels per farm in 2014

To facilitate benchmarking the average farm level characteristics of those Farm Business Survey (FBS) dairy farms in the 'top 25%', 'average' and 'bottom 25%' carbon footprint groups are presented within this section. These averages were determined by ranking the 109 FBS dairy farms from the 2014 year on the basis of their carbon footprint with unweighted average farm level characteristics subsequently calculated for each of the aforementioned carbon footprint groups.

Table 1 presents the average farm level physical characteristics of those farms in the 'top 25%', 'average' and 'bottom 25%' carbon footprint group. In addition, for each physical characteristic the percentage difference between those in the top and bottom carbon footprint groups is shown.

In comparing the 'top 25%' and 'bottom 25%' in table 1, it can be seen that the 'top 25%' are on average larger dairying businesses with higher milk yields and stocking densities. Associated with this, they also have higher levels of concentrate usage per cow and apply more fertiliser per hectare.

Table 1 – Average farm level physical characteristics (2014)[1]

	2014 All Farms	2014 Top 25%	2014 Bottom 25%	2014 % Difference
Number of farms	109	27	27	-
GHG Emissions (kg CO2e/kg ECM)	1.32	1.10	1.63	-32%
Adjusted forage area (ha per farm)	80.1	88.2	70.0	26%
Average number of dairy cows (per farm)	109.1	140.9	72.4	95%
Milk yield per cow (litres)	6578	7863	5170	52%
Total milk production (litres)	780867	1185619	371292	219%
Summer milk (%)	51%	50%	54%	-8%
Concentrates per cow (kg)	2301	2655	1824	46%
Concentrates per litre (kg)	0.34	0.33	0.35	-8%
Stocking Rate (cow equivalents per ha)	2.10	2.27	2.00	14%
Nitrogen used per hectare (kg)	154	177	125	42%
Cow equivalents-dairy cows (Q)	110	142	73	94%
Cow equivalents-other (Q)[2]	59	62	60	4%

1. Averages are across the associated characteristic result calculated for each farm in the group.
2. 'Cow equivalents-other (Q)' also includes those cow equivalents of any beef and sheep enterprises on the farm. For the purposes of calculating a carbon footprint for milk, the details associated with these enterprises have been excluded.

Table 2 presents the average financial results per cow for those farms in the 'top 25%', 'average' and 'bottom 25%' carbon footprint group. In addition, for each financial variable it presents the percentage difference between those in the top and bottom carbon footprint groups. In comparing the 'top 25%' and 'bottom 25%' groups, it can be seen that those in the 'top 25%' had output, variable cost and gross margin values per cow that were around 53-54% higher than the 'bottom 25%' group. This links in with the milk yields figures that were shown to be 52% higher for the 'top 25%' group (see table 1).

Table 2 – Average financial results per cow, 2014[1]

	2014 All Farms	2014 Top 25%	2014 Bottom 25%	2014 % Difference
Number of farms	109	27	27	0%
GHG Emissions (kg CO2e/kg ECM)	1.32	1.10	1.63	-32%
Milk (£ per cow)	1858	2229	1463	52%
Calves (£ per cow)	100	103	94	9%
Herd replacement (£ per cow)	-173	-194	-167	16%
Total Enterprise Output (£ per cow)	1785	2139	1390	54%
Concentrates (£ per cow)	556	662	433	53%
Other purchased feed (£ per cow)	20	25	12	112%
Hay, silage, forage and grazing (£ per cow)	180	211	143	47%
Sundries (£ per cow)	85	109	67	64%
Vet and medicines (£ per cow)	52	64	39	62%
Total Variable Costs (£ per cow)	893	1071	694	54%
Gross Margin (£ per cow)	893	1068	696	53%

1. Averages are across the associated financial result calculated for each farm in the group.

Table 3 presents the average financial results per litre for those farms in the 'top 25%', 'average' and 'bottom 25%' carbon footprint group. In contracting these per litre results with the per cow results presented in table 2 it can be determined that for 2014, both calf returns and herd replacement costs are higher per cow but lower per litre for the 'top 25%' group. Also, it can be concluded that replacement cost is the main factor causing the 6% difference in gross margin per litre between the 'top 25%' and 'bottom 25%' groups i.e. the results are suggesting an inverse relationship between milk yields and herd replacement costs per litre that ultimately results in a higher gross margin per litre.

Table 3 – Average financial results per litre, 2014[1]

	2014 All Farms	2014 Top 25%	2014 Bottom 25%	2014 % Difference
Number of farms	109	27	27	0%
GHG Emissions (kg CO2e/kg ECM)	1.32	1.10	1.63	-32%
Milk (p/litre)	28.24	28.44	28.21	1%
Calves (p/litre)	1.59	1.32	1.86	-29%
Herd replacement (p/litre)	-2.70	-2.41	-3.35	-28%
Total Enterprise Output (p/litre)	27.13	27.36	26.72	2%
Concentrates (p/litre)	8.26	8.08	8.35	-3%
Other purchased feed (p/litre)	0.29	0.32	0.23	35%
Hay, silage, forage and grazing (p/litre)	2.76	2.67	2.81	-5%
Sundries (p/litre)	1.28	1.37	1.28	7%
Vet and medicines (p/litre)	0.79	0.82	0.77	6%
Total Variable Costs (p/litre)	13.37	13.26	13.44	-1%
Gross Margin (p/litre)	13.76	14.10	13.28	6%

1. Averages are across the values of associated characteristic for each farm in the group.

3 Conclusions

This carbon foot printing study has shown that while the agriculture sector has made relatively modest progress in reducing total Greenhouse Gas emissions (i.e. a reduction of 5.2% since 1990), dairy farming (the only sector for which carbon intensity has been estimated) has made substantial progress in reducing its emissions on a per unit of production basis (i.e. a 30.7% reduction since 1990). The reason for this improvement is that Northern Ireland has experienced continued growth in total milk production (i.e. a 67% increase since 1990) which was driven primarily through increases in milk yield per cow. Therefore, this growth has spread the emissions burden associated with each dairy cow over more units of production. This has been counteracted to a certain extent by increased concentrate production / transport emissions associated with the higher concentrate usage which contributed to the growth in milk yields over the period.

In terms of inter-farm variability, the emissions intensity of production for the 109 Farm Business Survey dairy farms in 2014 was found to vary between 0.91 and 2.06 kg CO_{2e}/kg ECM (excl. Sequestration) with an average of 1.32. It was identified that the main factor causing variation in carbon footprint between the individual dairy farms was milk yield per cow. This factor was found to have an inverse relationship with carbon footprint. However, it was found that concentrate usage when expressed on either a 'per cow' or 'per litre' basis has no discernible relationship with carbon footprint levels. This therefore suggests that while increased concentrate usage has led to increases in average milk yields since 1990 it is not directly responsible for inter-farm variability in carbon footprint levels.

Another factor identified as causing variation in carbon footprint levels between individual dairy farms is the proportion of total cow equivalents that are lactating dairy cows. This factor was also found to have an inverse relationship with carbon footprint. The reasoning for this is that as the number of dairy replacements increases, their associated emissions also have to be spread over the milk produced. This highlights the importance of minimising the replacement rate and meeting target calving ages. Furthermore, it was deemed that replacement costs per litre can be lowered through higher yields.

Finally, there will be factors unmeasured in this study that will influence carbon footprint levels via their impact on milk yields and herd replacement rates. These factors will include land quality, management capabilities and genetic potential of the herd.

Glossary

AFBI – Agri-Food & Biosciences Institute

Benchmarking - the widely accepted term used when comparing the performance of individual businesses against standards of performance set for their industrial sectors.

Carbon dioxide equivalents (CO_{2e}) - a standard unit for measuring greenhouse gases emissions. It allows comparison of the various greenhouse gases based upon their global warming potential.

Carbon footprint -The amount of greenhouse gases produced by a particular activity or for the production of a particular entity.

Coefficient of determination - indicates the proportion of the variance in the dependent variable that is predictable from the independent variable. Referred to as the R-Squared.

DAERA - Department of Agriculture, Environment and Rural Affairs, Northern Ireland.

Dairy cow equivalents - is a mechanism for converting different categories of grazing livestock to a common denominator, in this case a dairy cow. Coefficients for the conversion of different categories of grazing livestock to cow equivalents are as follows: dairy cow = 1.0; beef cow = 0.8; breeding bull = 1.0; cattle over 2 years old = 0.8; cattle 1 to 2 years = 0.6; cattle under one year = 0.4; breeding ewe and lambs = 0.2; breeding ram = 0.2; lambs six months to 1 year = 0.1; other sheep over 1 year = 0.2.

Emissions intensity - average emissions released per unit of activity e.g. GHG emissions per litre of milk.

Energy corrected milk (ECM) - determines the amount of milk produced when adjusted to 3.5% butterfat and 3.2% protein.

Enteric fermentation - fermentation that takes place in the digestive systems of animals. Methane is produced in the rumen as a by-product of this process.

Farm Business Survey (FBS) - an annual survey that monitors the physical and financial performance of farms in Northern Ireland. The FBS is undertaken by DAERA.

Greenhouse Gases (GHG) – gases that absorb and emit heat and contribute to global warming e.g. carbon dioxide.

Gross margin - of an enterprise is its enterprise output less its variable costs.

Life cycle analysis – approach to assess emissions from the life cycle stages of a product.

Linear regressions - an approach to model the relationship between two variables by fitting a linear equation to observed data i.e. it models the relationship between a dependent variable and an independent variable.

PAS 2050 - Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

Population average - estimated average of all values in the population e.g. the average carbon footprint for all dairy farms in Northern Ireland.

P-value - used to determine the statistical significance of a relationship. In regression analysis it is used to determine whether a relationship is different from zero.

R-squared value - indicates the proportion of the variance in the dependent variable that is predictable from the independent variable. It is the coefficient of determination.

Sample average - is the average values for a specific variable as found by a sample. It is calculated by summing the values of each case and dividing by the number of cases.

Sequestration - process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form. Within agriculture, plants and soil sequester carbon as part of a natural process.

Statistical Significance - a statistically significant result is one that's not attributed to chance

UK GHG Inventory - a consistent time series of UK greenhouse gas emissions from 1990 onwards.

Unweighted average - during its calculation, the importance of individual cases is not accounted for i.e. they are considered equal.

Weighted average - an average calculated by multiplying the value for each case by an associated factor reflecting their importance.