Teagasc National Farm Survey 2017 Sustainability Report

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Abbreviations

CH_4	Methane
CO_2	Carbon dioxide
CSO	Central Statistics Office
ESD	EU Effort Sharing Decision
FPCM	Fat and protein corrected milk
GHG	Greenhouse gases
GM	Gross Margin
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Analysis
N	Nitrogen
NH_3	Ammonia
N_2O	Nitrous oxide
NFS	National Farm Survey
NUE	Nitrogen use efficiency
P	Phosphorus

1. Introduction - Agricultural Sustainability

Globally, we face the grand challenge of trying to feed a growing human population while attempting to cope with and minimise the environmental impacts of food production, especially in the context of climate change, water quality and biodiversity loss. Agricultural production must be both intensive and sustainable if these twin objectives are to be achieved simultaneously. To feed a growing global population, agricultural output must be increased without impacting on the capacity for future production or compromising the environment.

Agricultural systems are complex and tend to have multiple goals and wide-reaching effects which must be considered in unison. To measure and track the diverse components of a farm system, this report considers Irish agricultural production (and its component farm systems) in terms of its economic, environmental and social sustainability. Additionally, it evaluates Irish farmers' adoption of innovations, which will be central in driving the sector towards increased sustainability as well as productivity.

2. Measuring Farm Level Sustainability

The measurement of agricultural sustainability is challenging, as it is a broad concept covering diverse areas which may vary through time and space. As such, relevant indicators are used to assess the sustainability status of Irish farms. Such metrics can highlight particular areas of concern or trends through time and indicate areas where improvement may be needed.

Deriving a sustainability indicator set is difficult, as it requires detailed, accurate and consistent farm-level data across a wide range of attributes. The Teagasc National Farm Survey (NFS) provides such a dataset. The NFS is a representative sample of almost 900 farms across Ireland[1]. The survey collects data on an annual basis, with farms weighted so that nationwide representation is given in terms of size and farm type for the principal farm systems in Ireland. Indicators are derived from the NFS at farm level. This is important to ensure that aggregations can be made at an appropriate scale (for example, based on farm system type), and are capable of highlighting potential links or trade-offs between different indicators, depending on how individual farms are managed.

The Teagasc NFS is based on a nationally representative random sample which is selected annually in conjunction with the Central Statistics Office (CSO). Each farm is assigned a weighting factor so that the results of the survey are representative of the national population of farms (92,720 farms are represented by the Teagasc NFS in the 2017). Within the Teagasc NFS, farms are classified into major farming systems according to the standardised EU typology as set down by EU Commission regulation and applied by the EU Farm Accountancy Data Network (a more detailed explanation can be found in the Teagasc National farm report by Dillon et al., 2017a). This report displays results for the four dominant farm systems in Ireland, namely, dairy, cattle, sheep and tillage.

As the appropriate data are collected on an annual basis, it is possible to generate and compare indicators over time, even as methodologies are updated and data requirements

[1] The Teagasc NFS sampling frame is restricted to farms over €8,000 of standard output (equivalent to 6 dairy cows, 6 hectares of wheat or 14 suckler cows). A total of 92,720 farms are represented by the Teagasc NFS in the 2017. A small farm survey is conducted periodically to assess position on smaller farms (Dillon et al., 2017b).

evolve accordingly. This is demonstrated through a time-series analysis for a number of key indicators presented in this report. It is expected that based on scientific advances and emerging areas of interest, the indicator set will continue to evolve, remaining informative and relevant. Our aim is that as indicator methodologies develop, they will still be capable of being generated using Teagasc NFS data, ensuring the on-going inter-temporal assessment of the sustainability performance of Irish farm systems. Furthermore, as the NFS is part of the EU Farm Accountancy Data Network (FADN) there is scope for comparative analysis with other EU Member States.

3. Description of Sustainability Indicators

The indicators described here follow on from previous sustainability reports (Hennessy et al., 2013; Lynch et al., 2016a), with some updates based on methodological refinements. As described above, the indicators are grouped into four categories: **economic, environmental, social** and **innovation**.

3.1 Economic Indicators

Economic viability is essential to ensure that a farm system can sustain itself and that farming families are adequately compensated for their owned capital and labour. At a national level, agriculture is an important component of the Irish economy. The NFS is equipped to generate economic indicators, which are also submitted to FADN. As such financial and technical data are reported on an annual basis. The economic sustainability indicator set is therefore relatively unconstrained by issues relating to data availability and is designed to cover a range of important economic measures. The following economic indicators are presented in the report:

a) Economic Return to Land

The economic productivity of land is measured as gross output (€) per hectare of utilised agricultural area. Gross output is defined as total sales less purchase of livestock & crops, plus value of farm produce used in the household plus receipts for hire work, service fees etc. It also includes net change in inventory which for cows, cattle and sheep is calculated as the change in numbers valued at closing inventory prices. All non-capital grants, subsidies and premium payments are also included, as are income from land and quota lettings. Inter-enterprise transfers are then deducted so as to avoid double counting.

b) Profitability of Land

The profitability of a farm is measured as market based gross margin (gross margin excluding grants and subsidies, where gross margin is defined as gross output less direct costs) per hectare.

c) Productivity of Labour

In the NFS a distinction is made between family labour, which is generally unpaid, and hired labour, which in accounting terms represents a production cost to the farm. The return on unpaid farm labour is measured as family farm income per unpaid family labour unit. For consistency across the EU, a labour unit is defined as a person over 18 years old, working at least 1,800 hours a year (it is not possible to report in excess of one labour unit even where an individual works more than this). Labour unit equivalents of 0.75 and 0.5 are used for individuals aged from 16-18 and 14-16 years respectively.

d) Economic Viability

The economic viability of a farm business is measured by a binary variable, where a farm is defined as viable if family labour is remunerated at greater than or equal to the minimum wage and there is sufficient income to provide an additional five per cent return on non-land based assets employed on the farm.

e) Market Orientation

The market orientation is measured as the proportion of total output (€) that is derived from the market (generally the sales value of the farm's outputs), as opposed to grants and subsidies, which are treated as a non-market based output of the farm.

Table 1: Overview of Economic Indicators

Indicator	*Measure*	*Unit*
Economic return to land	Gross output per hectare	€ / hectare
Profitability	Market based gross margin per hectare	€ / hectare
Productivity of Labour	Family Farm Income per unpaid labour unit	€ / unpaid labour unit
Economic Viability	Economic viability of farm business	1=viable, 0=not viable
Market Orientation	Output derived from market rather than subsidies	%

3.2 Environmental Indicators

Agriculture can generate positive or negative environmental impacts depending on the specific activities undertaken on the farm. Agriculture is the principal land use in Ireland; hence environmental sustainability in agriculture is key to achieving national level objectives. The current set of NFS based environmental indicators focus on greenhouse gas (GHG) emissions, ammonia emissions, nitrogen and phosphorus use efficiency.

1. Greenhouse gas emissions

To minimise the extent and impacts of climate change, action is required to reduce global greenhouse gas emissions. Agriculture is the largest contributor to Irish greenhouse gas emissions by sector, with 33.3% of the national emissions total in 2017 (EPA, 2018). The agricultural sector is under pressure to reduce its emissions in the context of Ireland's commitment to reduce national GHG emissions by 20% by 2020, under the current EU Effort Sharing Decision (ESD), while a more stringent target of a 30% reduction has been agreed for 2030. Maintaining or even increasing food production will be very difficult while reducing aggregate emissions (Breen et al., 2010; Lynch et al., 2016b). Relevant indicators are required to track the progress being made in emissions reductions in agriculture and how this relates to the level of food production. The IPCC (Intergovernmental Panel on Climate Change) methodology is the principal method of estimating GHG emission indicators across different farm systems in this report, and are calculated as follows:

a. **Total agricultural emissions** are measured per farm, with emissions also disaggregated to show the emissions originating from different farm enterprises (dairy, cattle, sheep and crops).
b. **Agricultural greenhouse gas emissions per unit of output/hectare** are derived so that the total emissions of the farm can be decomposed into components relating to each of the farm's main outputs (milk, cattle or sheep live-weight and crop outputs). In addition, GHG emissions per € of output and per hectare are used to illustrate greenhouse gas emissions per € of output that are generated on farms with dissimilar levels of agricultural output.
c. **Emissions from on-farm energy use per unit of relevant output** measures emissions from electricity and fuel use associated with agricultural production activities on the farm. As per the IPCC methodology, these greenhouse gas emissions are considered separately from agricultural greenhouse gas emissions.

2. Nitrogen use

Nitrogen (N) is an important element in agricultural production, but the loss of excess N poses a significant risk to the aquatic environment. The nitrogen use indicators follow an input-output accounting methodology as described below.

a. **Nitrogen balance** (per hectare farmed), is used as an indicator of the potential magnitude of nitrogen surplus which reflects the risk of nutrient losses to water bodies, all other things being equal. It is calculated on the basis of N inputs less N outputs on a per hectare basis at the farm gate level.
b. **Nitrogen use efficiency (NUE)** is used to highlight the proportion of N retained in the farm system (N outputs / N inputs). This is a generic measure allowing comparison across disparate farm types at the farm gate level.
c. **Nitrogen surplus per unit of output produced** is a measure derived so that the total N surplus of the farm can be decomposed into components relating to each of the farm's main outputs (milk, cattle or sheep live-weight and crop outputs). For dairy systems, it is also expressed in kg of milk produced per kg of N surplus.

3. Phosphorus use

Similar to nitrogen, phosphorus (P) is an important element in agricultural production and its loss poses a significant risk to the aquatic environment. Phosphorus use indicators, like N use indicators, also follow an input-output accounting methodology described previously. However, it should be noted that unlike N, phosphorus can remain in the soils for significant periods of time and is available to be stored and mined, hence P balance and efficiency should be interpreted with caution without reference to the soil P status of the farm.

a. **Phosphorus balance** (per hectare farmed), is used as an indicator of the potential magnitude of phosphorus surplus which may result in nutrient losses to water bodies all other things being equal. It is calculated on the basis of P inputs less P outputs on a per hectare basis at the farm level.
b. **Phosphorus use efficiency** is used to highlight the proportion of P retained in the farm system (P outputs / P inputs). This is a generic measure allowing comparison across different farm types.

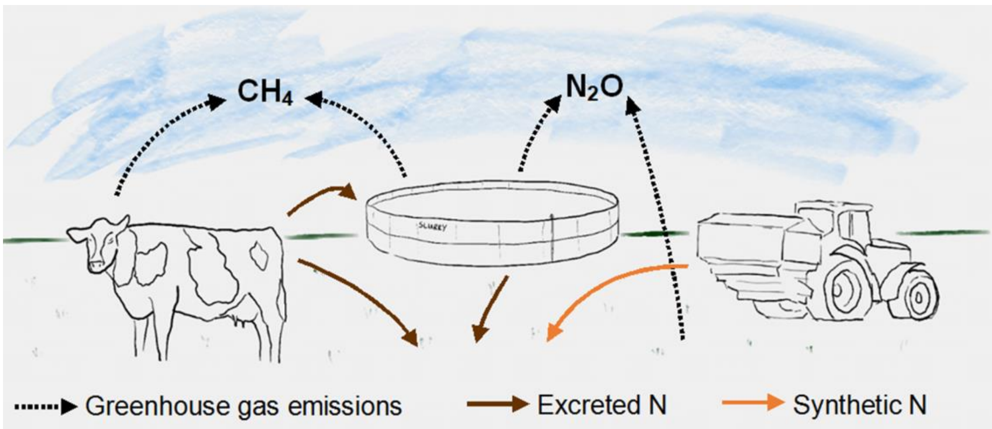
Table 2: Overview of Environmental indicators

Indicator	*Measure*	*Unit*
Ag. GHG emissions per farm	GHG emissions	Tonnes CO_2 equivalent / farm
Ag. GHG emissions per hectare	GHG emissions per hectare	Tonnes CO_2 equivalent / hectare
Ag. GHG emissions per kg of output	GHG emissions efficiency	kg CO_2 equivalent / kg output *AND* kg CO_2 e / € output
Energy GHG emissions per farm	Farm GHG energy use efficiency	kg CO_2 equivalent / kg output
Energy emissions per kg of output	Energy GHG emissions efficiency	kg CO_2 equivalent / kg output *AND* kg CO_2 e / € output
Ammonia emissions per farm	NH_3 emissions	Tonnes NH_3 equivalent / farm
Ammonia emissions per hectare	NH_3 emissions per hectare	Tonnes NH_3 equivalent / hectare
Ammonia emissions per kg of output	NH_3 emissions efficiency	kg NH_3 equivalent / kg output *AND* kg NH_3 / € output
Nitrogen (N) balance	N transfer risk	kg N surplus / ha^{-1}
Nitrogen (N) use efficiency	N application efficiency	% N outputs / N inputs
N surplus per kg of output	N emissions efficiency	kg N surplus / kg output
Phosphorus (P) balance	P transfer risk	kg P surplus / ha^{-1}
Phosphorus (P) use efficiency	P application efficiency	% P outputs / P inputs

Calculating Greenhouse Gas Emissions:

IPCC Methodology: The greenhouse gas emissions indicators are in the first instance calculated following the IPCC methodology accounting conventions and Irish emission factors as employed in the 2017 National Inventory Report for Ireland (Duffy et al., 2017). The three main agricultural emissions categories are methane (CH_4) emissions from enteric fermentation by ruminant livestock, CH_4 and nitrous oxide (N_2O) emissions from the production and storage of livestock manures, and N_2O emissions resulting from the application of manures and synthetic fertilisers to agricultural soils. A complicating factor inherent in a farm based approach, (as opposed to a national emissions inventory approach to emissions measurement), is that animals can move freely between farms via inter-farm sales. Accordingly, an inventory approach is used whereby the CH_4 emissions and manure production of each livestock category are adjusted to reflect the portion of the year an animal is present on the farm. For reporting purposes all non-carbon dioxide (CO_2) emissions are converted to CO_2 equivalents using appropriate global warming potentials for CH_4 and N_2O which are respectively 25 and 298 times greater than the GWP of CO_2.

Figure 1: An illustration of some of the major agricultural greenhouse gas emissions



Emissions resulting from on-farm fuel and electricity use are considered independently, as they are a separate IPCC category. Energy emissions (CO_2 only) are estimated from expenditure on electricity and fuels (relevant quantities used are estimated by using national average prices (CSO, 2018; SEAI, 2018)) and applying national level emissions factors to these quantities. It should be noted that the accounting conventions used here represent the greenhouse gas emissions from Irish agriculture as reported in the Irish National Inventory Report (Duffy et al., 2017), and are hence relevant to Ireland's commitments. This does not represent a full life-cycle assessment (LCA) approach, which would include embedded emissions, for example the emissions generated in the production of feeds produced elsewhere, but brought onto a farm.

LCA Methodology: An alternative method to the IPCC approach to measuring GHG emissions is the Life-Cycle Assessment approach which accounts for emissions through the entire food production supply chain. LCA is a holistic systems approach that aims to quantify the potential environmental impacts e.g. GHG emissions, generated throughout a product's life cycle, from raw-material acquisition through production, use, recycling and final disposal. Thus it accounts for all GHG emissions from the farm up to the point of product sale. It is generally expressed per unit of product produced. The LCA approach attempts to capture all emissions associated with a product. It therefore ignores national boundaries and seeks to enumerate all emissions along the chain, irrespective of country of origin.

Considerably more data are required to conduct an LCA study or to produce a carbon footprint analysis for each product produced on a farm. At present such detailed data are only available for dairy farms participating in the NFS and as such it was only possible to conduct a carbon LCA based footprint analysis of milk production using NFS data. The Moorepark Dairy LCA model was used for this analysis (O'Brien et al., 2014). This model, which is accredited by the National Carbon Trust (UK), has previously been used to estimate the carbon footprint of milk production on a number of Teagasc research farms as well as a sample of farms supplying a particular Irish dairy processor. The system boundaries of the Moorepark LCA model are defined to include all emissions associated with the dairy production system up to the point where milk is sold from the farm. The advantage of applying the Moorepark Dairy LCA model using NFS data is that the Teagasc NFS is nationally representative of Irish dairy production and thus reflects the full spectrum of dairy farming conditions in the country and as such allows us to produce a nationally representative LCA based carbon footprint measure.

Additional data over and above those normally collected by the Teagasc NFS were required to make the Moorepark LCA model operational (and is available since 2013). The additional data included information on the length of the grazing season, slurry spreading methods used, timing of slurry application, use of agricultural contractors and type of electricity provider. As with the other indicators presented in this report, emphasis should not be placed on the absolute level of the carbon footprint measure, but rather the direction in which the indicator evolves over time. The main objective of this research is to establish indicators with which future progress in sustainability performance can be documented.

Calculating Ammonia Emissions

The EU and its Member States are parties to the Convention on Long-Range Transboundary Air Pollution (CLRTAP), which regulates trans-boundary air pollutants, including ammonia. Within the EU, ammonia emissions are regulated through the National Emissions Ceiling (NEC) Directive (EU, 2001). Close to 99% of Ireland's ammonia emissions originate within agriculture, with their source being animal waste and the application of synthetic fertilisers. The fact that ammonia emissions in Ireland come almost exclusively from agriculture means that any future national ammonia reduction target for Ireland would de facto represent a reduction target to be achieved by the agriculture sector. The current ceiling (2010-2019) on Ireland's ammonia emission is set at 116 kilotonnes. From 2020 Ireland will have an ammonia ceiling of 112.2 kilotonnes representing a 1% ammonia reduction relative to the 2005 level. A further reduction target of 5% (107.6 kilotonnes) relative to the 2005 level is to be achieved by 2030. Ammonia emissions are calculated in this report by following the national inventory methodology applied by the Environmental Protection Agency (EPA).

Calculating Nitrogen and Phosphorus Balances

Nitrogen (N) and Phosphorus (P) use indicators follow a nutrient accounting approach based on Buckley et al. (2015). N and P exports from the farm are subtracted from imports to the farm to give a farm gate balance. Exports comprise the N and P component of milk, crops, wool and livestock sold (including livestock for slaughter) from the farm. Imports are comprised of fertilisers applied, feeds purchased and livestock brought onto the farm. At present, the volumes of manure or slurry imported and/or exported by farms are not recorded, and so these farms are excluded from N and P balance indicators calculation. It should be noted that the N and P indicators do not provide estimates of losses to water, as such losses are complex and driven by site specific biophysical factors and weather conditions. N and P balances are used as an indicator of potential risk of loss of nutrients, all other things being equal and cover most of the key management decisions over which the farmer has direct control.

3.3 Social Indicators

A farm will only be sustainable if employment in the industry can provide a suitable economic return for the labour used, but also if farm operators and families have an acceptable quality of life from their farming and non-farming activities. If farming is not socially sustainable, individuals may exit the sector, or there may be a lack of farmers who are willing to take over farms when older farmers retire from farming. In addition, as agriculture is often the predominant economic activity in many rural areas, the social impacts of farming are also important in maintaining employment and social wellbeing in the broader rural community. The design of social sustainability indicators is subjective in nature and on-going efforts are being made to improve the farmer, animal and community well-being aspects of social sustainability within the Teagasc NFS. Based on the current available data the following indicators are reported upon:

a) Household vulnerability

The household vulnerability indicator is a binary indicator, where a farm is defined as vulnerable if the farm business is not economically viable (using the economic viability indicator described earlier), and the farmer or farmer's spouse has no off-farm employment income source.

b) Formal agricultural education

This is a binary indicator that measures whether or not the farmer has received any formal agricultural training, at any level. Agricultural education can be an important factor in farm succession, as well as having a role in the nature of wider farm management decisions that can affect other dimensions of farm sustainability.

c) High Age Profile

Farms are defined as having a high age profile if the farmer is aged over 60, and there are no members of the farm household younger than 45. This indicator shows whether the farm is likely to be demographically viable.

d) Isolation risk

Isolation risk is also measured using a binary variable, depending on whether or not the farmer lives alone. It is an important consideration, given the continued trend for migration from rural to urban areas, and the ageing population of farmers in Ireland.

e) Work Life Balance

This indicator is the number of hours worked by the farmer on the farm. It should be noted that this does not include time spent in off-farm employment.

Table 3: Overview of Social indicators

Indicator	***Measure***	***Unit***
Household vulnerability	Farm business is not viable and no off-farm employment	Binary variable: 1= vulnerable
Agricultural education	Formal agricultural training received	Binary variable, 1= agricultural training received
Isolation Risk	Farmer lives alone	Binary variable, 1=isolated
High Age Profile	Farmer is over 60 years old, and no members of household under 45	Binary variable: 1=high age
Work Life Balance	Work load of farm	Hours worked on the farm

3.4 Innovation Indicators

More efficient production has the potential to increase profitability while reducing negative environmental and social effects, thereby assisting progress towards more sustainable agriculture. Innovations that can lead to increased sustainability may be novel technologies, newly developed or applied, or may be better management techniques. Hence, it is important to measure uptake of such innovations to ensure that updated science and knowledge is being translated into farm practices and secondly that the use of these technologies gives the anticipated environmental, economic or social benefits. As a result, the innovation indicators selected here are a combination of specific technologies or practices employed by the farmer, as well as farmer membership in groups which may be positively allied with increased adoption of broader innovations. All of the innovation indicators are scored as binary variables, either where a specific technology or practice is used or whether a farmer is a member of the given group. Innovation indicators can be especially useful to compare with financial performance, as they will highlight the benefits of specific technologies or behaviours.

Dairy innovation indicators

- ***Milk recording*** (the practice of keeping detailed records of individual cow performance) was identified as a key aspect of dairy farm management practice from which farms could build on and improve herd health performance, breeding and milk yield.
- ***Discussion group membership*** was selected as indicating a degree of interaction with extension services and peers.
- ***Spring slurry spreading*** (spreading at least 50% of total slurry between January and April) was identified as an important practice to minimise losses to the environment and maximise grass production.
- ***Liming* and *Reseeding*** were identified as important practices in grassland management.

Cattle and sheep innovation indicators

Sheep and drystock cattle systems used a common set of innovation indicators. These are:

- ***Discussion group membership*** was selected as indicating a degree of interaction with extension services and peers.
- ***Spring slurry spreading*** (spreading at least 50% of total slurry between January and April) was identified as an important practice to minimise losses to the environment and maximise grass production.
- ***Liming* and *Reseeding*** were identified as important practices in grassland management.

Tillage innovation indicators

- ***Forward selling*** was selected as an innovative risk management strategy for tillage farms.
- ***Discussion group membership*** was selected as indicating a degree of interaction with extension services and peers.
- ***Liming*** was identified as important practices in arable production.
- ***Growing a main break crop*** (oilseed rape, peas, beans, linseed) was identified as best practice for tillage farms for disease and pest control.

Table 4: Overview of Innovation indicators

Dairy	***Cattle***	***Sheep***	***Tillage***
Discussion Group	Discussion Group	Discussion Group	Discussion Group
Liming	Liming	Liming	Liming
Spring slurry spreading*	Spring slurry spreading*	Spring slurry spreading*	Forward Selling
Reseeding	Reseeding	Reseeding	Break crop
Milk Recording			

*****(>50% slurry spread during the period January - April)

4. Sustainability Indicator Results 2017

An overview of the main diagrams used to express sustainability indicator results are provided below. Boxplots are used to display continuous data and allow the visualisation of the distribution of the results. The boxplots used here show the 10th, 25th, 50th, 75th and 90th percentiles of the sample population weighted distribution. An annotated example is shown in Figure 2 below, demonstrating the range in gross margin per hectare for dairy farms. The percentile measures are the values at which the stated percentages of farms fall below. For example, the 50th percentile (the median) in Figure 2 lies at approximately €1,400 per hectare, meaning that 50% of farms had a gross margin per hectare below this value (and conversely, 50% of farms had a gross margin per hectare greater than this value). A shorter range between percentiles indicates farms within this range have similar levels of performance. In the dairy example below, the distance between the 90th and 75th percentiles is greater than the distance between the 50th and 75th percentiles, indicating that a larger number of dairy farms were closer to this central range, with a wider spread among farms earning significantly more. For indicators with binary scores, bar charts show the proportion of farms that scored positively for the given indicator, as shown for dairy farm economic viability in Figure 3 below. To give an impression of how a given (non-economic) indicator relates to the economic performance of a farm, for most indicators, farms are segmented into the top, middle and bottom performing thirds based on gross margin per hectare. This is also demonstrated below in the example in Figure 3, where it can be seen in this hypothetical case that 88% of the top third of dairy farms ranked by gross margin (GM) per hectare were economically viable, compared to 34% for the bottom third.

Figure 2: Example Boxplot Gross Margin € per hectare

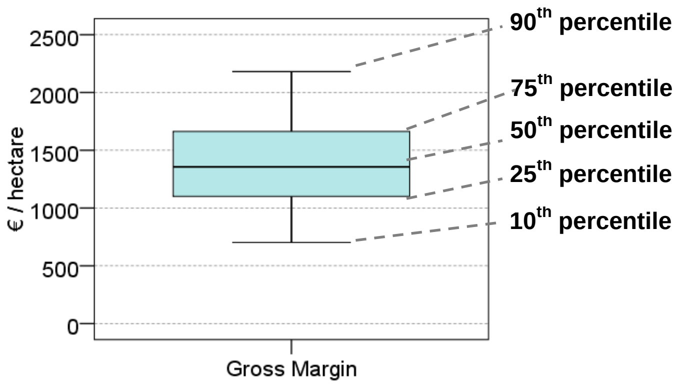
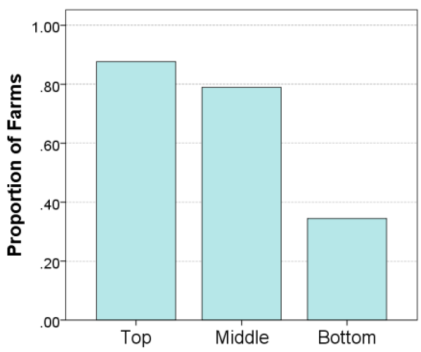


Figure 3: Example Bar Chart Proportion of farms

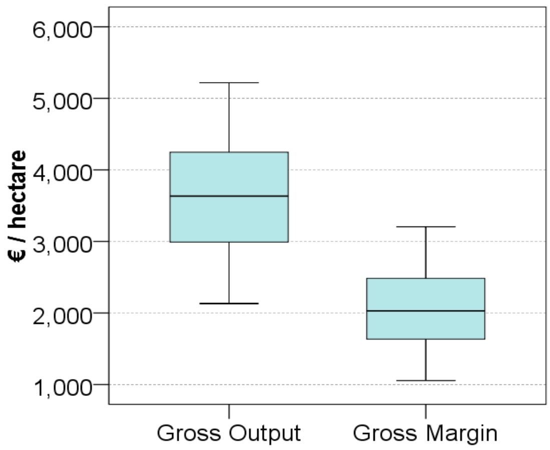


4.1 Dairy Farms

Economic Sustainability Indicators

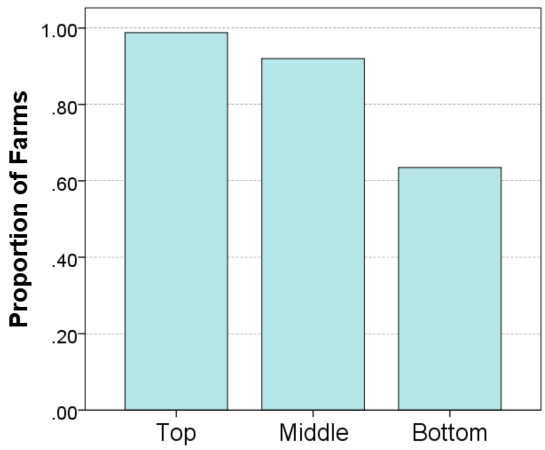
Figure 4 indicates that in 2017, the average dairy farm output per hectare was €3,720, and the average market gross margin per hectare was €2,111.

Figure 4: Economic Return and Profitability of Land: Dairy Farms



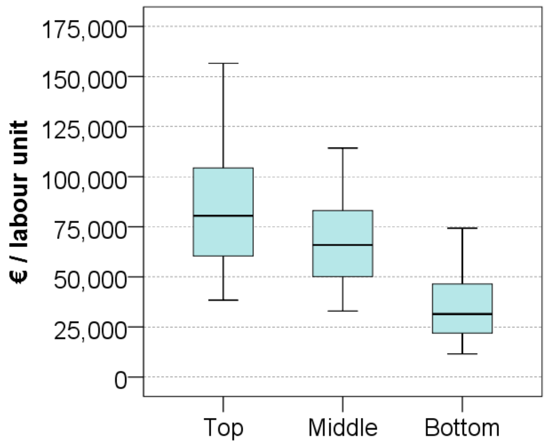
Overall 85% of dairy farms were economically viable. This ranged from 99% for the top one third performing dairy farms to 64% for the bottom third as shown in Figure 5.

Figure 5: Economic Viability: Dairy Farms



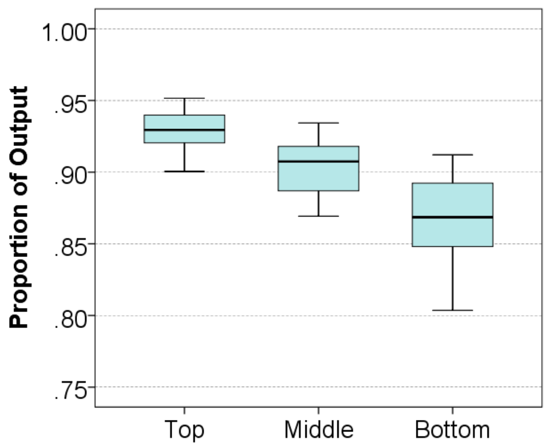
Average income per labour unit (unpaid family labour) for dairy farms in 2017 was €68,646. Average income per labour unit was €95,734, €71,253 and €37,582 for the top, middle and bottom performing farms respectively. However, there was a large range in the return to labour for dairy farms, especially for the higher performing farms as seen in Figure 6.

Figure 6: Productivity of Labour: Dairy Farms



On average, dairy farms derived 90% of gross output directly from the market in 2017. The degree of market orientation was highest for the top performing third of dairy farm and the range was largest among the bottom third, as illustrated in Figure 7.

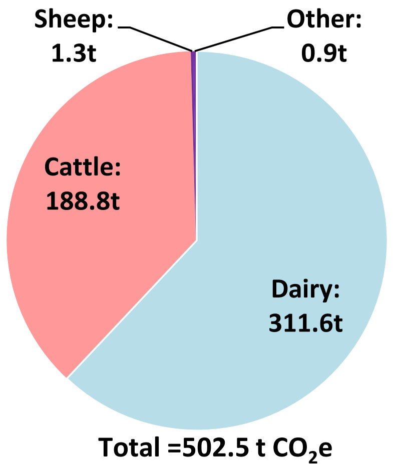
Figure 7: Market Orientation: Dairy Farms



Environmental Sustainability Indicators

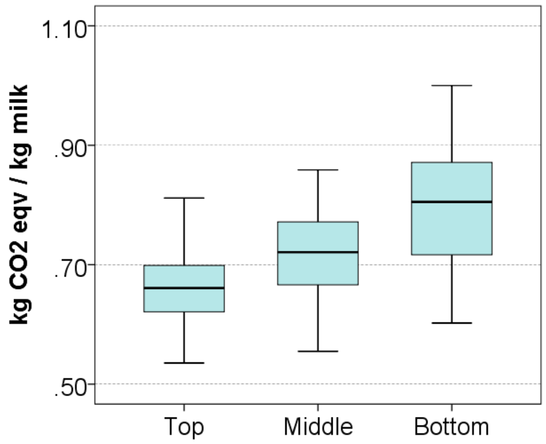
Figure 8 indicates that the average dairy farm emitted 502.5 tonnes of agricultural GHG (in CO_2 equivalents) in 2017. It should be noted that this measurement is based on the IPCC definition of agricultural emissions, and is not a full life-cycle assessment that would include embedded emissions in agricultural inputs, such as purchased feed. The majority of dairy emissions, 62%, were from dairy milk based output, with 37.5% allocated to beef production on Irish dairy farms (includes cull cows and calf sales / transfers mainly). The remaining emissions, less than 1%, of emissions were associated with sheep and crop production on dairy farms.

Figure 8: Agricultural GHG Emissions for the average Dairy Farm



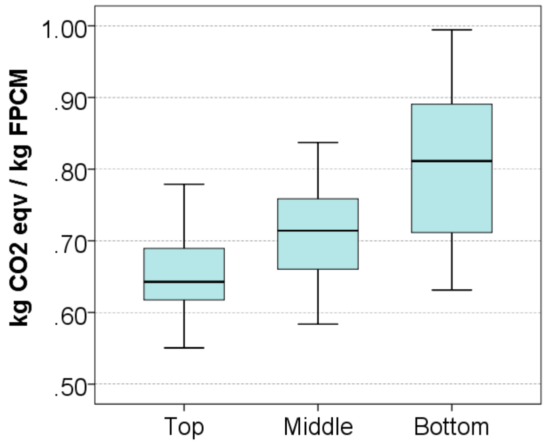
Emissions allocated to dairy output are expressed per kilogramme of milk output. The average farm emitted 0.733 kg CO_2 equivalent per kg of milk produced[2]. Figure 9 shows that farms with the best economic performance also have the lowest emissions intensity per kg of milk produced.

Figure 9: Agricultural GHG Emissions per kg of milk: Dairy Farms



Emissions allocated to dairy output are also expressed per kg of fat and protein corrected milk (FPCM) which is standardized to 4% fat and 3.3% true protein per kg of milk. The average farm emitted 0.723 kg CO_2 equivalent per kg of FPCM produced. Figure 10 again shows that farms with the best economic performance also have the lowest emissions intensity per kg of FPCM produced.

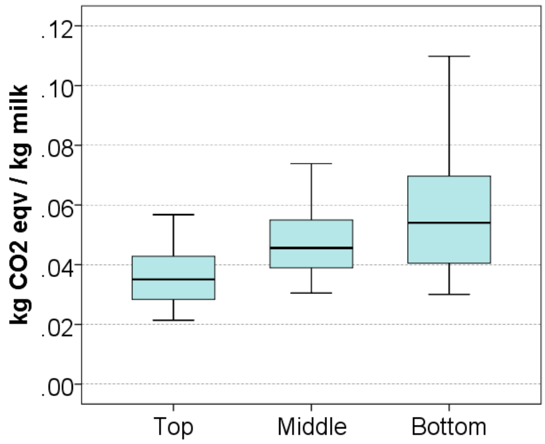
Figure 10: Agricultural GHG Emissions per kg of FPCM: Dairy Farms



The average energy and fuel based GHG emissions was 0.05 kg CO_2 equivalent per kg of milk. Figure 11 indicates that as with agricultural GHG emissions intensity, lower energy usage related GHG emissions per kg of milk produced is prevalent among farms with better economic performance.

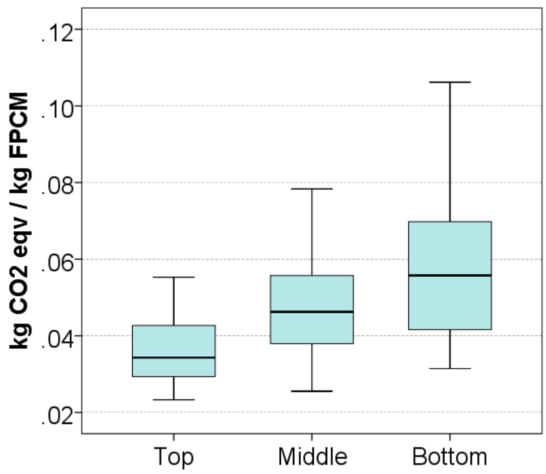
[2] Convert kg to litre by multiplying by 1.03

Figure 11: Energy use related GHG Emissions per kg of Milk: Dairy Farms



The average energy and fuel based GHG emissions were 0.0504 kg CO_2 equivalent per kg of FPCM produced. Figure 12 again shows that the top economic performers were more efficient in terms of FPCM produced per kg of energy related CO_2 emissions, in common with the agricultural emissions as seen in Figure 10.

Figure 12: Energy GHG Emissions per kg of FPCM: Dairy Farms



Using the LCA approach (including both agricultural and energy based emissions) the farm average carbon footprint of milk was 1.14 kg CO_2 equivalent per kg of FPCM. This is consistent with results produced by Bord Bia using a similar approach with farm level data collected via the Bord Bia Origin Green programme (Bord Bia, Forthcoming). Figure 13 again shows that lower emissions per kg of FPCM (on an LCA basis) was more prevalent among the higher economic performing farms.

Figure 13: Total LCA based GHG emissions (Agriculture & Energy) per kg of FPCM: Dairy Farms

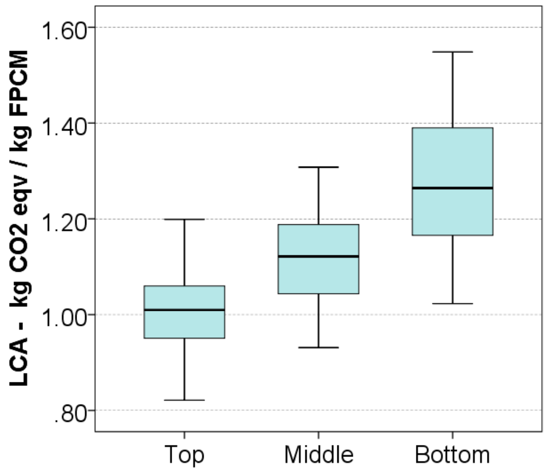
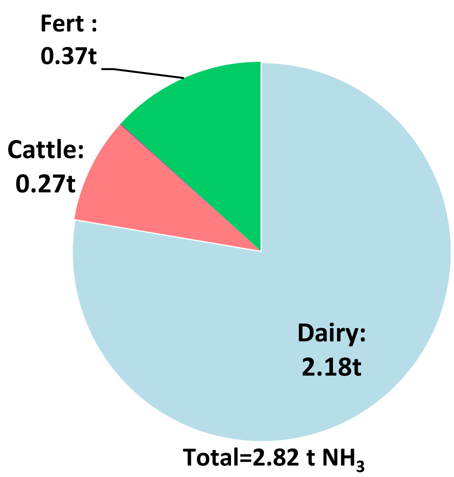


Figure 14 indicates that the average dairy farm emitted approximately 2.82 tonnes of ammonia (NH_3) emissions in 2017 based on EPA national inventory methodology. The majority of dairy emissions, 77%, were from milk based output, with 10% allocated to beef output (includes cull cows and calf sales / transfers mainly). The remaining emissions are accounted for by chemical N fertiliser application at 13%.

Figure 14: Total Ammonia Emissions for the average Dairy Farm



The average dairy farm emitted 0.0059 kg of NH_3 per kg of FPCM produced. Figure 15 again shows that the top economic performing dairy farmer produced milk at a lower NH_3 emissions intensity compared to the middle and bottom cohorts. This result was replicated when examining the outcome on a kg of milk output basis as outlined in Figure 16.

Figure 15: Ammonia Emissions per kg of FPCM: Dairy Farms

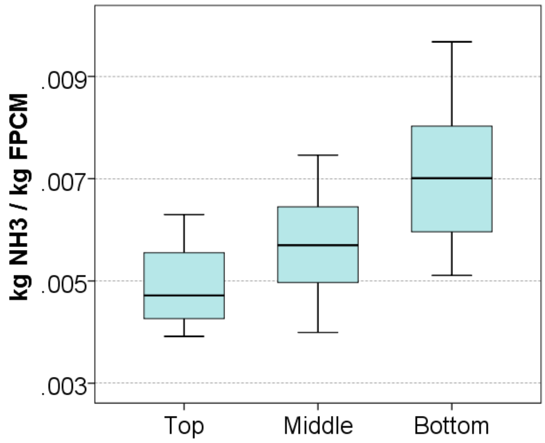
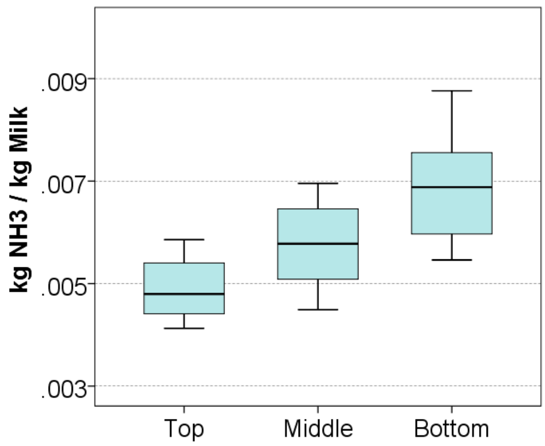
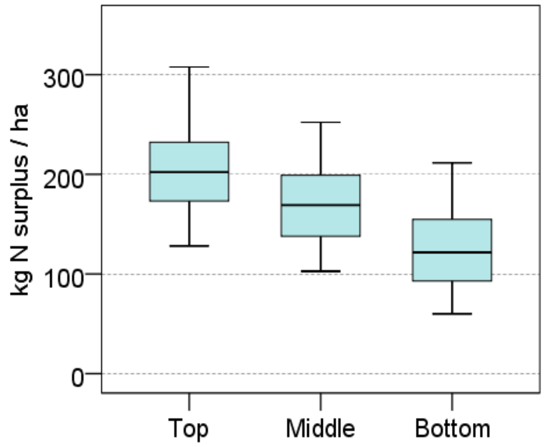


Figure 16: Ammonia Emissions per kg of Milk: Dairy Farms



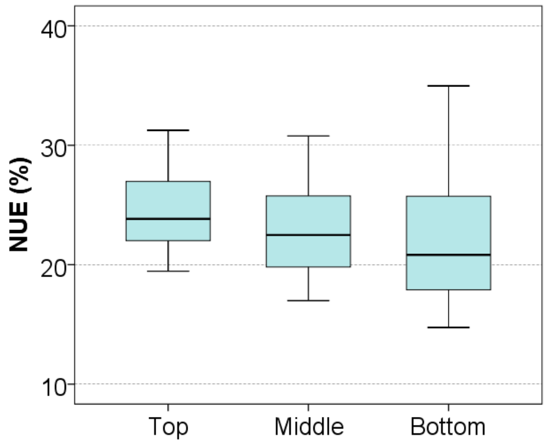
Nitrogen balance (excess of N inputs over outputs) averaged 171.9 kg N surplus per hectare across all dairy farms. Figure 17 indicates that higher N surpluses per hectare are related with higher economic performance; this is due to the greater production intensity on economically better performing farms.

Figure 17: N Balance per ha: Dairy Farms



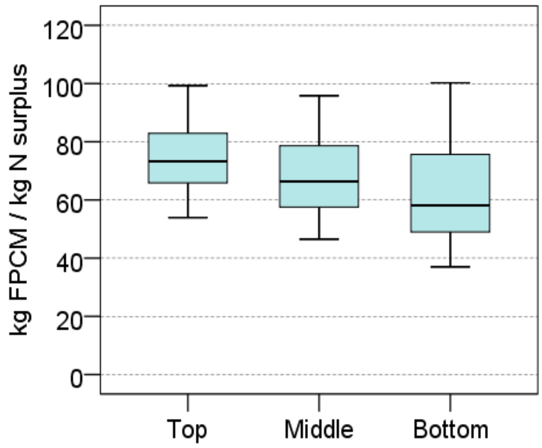
The average dairy farm had a nitrogen use efficiency of 24.4%. Figure 18 demonstrates the slightly higher N use efficiency was more evident among the higher economic performing farmers, with the largest range prevalent among the bottom third cohort.

Figure 18: N Use Efficiency: Dairy Farms



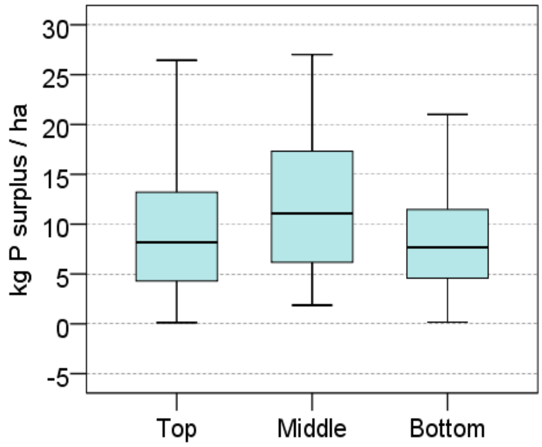
The average farm produced 70.9 kg of FPCM per kg of surplus nitrogen. Figure 19 shows that higher nitrogen use efficiency (NUE) of milk production was linked with higher economic performance, with the top and middle cohorts producing more kg of FPCM per kg of surplus nitrogen.

Figure 19: NUE of Milk Production by product



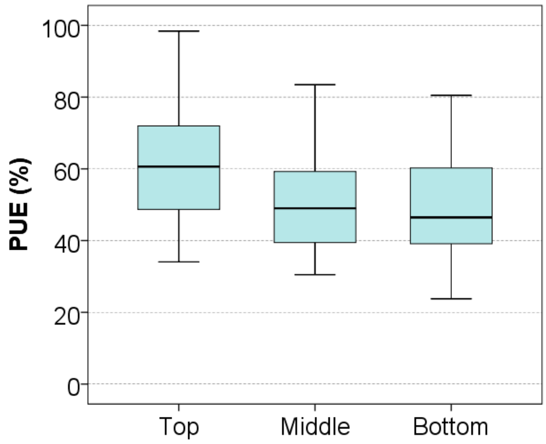
Phosphorus balance (excess of inputs over outputs) averaged 11.4 kg P surplus per hectare across all dairy farms. Figure 20 shows that there was a larger range of results, especially for the top performers.

Figure 20: P Balance per ha: Dairy Farms



The average dairy farm had a P use efficiency of 58.4%. Figure 21 indicates higher P use efficiency was again more prevalent among the higher economic performing farmers.

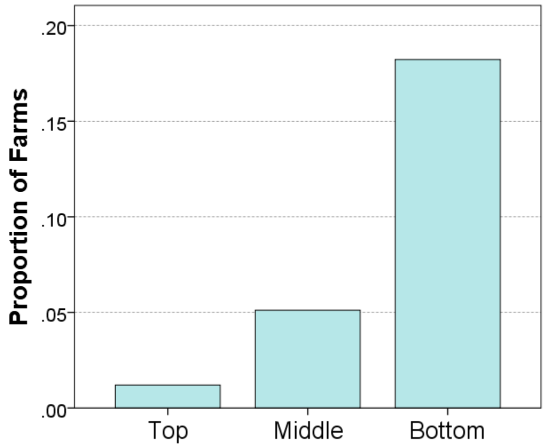
Figure 21: P Use Efficiency: Dairy Farms



Social Sustainability Indicators

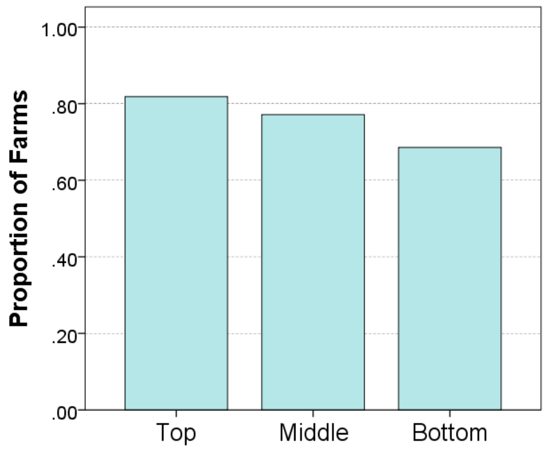
Only a minority of dairy farm households, 8%, fell into the vulnerable category (non-viable and no off-farm employment). Figure 22 shows that there were considerable numbers of households at risk among those farms with the lowest gross margin (18% among bottom third).

Figure 22: Household Vulnerability: Dairy



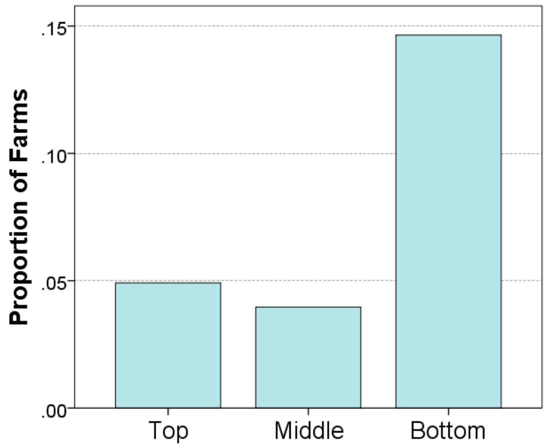
Overall, 76% of dairy farmers had received formal agricultural education of some description. Figure 23 shows that agricultural training rates were slightly higher across the middle and top performing cohorts.

Figure 23: Agricultural Education: Dairy



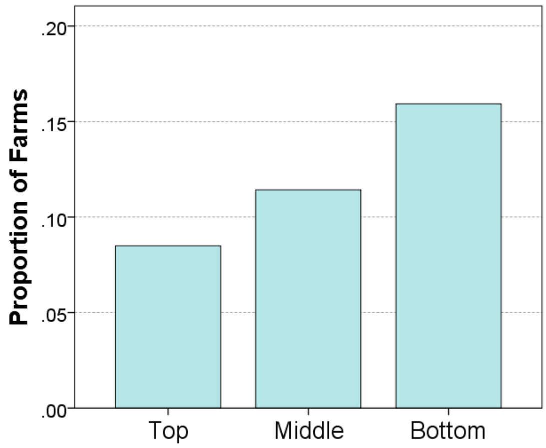
Only 8% of dairy farmers were living alone and were thus classified as being at risk of isolation. Figure 24 indicates that the risk was lowest for the top preforming cohort.

Figure 24: Isolation Risk: Dairy Farms



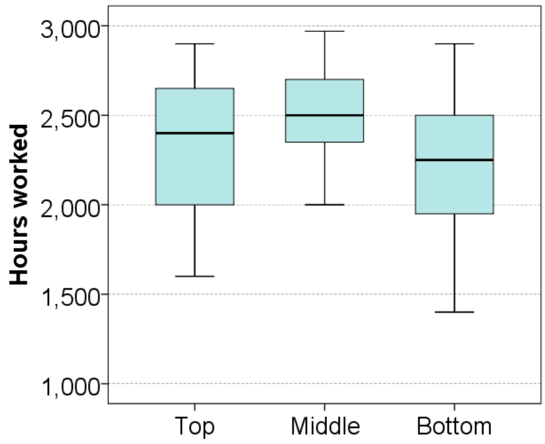
Across all dairy farms, 12% were identified as having a high age profile. Figure 25 shows that this was highest for the weaker economic performing farms.

Figure 25: High Age Profile: Dairy Farms



On average, dairy farmers worked 2,341 hours per year on-farm (approximately 45 hours per week). Figure 26 shows that hours worked was highest for farms in the middle 1/3, ranked by economic performance. However, this figure does not take into consideration off-farm employment, or the share of hours worked by other staff or family members.

Figure 26: Hours Worked: Dairy Farm Operator

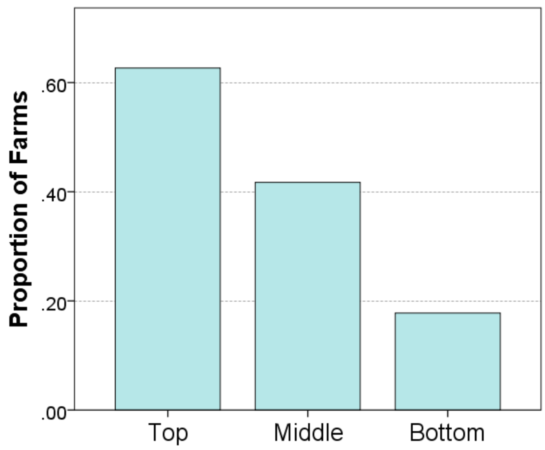


Dairy Innovation Indicators

The innovation indicators analysed for dairy farms were, the use of milk recording, membership of a dairy discussion group, whether at least 50% of slurry was spread in the period January-April as well as liming & grass reseeding rates.

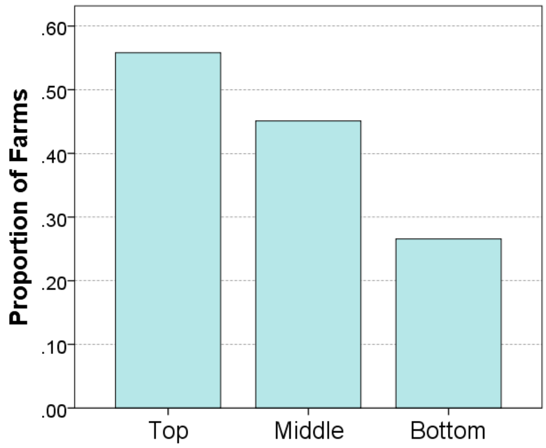
Figure 27 shows that those farms with better economic performance were more likely to use milk recording. Over 63% of the dairy farmers in the top group were milk recording, compared to 18% in the bottom group.

Figure 27: Milk Recording: Dairy Farms



Better economic performance was more prevalent among discussion group members. Membership rates were higher across the top group, at over 56%, compared to 27% in the bottom cohort, as shown in Figure 28.

Figure 28: Discussion Group: Dairy Farms



The application of the majority of slurry in early spring was slightly higher across the top and middle performing cohorts, as seen in Figure 29.

Figure 29: Spring Slurry: Dairy Farms

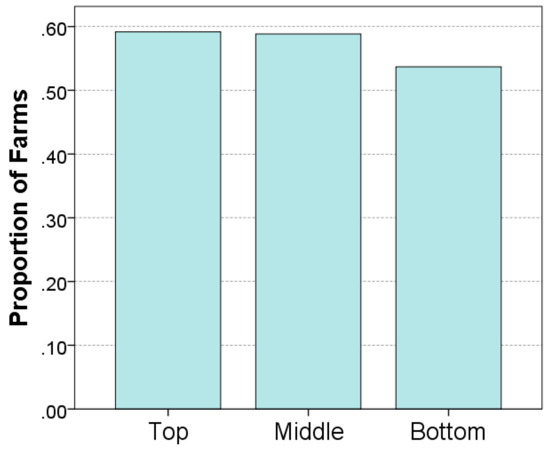


Figure 30 shows that liming was more prevalent among with higher economic performers, with 40% the top performing group engaging with this activity, compared to 25% for the bottom group.

Figure 30: Liming: Dairy Farms

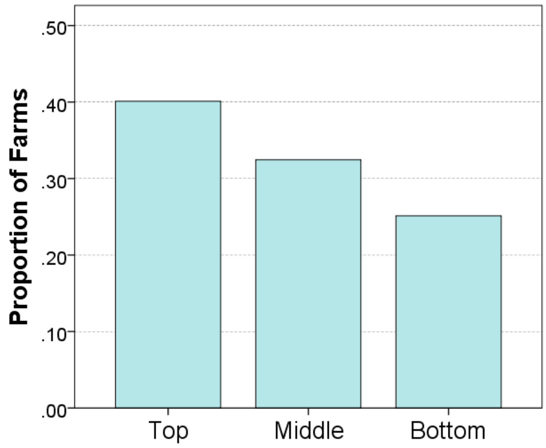
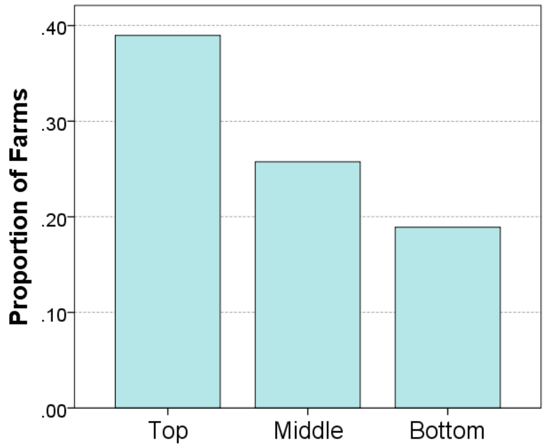


Figure 31 shows that reseeding was also more common across with higher economic performing farms. Twice as many farmers in the top group (39%) engaged in reseeding of grassland compared to the bottom group (19%).

Figure 31: Reseeding: Dairy Farms



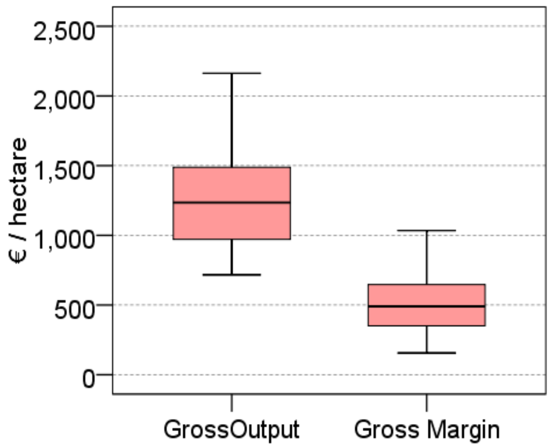
4.2 Cattle Farms

Cattle farms include both cattle rearing (mainly suckler based) and cattle finishing systems. Results for the economic, environmental and social sustainability indicators in 2017 are presented below.

Economic Sustainability Indicators

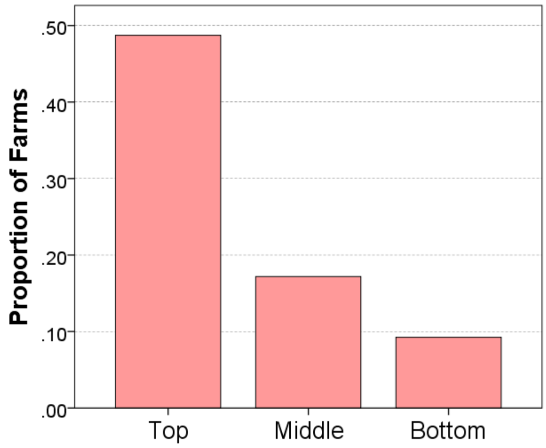
As shown in Figure 32, the average output per hectare for cattle farms in 2017 was €1,336, and the average gross margin per hectare was €533.

Figure 32: Economic Return and Profitability of Land: Cattle Farms



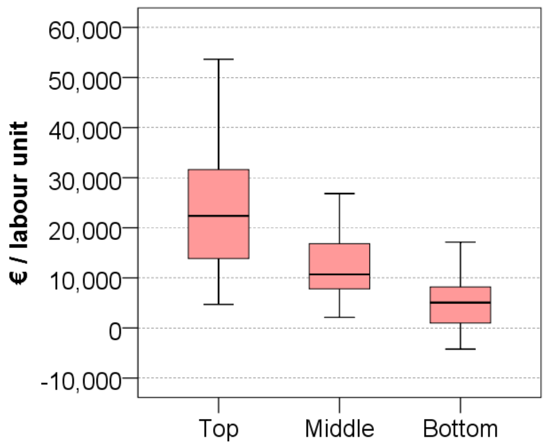
Only 25% of all cattle farms in the Teagasc NFS were defined as economically viable. Figure 33 shows that this ranged from 49%, 17% and 9% respectively, for the top, middle and bottom cohorts of farms by economic performance.

Figure 33: Economic Viability: Cattle Farms



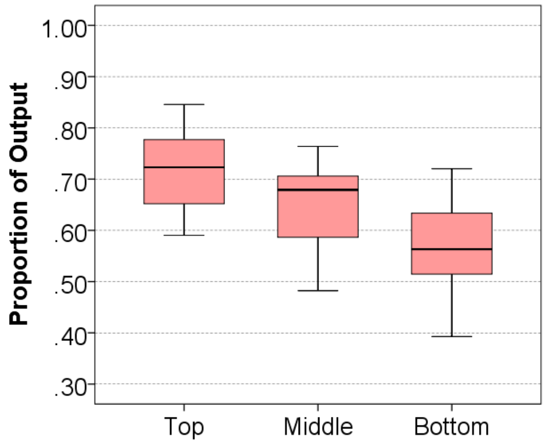
Across all cattle farms, the average income per labour unit was €16,909 in 2017. Figure 34 shows that this average was skewed by the top third of farms which included a large number of higher earners, with a mean income per labour unit of €30,126, compared with €13,245 and €7,013 for the middle and bottom cohorts of cattle farms respectively. Median income across the groups was €22,365, €10,694 and €5,064 respectively.

Figure 34: Productivity of Labour: Cattle



Market based output accounted for 64% of gross output across all cattle farms, with the remaining 36% provided by direct payments. Figure 35 shows greater market orientation was more likely across farms with better economic performance.

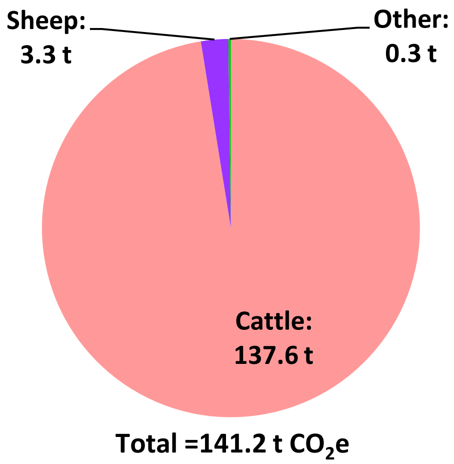
Figure 35: Market Orientation: Cattle Farms



Environmental Sustainability Indicators

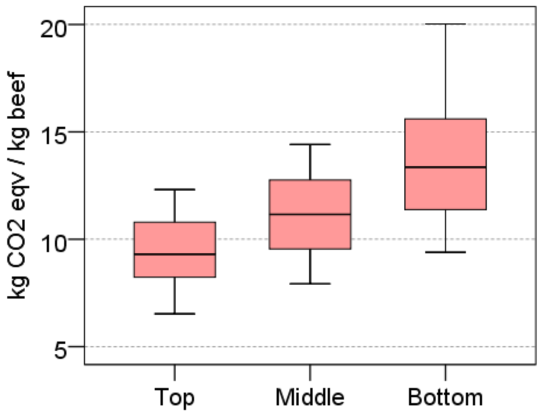
The average cattle farm emitted 141.2 tonnes CO_2 equivalents of agricultural GHGs in 2017. Figure 36 shows that beef production generated the overwhelming majority, 98%, of these emissions. Sheep were responsible for approximately 2% of total emissions on Irish cattle farms, and a very small proportion (less than 0.2%) was derived from other sources.

Figure 36: Agricultural GHG Emissions for the average Cattle Farm



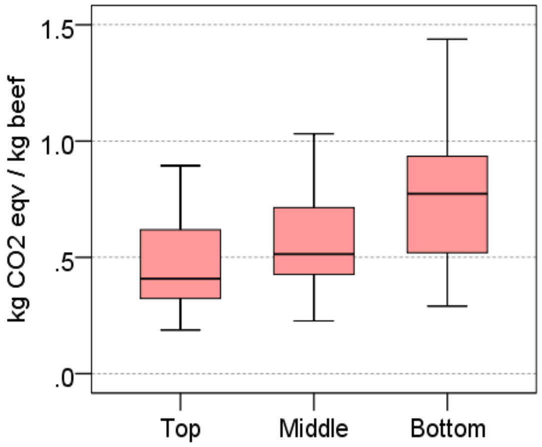
The emissions generated by cattle are assigned per kg of live-weight output (estimated using CSO price data). Figure 37 illustrates that there is a large range of emissions per unit of beef live-weight output. There was a positive association between emissions efficiency and economic performance. The top performing third of farms emitted, on average, 9.6 kg CO_2 equivalent per kg of live-weight beef, compared with 14.9 kg for the bottom performing third of cattle farms. The average level of emissions across all farms was 11.9 kg CO_2 equivalent per kg beef of live-weight produced.

Figure 37: Agricultural GHG Emissions per kg live-weight beef produced: Cattle Farms



On average, electricity and fuel based GHG emission across all farms was 0.60 kg of CO_2 equivalent per kg beef live-weight produced. Figure 38 indicates that energy based GHG emissions per unit of product was also lower on farms with better economic performance. The top third produced an average of 0.5 kg CO_2 energy-based emissions per kg of live-weight beef produced, while for the bottom performing third this figure was 0.72 kg.

Figure 38: Energy use related GHG Emissions per kg live-weight beef: Cattle Farms



The average cattle farm emitted 0.74 tonnes of ammonia (NH_3). In all 93% of total NH_3 emissions were linked with beef production, 5% was associated with chemical N fertilisers and the remaining proportion with sheep production on cattle farms as shown by Figure 39.

Figure 39: Total Ammonia Emissions for the average Cattle Farm

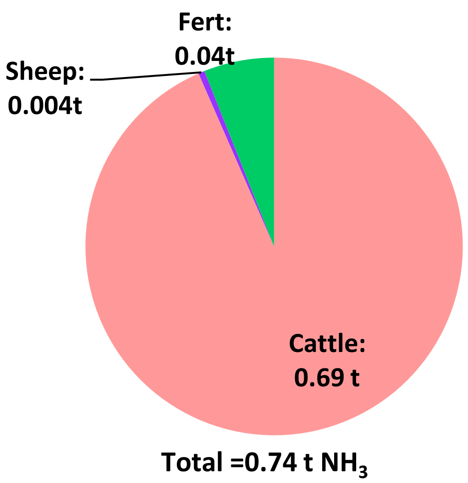


Figure 40 indicates that the more profitable cattle farmers are producing live-weight beef at a lower level of ammonia intensity. There was a large range of results, especially for the bottom performing cohort of cattle farmers. On average a kg of live-weight beef was produced at an intensity of 0.0633 kg of NH_3.

Figure 40: Ammonia Emissions per kg live-weight beef produced: Cattle Farms

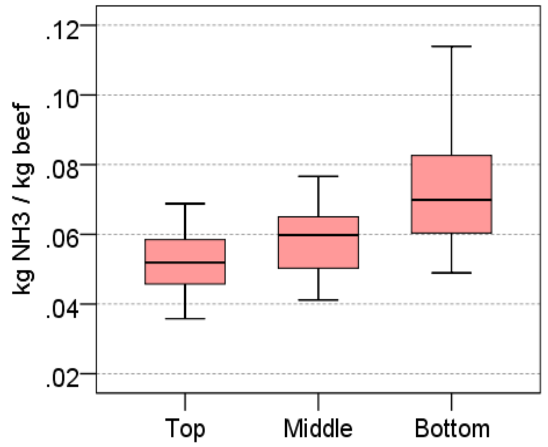
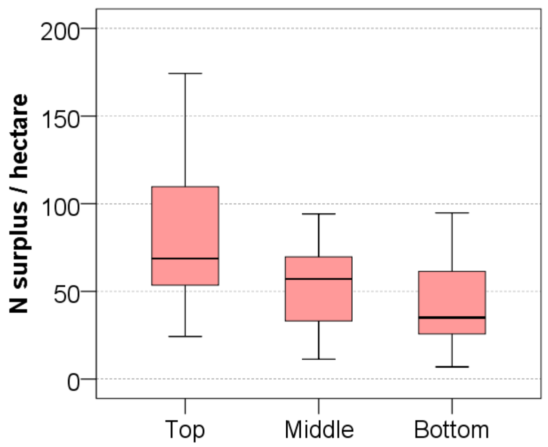


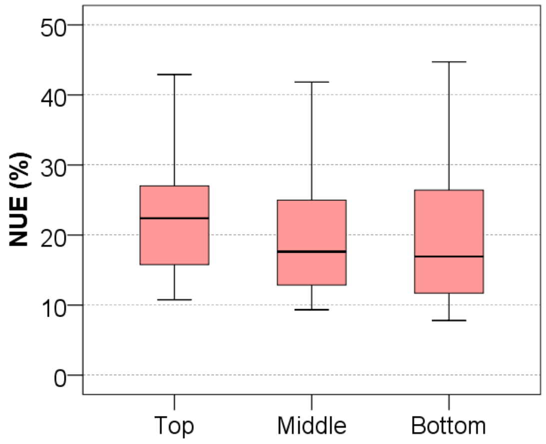
Figure 41 indicates that nitrogen surplus per hectare tended to be higher on the cattle farms that also performed better economically. In general, these farms are operated more intensively. The top performing third of farms had an average nitrogen surplus of 89.7 kg N per hectare, compared to 47.8 kg N per hectare for the bottom third of farms.

Figure 41: N Balance per ha: Cattle Farms



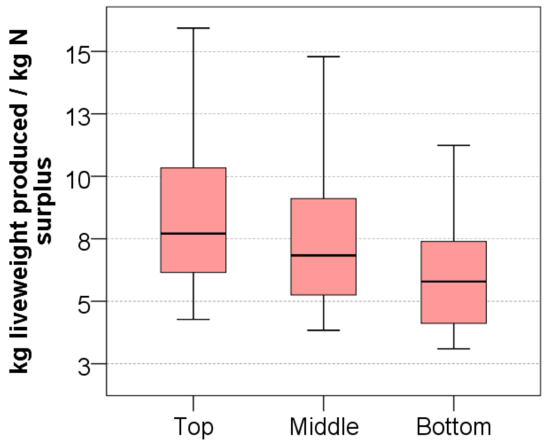
The average nitrogen use efficiency across all cattle farms was 24.2%, but the range in NUE across the sample of cattle farms was significant, as shown in Figure 42. Despite the higher application rates, NUE tended to be higher on the farms with better economic performance.

Figure 42: N Use Efficiency: Cattle Farms



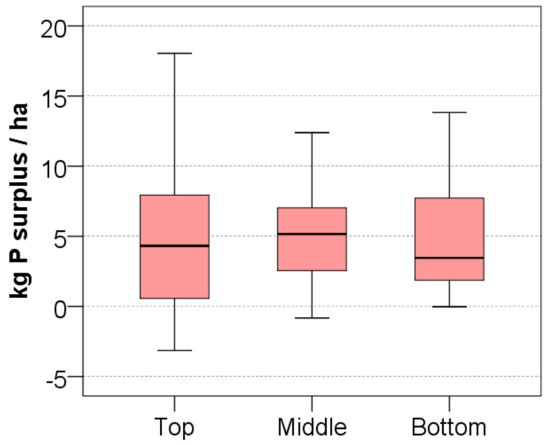
On average cattle farms produced 9.2 kg of live-weight output per kg of N surplus. Higher N use efficiency (NUE) of beef production was prevalent on the higher economic performing farms, with the top performers producing more beef live-weight per kg surplus nitrogen as illustrated in Figure 43.

Figure 43: NUE of beef production by product



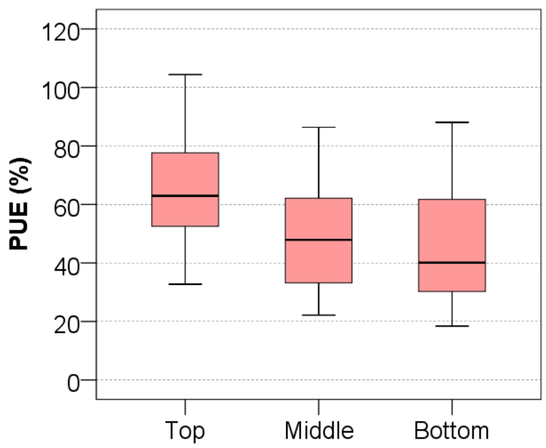
At the farm gate boundary the P surplus across all cattle farms averaged 6.2 kg per hectare. The P surplus range was largest for the top performing as shown in Figure 44.

Figure 44: P Balance per ha: Cattle Farms



At the farm gate boundary the average farm P use efficiency across all cattle farms was 64%. Figure 45 shows that higher P use efficiency was again more prevalent across better economic performing farms, which ranged from 69% for the top third to 50% for the bottom third of cattle farmers.

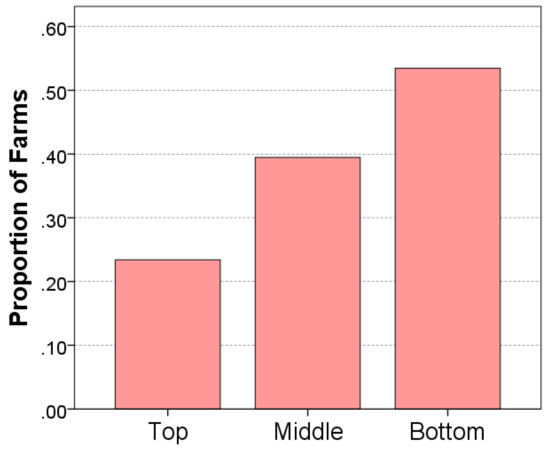
Figure 45: P Use Efficiency: Cattle Farms



Social Sustainability Indicators

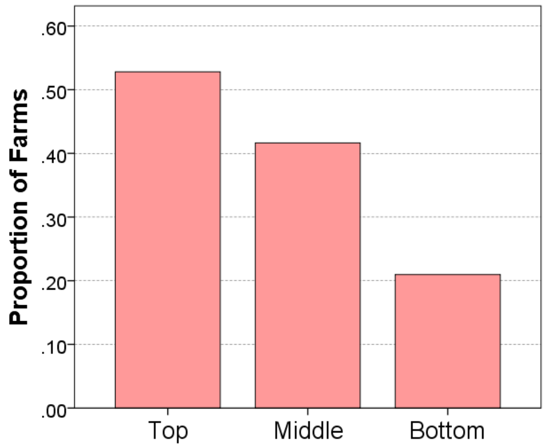
Overall, 39% of all cattle farms were considered vulnerable (non-viable with no off-farm employment). Figure 46 confirms that this vulnerability was linked with weaker economic performance, with 39% and 54% of the middle and bottom third of farms deemed vulnerable compared to 23% of the top third.

Figure 46: Household Vulnerability: Cattle



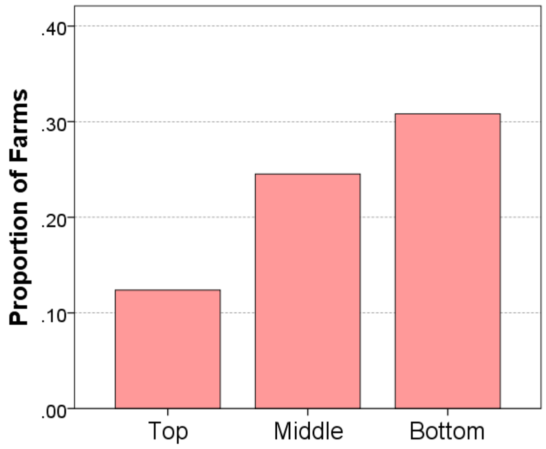
A total of 38% of cattle farmers had some form of agricultural education. Figure 47 indicates that higher levels of educational attainment were more common among the better economic performing farms.

Figure 47: Agricultural Education: Cattle Farms



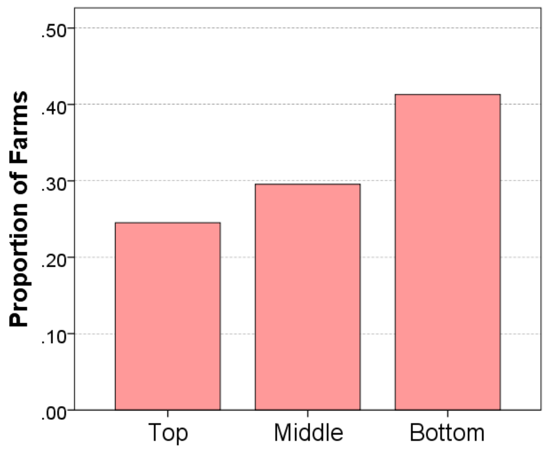
Overall, 23% of cattle farm operators were classified as being at risk of isolation; i.e. where the farmer lives alone. This was especially prevalent among farms with lower profitability, where 31% of the bottom third lives alone as shown in Figure 48.

Figure 48: Isolation Risk: Cattle Farms



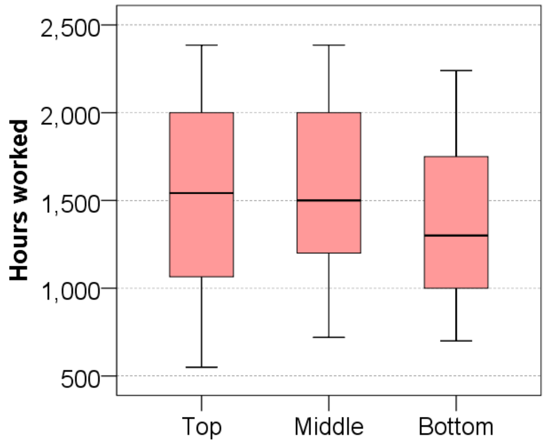
Additionally, 32% of cattle farms were classified as having a high age profile. As with other indicators of social sustainability, this was more prevalent among the weaker economic performing farms as shown in Figure 49.

Figure 49: High Age Profile: Cattle Farms



The average cattle farm operator worked on farm for 1,508 hours across the year (an average of 29 hours per week). It should be noted that 40% of cattle farmers work off-farm, so these figures are not necessarily indicative of overall work-life balance.

Figure 50: Hours Worked: Cattle Farms



Cattle Farm Innovation Indicators

Four innovation indicators were examined for cattle farms: whether at least 50% of slurry was spread in the period January-April, whether a farmer was applying lime, whether a farmer reseeded grassland and whether the farmers was a member of a discussion group.

Figure 51 shows that those in the top and middle groups by economic performance had higher spring-time slurry application rates compared to the middle and bottom cohorts.

Figure 51: Spring Slurry: Cattle Farms

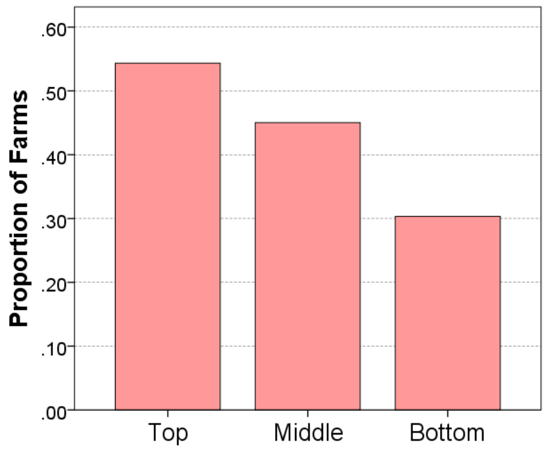


Figure 52 shows that liming rates were higher for the top performing cattle farmers at 19% compared to 14% and 11% for the middle and bottom cohorts respectively.

Figure 52: Liming: Cattle Farms

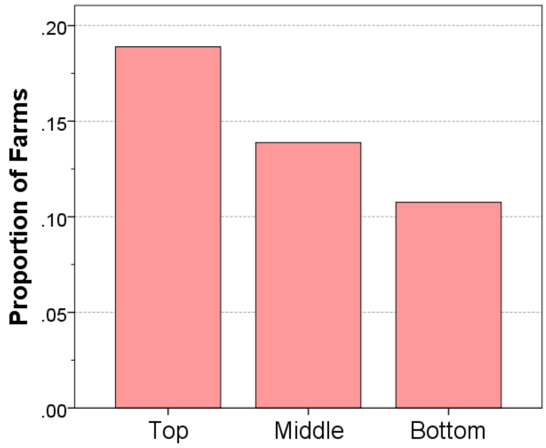
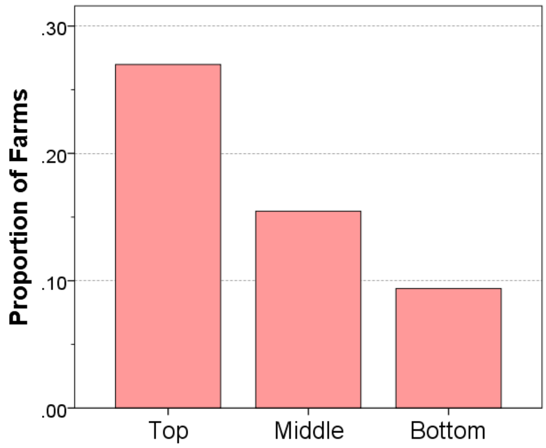


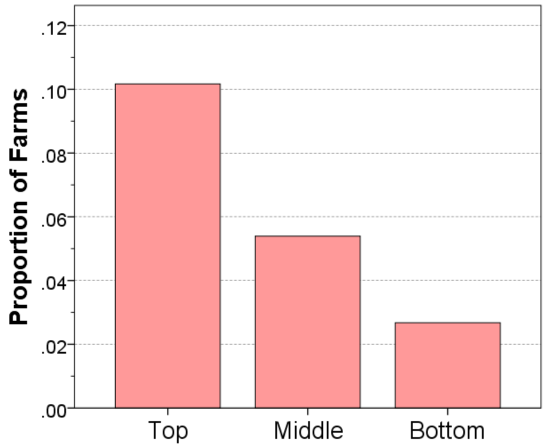
Figure 53 shows that membership of a discussion group was more common among the higher economic performing farmers at 27% compared to 9% in the bottom cohort.

Figure 53: Discussion Group: Cattle Farms



Higher levels of reseeding were reported among higher economic performing farms. The top group of farmers were three times more likely to reseed compared to the bottom group, as seen in Figure 54.

Figure 54: Reseeding: Cattle Farms

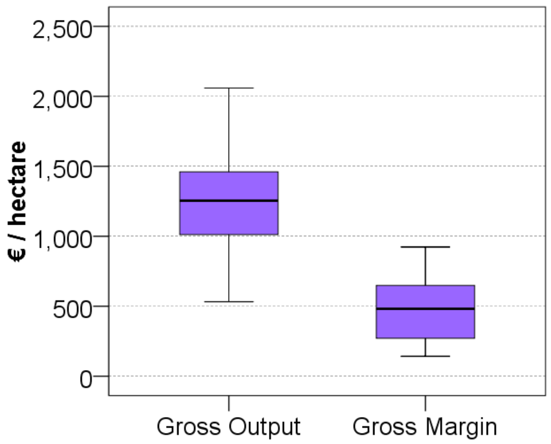


4.3 Sheep Farms

Economic Sustainability Indicators

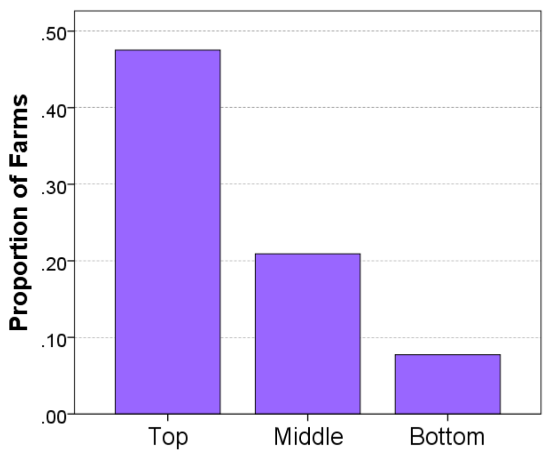
Figure 55 illustrates that the average gross output per hectare for sheep farms was €1,375 in 2017, and the average gross margin was €545 per hectare.

Figure 55: Economic Return and Profitability of Land: Sheep Farms



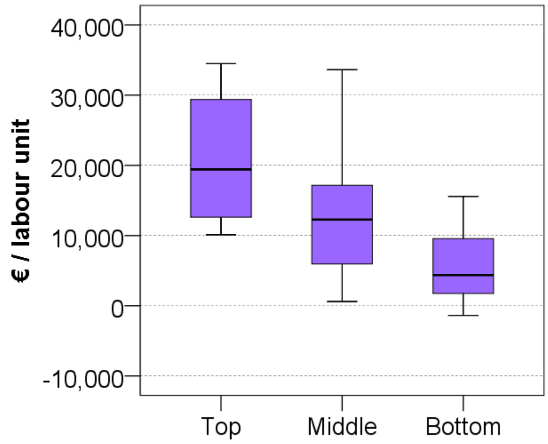
Across all sheep farms, 27% were defined as economically viable. Figure 56 indicates that this ranged from 48% for the top third to 7% for the bottom third of farms.

Figure 56: Economic Viability: Sheep Farms



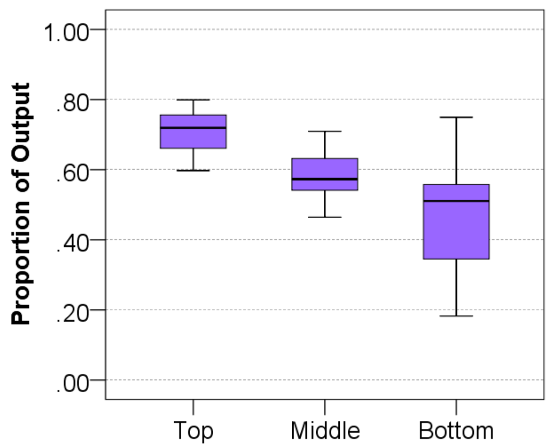
The average income per labour unit on sheep farms was €17,043. In common with cattle farms, there was a large range in economic performance, with the top third of sheep farms earning a mean income per labour unit of €26,643, compared with only €7,241 for the bottom third, which also had a number of farms making net losses (Figure 57).

Figure 57: Productivity of Labour: Sheep Farms



For the average sheep farm, approximately 60% of output was generated from the market, and 40% from direct payments. Figure 58 indicates that this was positively allied with economic performance, with the top third of farms based on economic performance producing 67% of output from the market, while the bottom third on average generated 52% of farm gross output from the market.

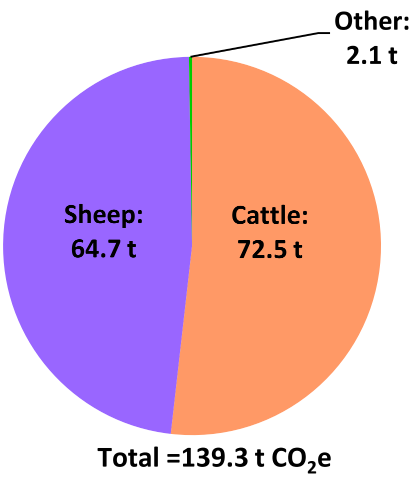
Figure 58: Market Orientation: Sheep Farms



Environmental Sustainability Indicators

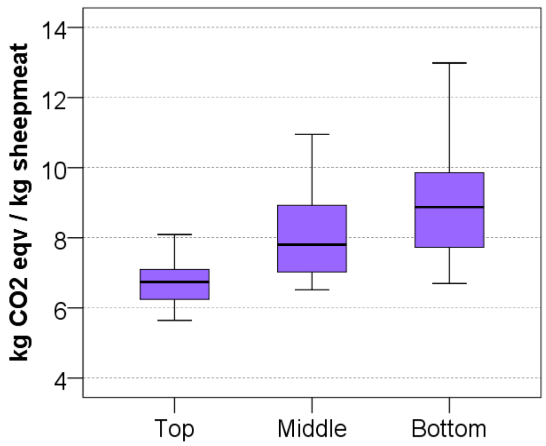
In 2017, the average sheep farm emitted approximately 139.3 tonnes CO_2 equivalents of agricultural GHG. Figure 59 indicates that just under half (46%) of these emissions were generated by the sheep enterprise, with over half (52%) generated by cattle enterprises present on specialist sheep farms, with the remaining 2% coming from other sources, mainly crop fertilisation.

Figure 59: Agricultural GHG Emissions for the average Sheep Farms



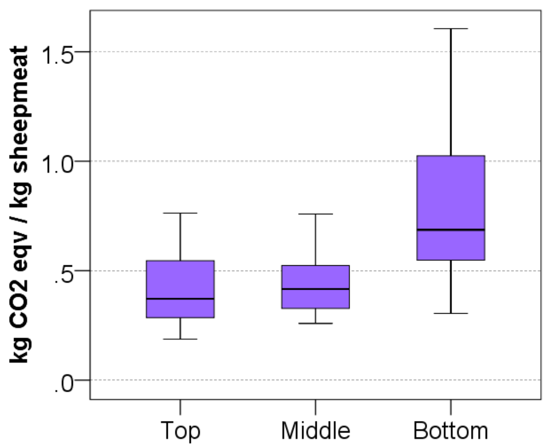
The GHG emissions generated by sheep are shown per kg of live-weight output produced (estimated using CSO price figures). Figure 60 shows that emissions intensity per kg of live-weight produced were negatively allied with economic performance. The top third of farms generated 6.7 kg CO_2 equivalent per kg live weight compared to 8.4 and 9.4 kg CO_2 equivalent for the middle and bottom cohorts respectively.

Figure 60: Agricultural GHG Emissions per kg live-weight produced: Sheep Farms



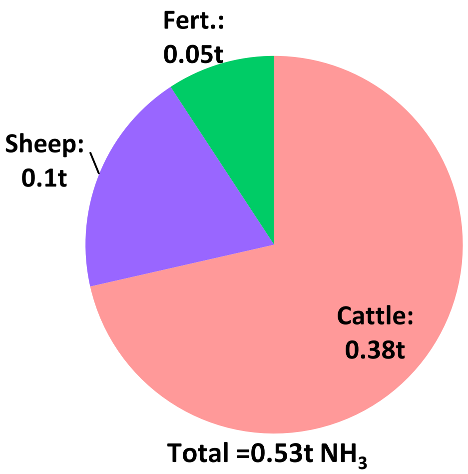
Better economic performance was also linked with lower electricity and fuel based GHG emissions per unit of output. Figure 61 shows that the bottom third of farms in economic terms emitted 0.87 kg CO_2 equivalent per kg live-weight sheep meat produced from energy based emissions, compared to 0.47 kg CO_2 for the top third of sheep farms.

Figure 61: Energy use related GHG Emissions per kg live-weight produced: Sheep Farms



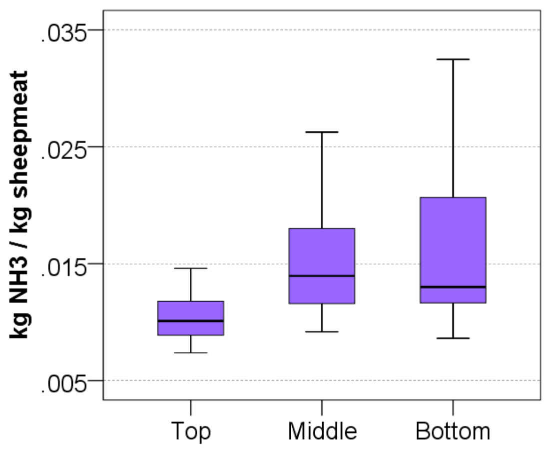
On average a specialist sheep farm emitted 0.53 tonnes of ammonia in 2017. Even though the main output on these farms is sheep based, the majority of the NH_3 emission related to cattle production (72%) with only 19% relating to sheep production. The remaining portion related to chemical fertilisers applied.

Figure 62: Total Ammonia Emissions for the average Sheep Farm



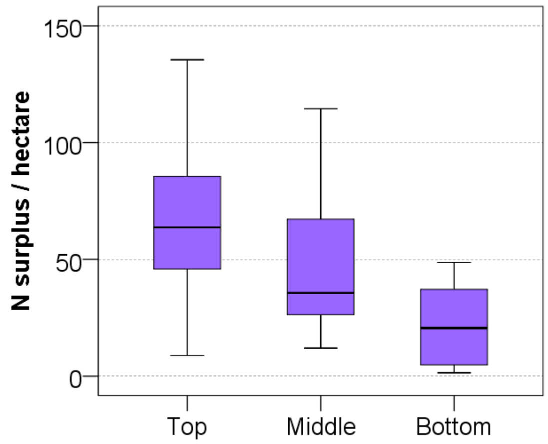
Lower ammonia emissions intensity of production was again more common among the better economic performing sheep farms. Farms in the top performing cohort produced a kg of live-weight sheep meat with lower NH_3 emissions as seen in Figure 63. On average sheep farmers produced a kg of live-weight sheep meat at 0.016 kg of NH_3 emissions.

Figure 63: Ammonia Emissions per kg live-weight produced: Sheep Farms



As with cattle farms, sheep farm nitrogen surplus per hectare was positively aligned with economic performance, due to greater production intensity on the more profitable sheep farms. Figure 64 shows that the top third of farms, ranked by gross margin per hectare, had an average nitrogen surplus of 70.6 kg per hectare, compared with 58.2 and 28.9 kg per hectare for the middle and bottom cohorts respectively.

Figure 64: N Balance per ha: Sheep Farms



The average NUE across all sheep farms was 31.5%. The Teagasc NFS sheep farm sample includes a number of extensive hill farms, which typically have very low N inputs, and this can result in high NUE values, even where overall output and profitability are lower (Figure 65).

Figure 65: N Use Efficiency: Sheep Farms

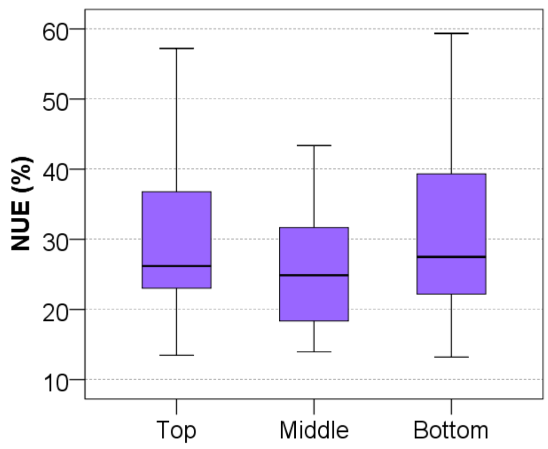
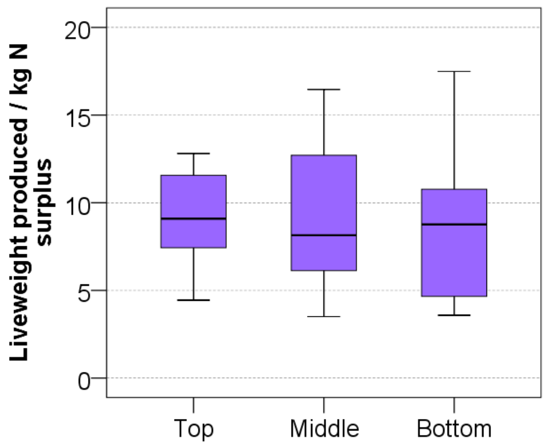


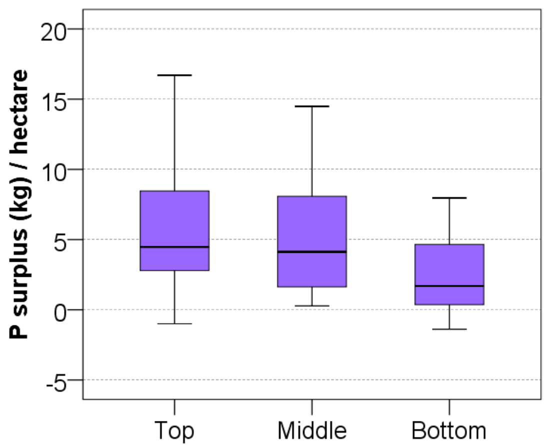
Figure 66 shows that the N surplus per kg of live-weight sheep meat produced tends to be positively aligned with economic performance, with the top third producing more live-weight output per kg of N surplus generated. The average across all sheep farms was 10.7 kg.

Figure 66: NUE by product of Sheep Farms



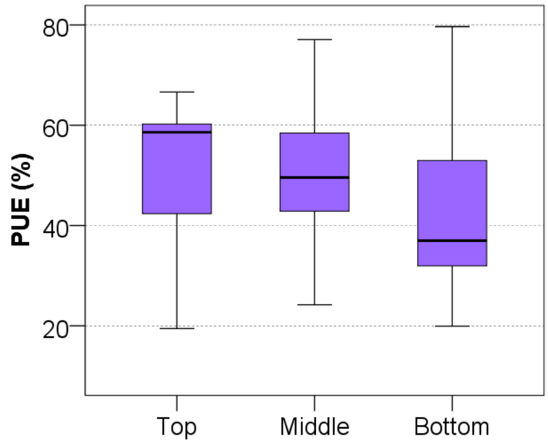
P balances across all specialist sheep farms were 4-8 kg per ha on average. Higher P balances were associated with better economic performance as illustrated in Figure 67.

Figure 67: P Balance per ha: Sheep Farms



Farm gate level P use efficiency averaged 63.6% across all sheep farms. Figure 68 shows that higher P use efficiency was more prevalent among the better economic performing farms.

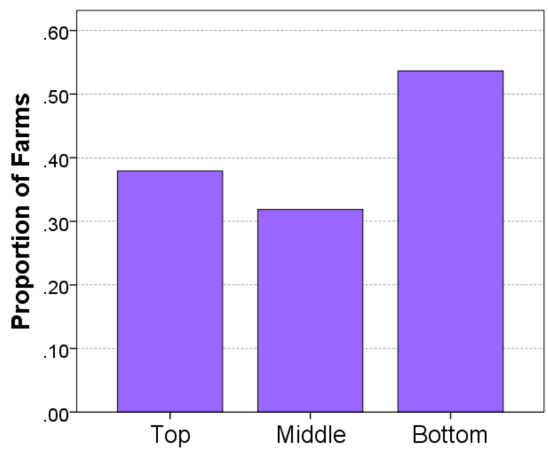
Figure 68: P use efficiency: Sheep Farms



Social Sustainability Indicators

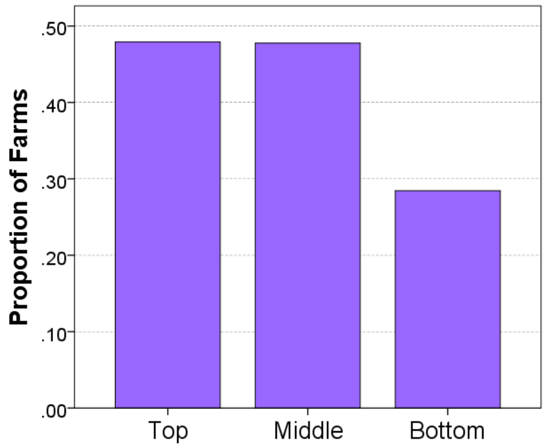
Forty-one per cent of all sheep farms were considered vulnerable in 2017. Figure 59 indicates that this ranged from 38% for the top performing sheep farms to 54% for the bottom third.

Figure 69: Household Vulnerability: Sheep Farms



Overall, 42% of sheep farmers had received formal agricultural education. There was no difference in the prevalence of agricultural education between the top and middle group of sheep farmers. However, the share of farmers in the bottom third of farms were much less likely to have undergone training at less than 30%. Figure 70 shows that agricultural training was associated with better economic performance.

Figure 70: Agricultural Education: Sheep Farms



On average, 12% of all specialist sheep farms were classified as being at risk of isolation. Figure 71 shows that this was significantly higher among the bottom cohort of sheep farms at 23%.

Figure 71: Isolation Risk: Sheep Farms

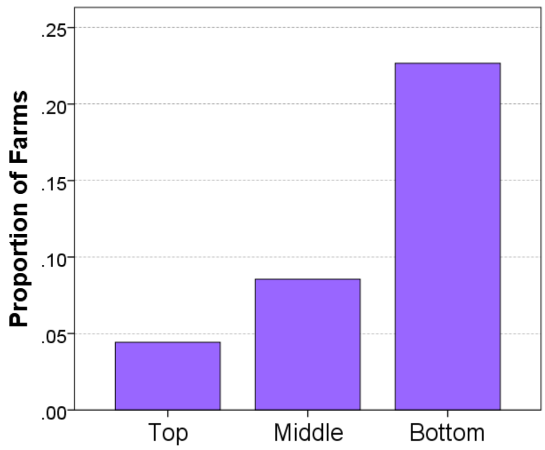
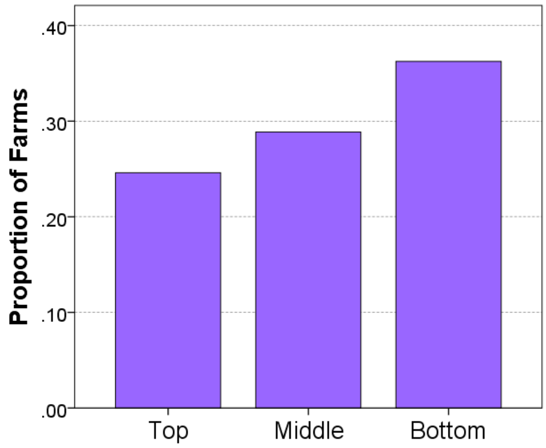


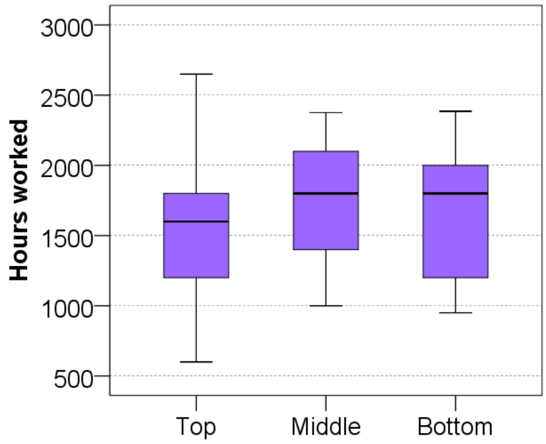
Figure 65 shows that the high age profile was generally more common among the bottom cohort of specialist sheep farms (36%) as compared to the top and middle groups.

Figure 72: High Age Profile: Sheep Farms



Sheep farmers worked an average of 1,644 hours per year (or 31.6 hours a week). In common with cattle farms, it should be noted that this may not capture their true work/life balance, as 34% of sheep farmers are also engaged in off-farm work (Figure 73).

Figure 73: Hours Worked: Sheep Farms



Sheep Farm Innovation Indicators

The four innovation indicators selected for sheep farms were the same as those for cattle: whether at least 50% of slurry was spread in the period January-April, whether a farmer was applying lime, whether a farmer was reseeding and whether or not the farm operator was a member of a discussion group.

Greater levels of springtime application of slurry were more common across the middle cohort at 44%. However, it should be noted that sheep farms tend to be more associated with farm yard manure type storage systems which might not lend themselves to early season application.

Figure 74: Spring Slurry: Sheep Farms

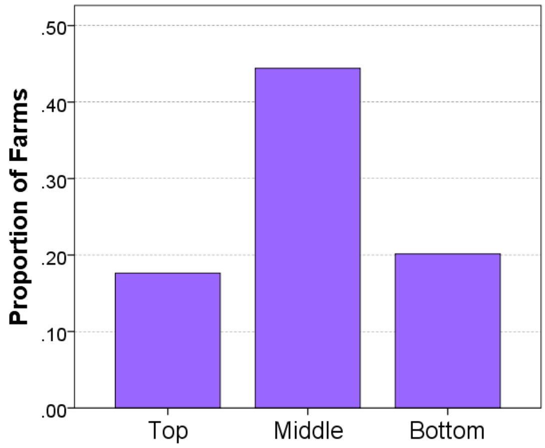


Figure 75 shows that liming activity was again more prevalent across the better economic performing farms with 28 and 29% of the top and middle cohorts engaged in liming compared to only 9% of the bottom group.

Figure 75: Liming: Sheep Farms

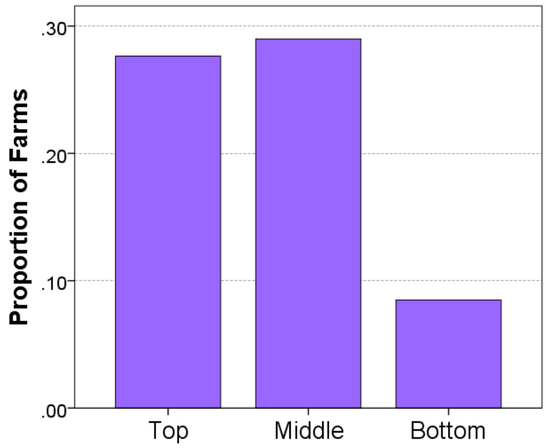


Figure 76 shows that low levels of reseeding were evident for specialist sheep farms across all three groups.

Figure 76: Reseeding: Sheep Farms

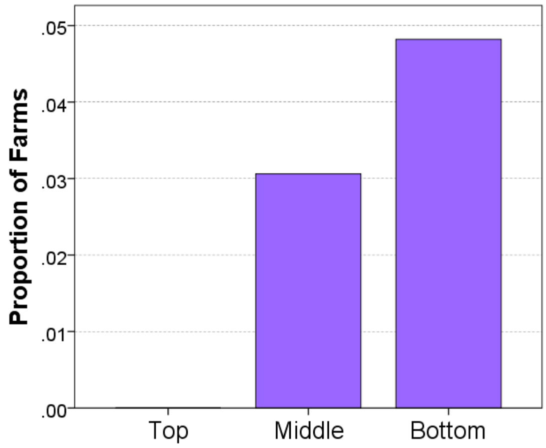
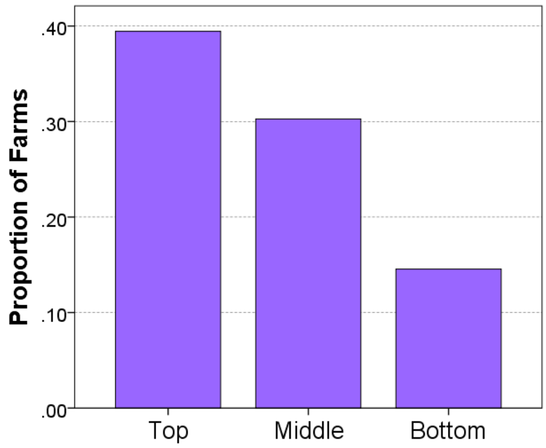


Figure 77 shows that membership of a discussion group was higher among the top third of farmers at 39%, compared to approximately 30% for the middle group and 15% for the bottom group.

Figure 77: Discussion Group: Sheep Farms

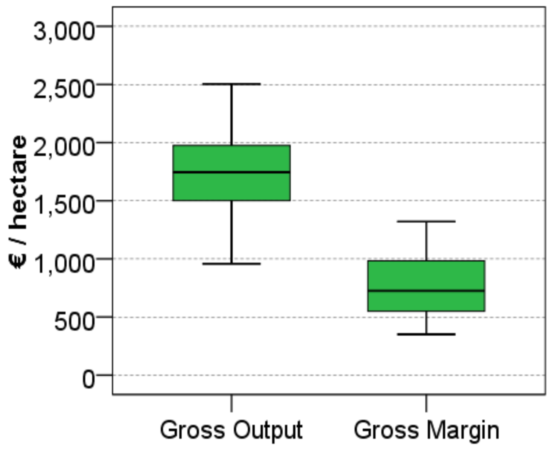


4.4 Tillage Farms

Economic Sustainability Indicators

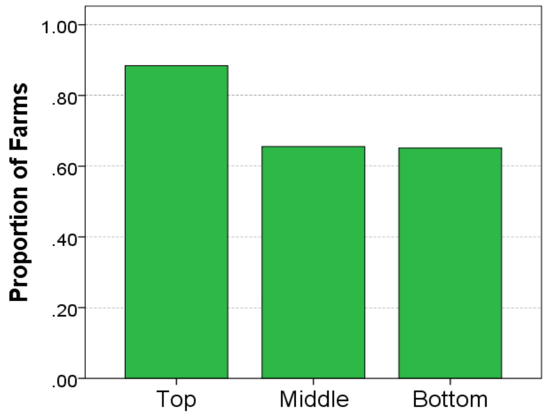
Figure 78 shows that the average gross output per hectare for tillage farms was €1,734 and the average gross margin per hectare was €817 in 2017.

Figure 78: Economic Return and Profitability of Land: Tillage Farms



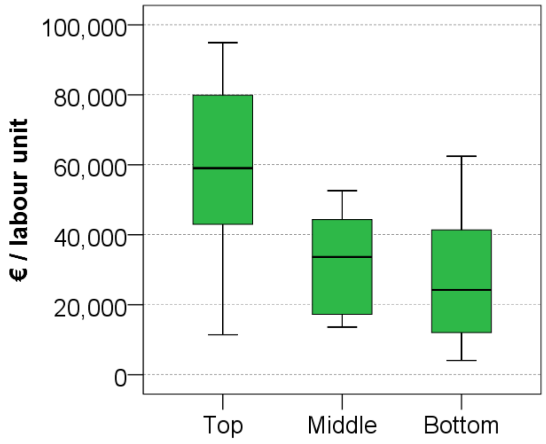
Overall, 74% of tillage farms were classified as economically viable. Figure 79 shows that the middle and bottom groups had lower levels of viability at 66% compared to 88% for the top group.

Figure 79: Economic Viability: Tillage Farms



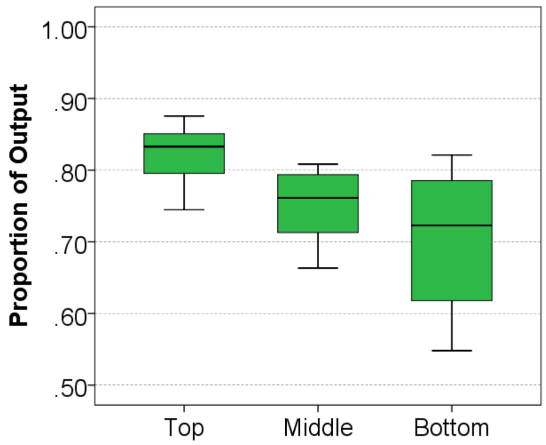
The average tillage income per labour unit (for unpaid owned family labour) was €44,330. Figure 80 indicates a large range in incomes, with the top one-third (ranked by gross margin per hectare) earning an average of €63,004 per labour unit, and the middle and bottom thirds earning €36,044 and €31,602 per labour unit respectively. For some of the most profitable tillage farms, income per labour unit is especially high due to the large proportion of the labour utilised on tillage farms being undertaken indirectly by hired labour (via the use of external contractors).

Figure 80: Productivity of Labour: Tillage Farms



Tillage farms received 75% of their output value from the market on average. Figure 81 shows that the top third of tillage farms derived 82% of farm output from the market, and the bottom third 71% on average.

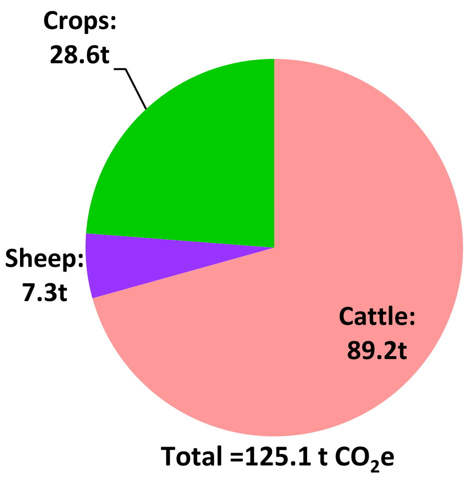
Figure 81: Market Orientation: Tillage Farms



Environmental Sustainability Indicators

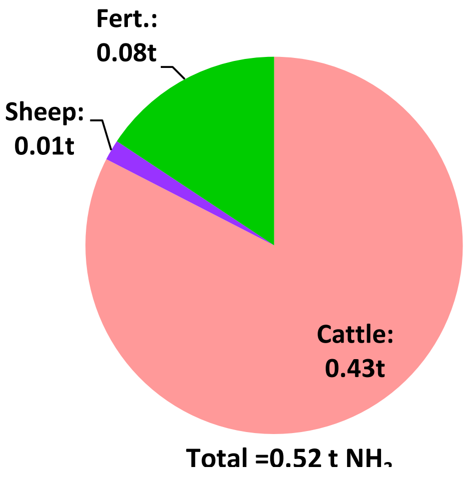
The average tillage farm emitted 125.1 tonnes CO_2 equivalents of agricultural GHG in 2017. This is illustrated in Figure 82, which indicated that approximately 23% was from crop production. Despite being specialised in crop production, 71% of tillage farm emissions were from cattle present on these farms, with a further 5% from sheep.

Figure 82: Agricultural GHG Emissions for the average Tillage Farm



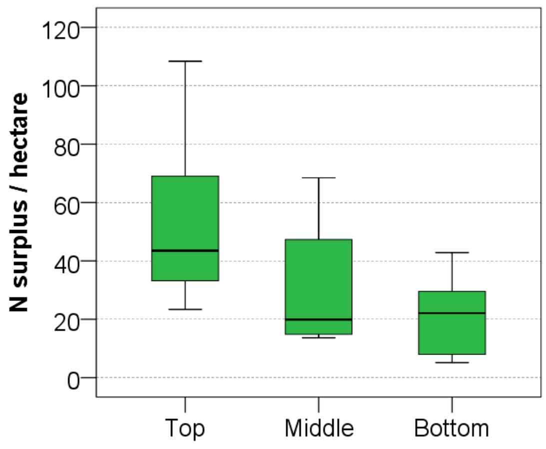
Tillage farms on average emitted 0.52 tonnes of ammonia in 2017. Again even though the main output is crop related the majority of emissions are associated with cattle rearing (83%). The majority of remaining emissions 15% was associated with chemical fertiliser application.

Figure 83: Total Ammonia Emissions for the average Tillage Farm



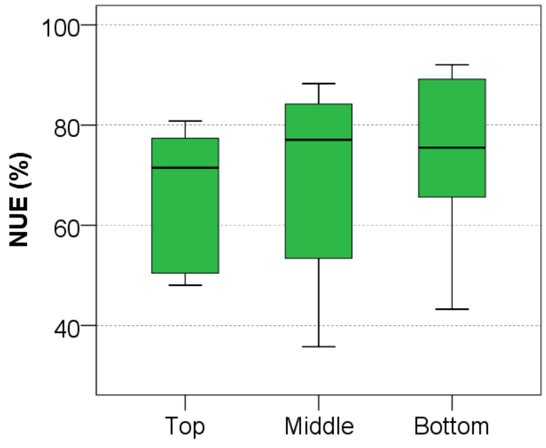
The average N surplus was 43 kg per hectare, but there was a large range in the results. Figure 84 shows higher N surpluses were aligned with higher economic performance. It should be noted that not all tillage farms from the Teagasc NFS are included here, as some farms import manure, quantities of which are not currently recorded. Hence, this cohort was excluded from the analysis.

Figure 84: N Balance per hectare: Tillage Farms



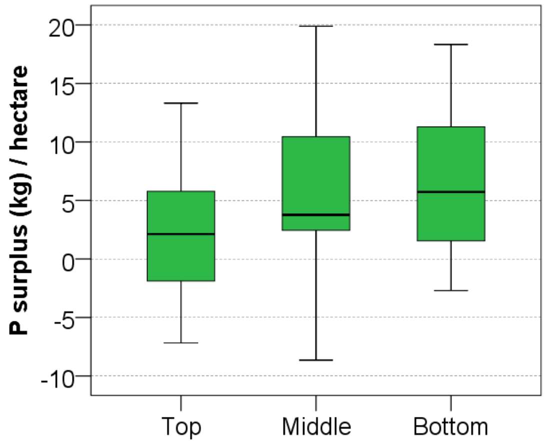
Across all tillage farms, the average N use efficiency was circa 70%. Average N use efficiency was similar across the groups, ranging from 67% to 72% (as illustrated in Figure 85).

Figure 85: N Use Efficiency: Tillage Farms



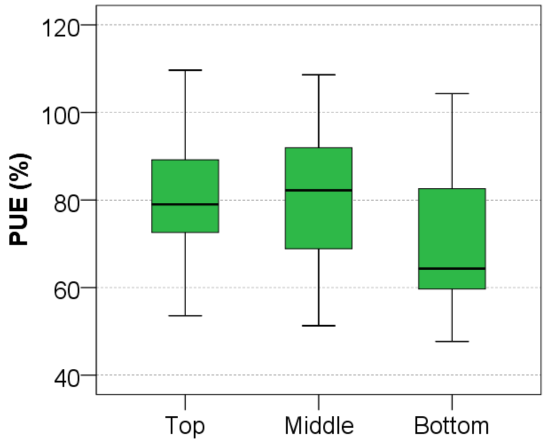
The average P balance across all tillage farms was 4.6 kg per hectare. However, as illustrated in Figure 86. There was a large range of results around these averages.

Figure 86: P Balance per hectare: Tillage Farms



P use efficiency averaged circa 91% across all tillage farms. P use efficiency tended to be higher across the middle and top groups compared to the bottom cohort as illustrated by Figure 87.

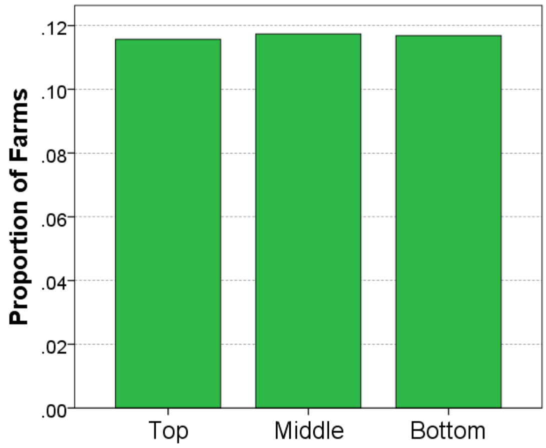
Figure 87: P Use Efficiency: Tillage Farms



Social Sustainability Indicators

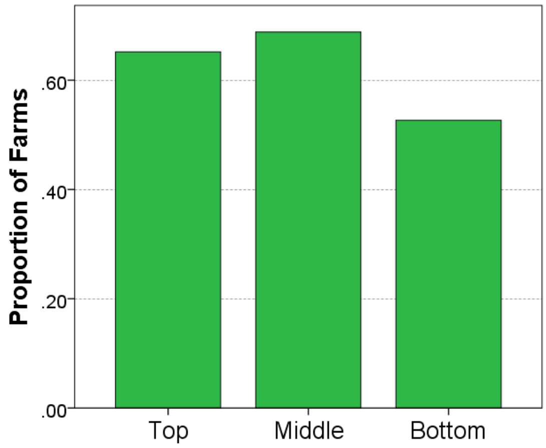
A total of 11% of tillage farms are considered economically vulnerable on average. Figure 88 indicates that this rate is uniform across the top, middle and bottom cohorts.

Figure 88: Household Vulnerability: Tillage



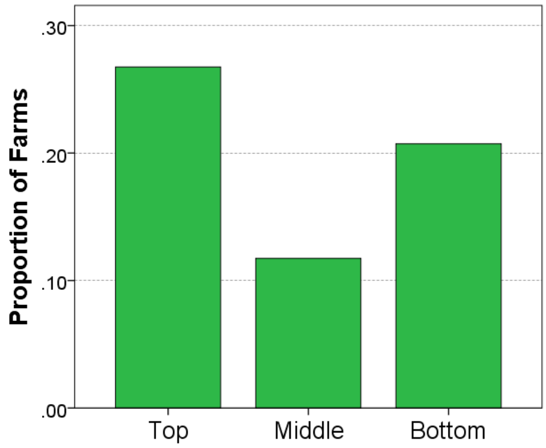
A total of 61% of tillage farmers had received some form of agricultural education or training. Figure 89 shows that this rate was slightly lower for the bottom performing third of tillage farms.

Figure 89: Agricultural Education: Tillage Farms



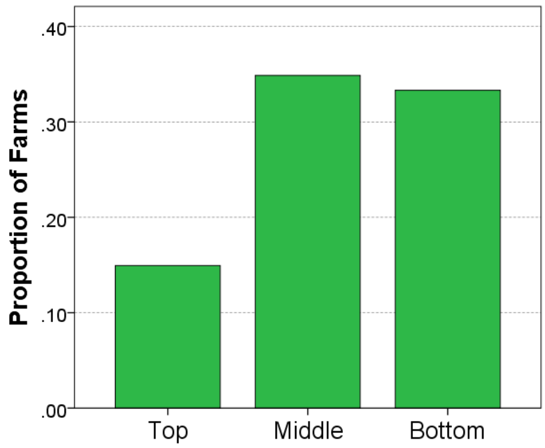
Overall, 19% of tillage farms were identified as at being of risk of isolation (where the farm operator lived alone). This rate was highest across the top performing cohort at 27% as illustrated by Figure 90.

Figure 90: Isolation Risk: Tillage Farms



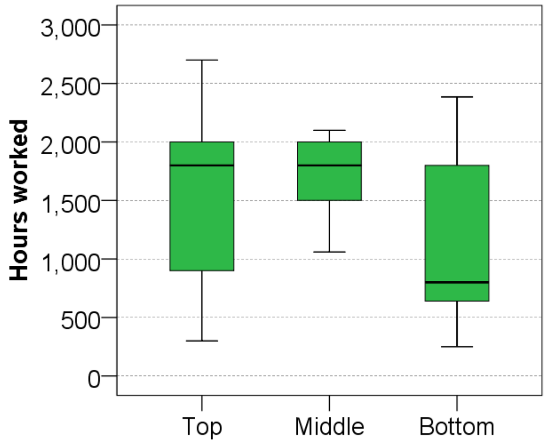
An average of 28% of tillage farms were identified as having a high age profile. Figure 91 shows that almost one-third of farm households in the bottom and middle group respectively had a high age profile, compared to 15% for the top cohort.

Figure 91: High Age Profile: Tillage Farms



The average tillage farmer worked 1,462 hours per year (28 hours per week). However, Figure 92 shows that the average was considerably lower for the bottom third of farms, ranked by gross margin per hectare, at 1,133 hours per year (22 hours a week). Results indicate that the bottom cohort tend to hire more contractors to do field work hence reducing their own time contribution.

Figure 92: Hours Worked: Tillage Farms



Tillage Innovation Indicators

The innovation indicators examined for tillage farms were: liming rates, engaging in forward selling of crops, membership of a discussion group and growing of a break crop.

Figure 93 shows that the liming rates were similar for the top and bottom performing cohorts at 37% and 34% respectively, compared to 23% for the middle cohort.

Figure 93: Liming: Tillage Farms

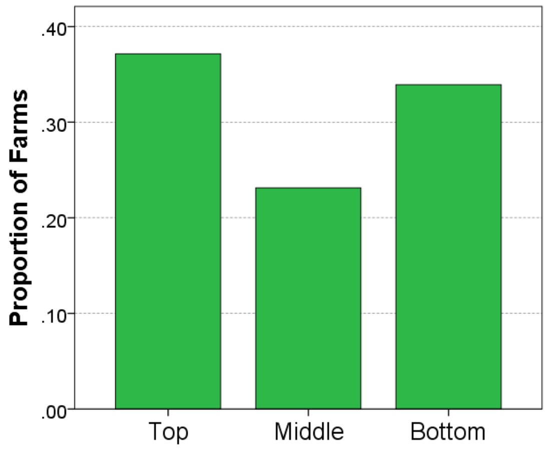


Figure 94 shows that the forward selling of crops was very limited in 2017 with only a small percentage of the top and middle group of tillage farms (4%) engaging in this activity.

Figure 94: Forward selling: Tillage Farms

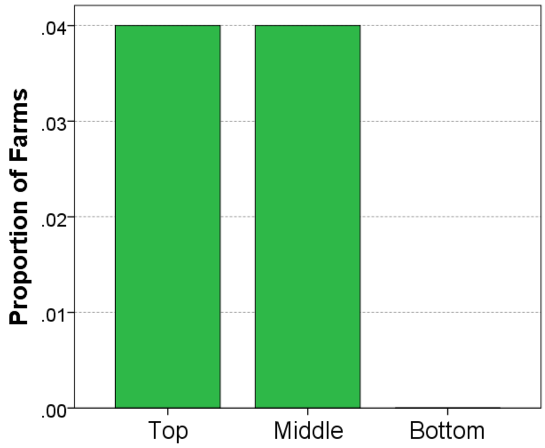


Figure 95 shows that those farms where the operator was a member of a discussion group performed better economically Between 25% and 29% of farms in the top and middle groups respectively were in a discussion group, compared to 17% for the bottom cohort.

Figure 95: Discussion Group: Tillage Farms

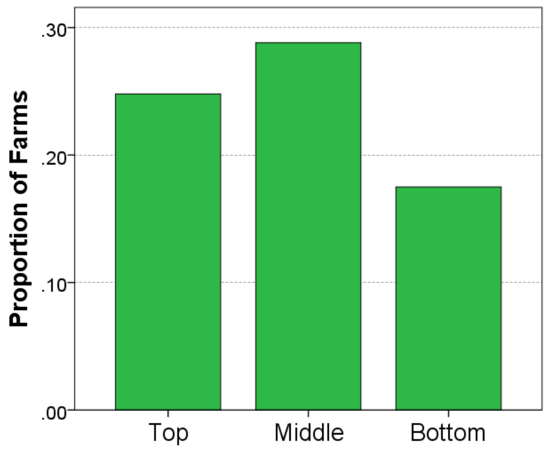
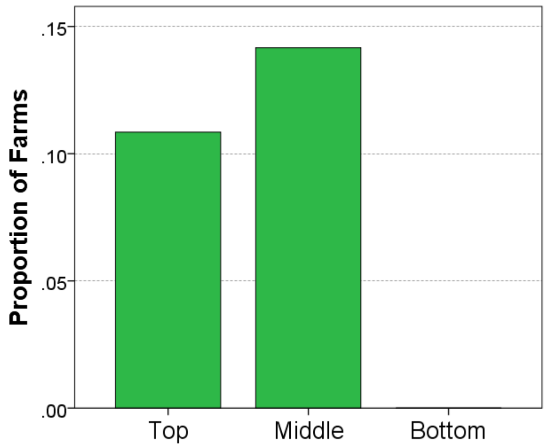


Figure 96 shows that higher economic performance was positively associated with the growing of a break crop.

Figure 96: Break Crops: Tillage



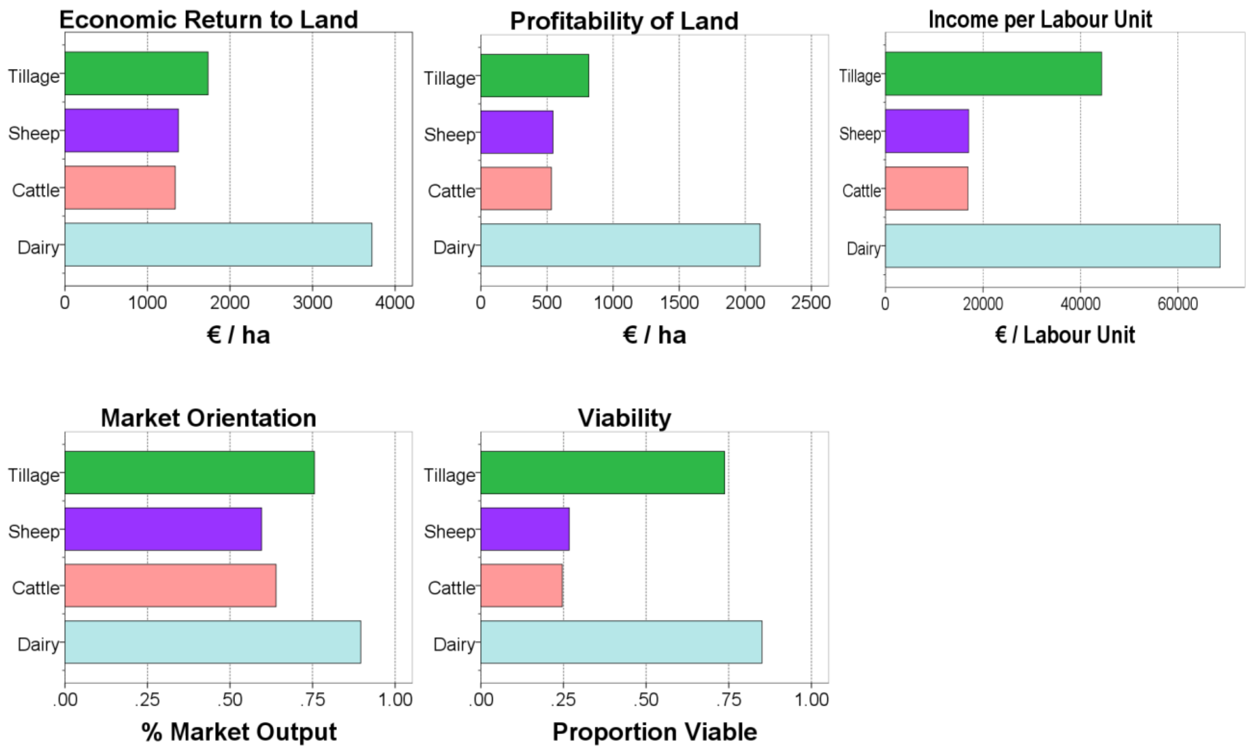
5. Farm System Comparisons 2017

Economic Indicators: A comparison of economic sustainability across different farm types is shown in Figure 97 below. In general, dairy farms show the strongest economic performance, significantly ahead of all other systems in terms of economic return and profitability on a per hectare basis.

Tillage was ahead of both cattle and sheep (which were similar) for economic return and profitability of land per hectare but was lower than dairying in terms of income per labour unit. Cattle and especially sheep farms returned significantly lower income per labour unit in comparison to dairying and tillage farms in 2017.

The farm systems are most similar in terms of market orientation, with dairy and tillage having the greatest share of outputs from the market. Cattle and sheep farms are most at risk financially, with only around 25% within both systems classed as economically viable. Dairy farms were the most economically viable followed by tillage systems.

Figure 97: Economic Sustainability: Farm System Comparison 2017 (average per system)



It is important to note that these are average values for each farm type and that earlier analysis has highlighted the range around these average values in the case of each farm system type.

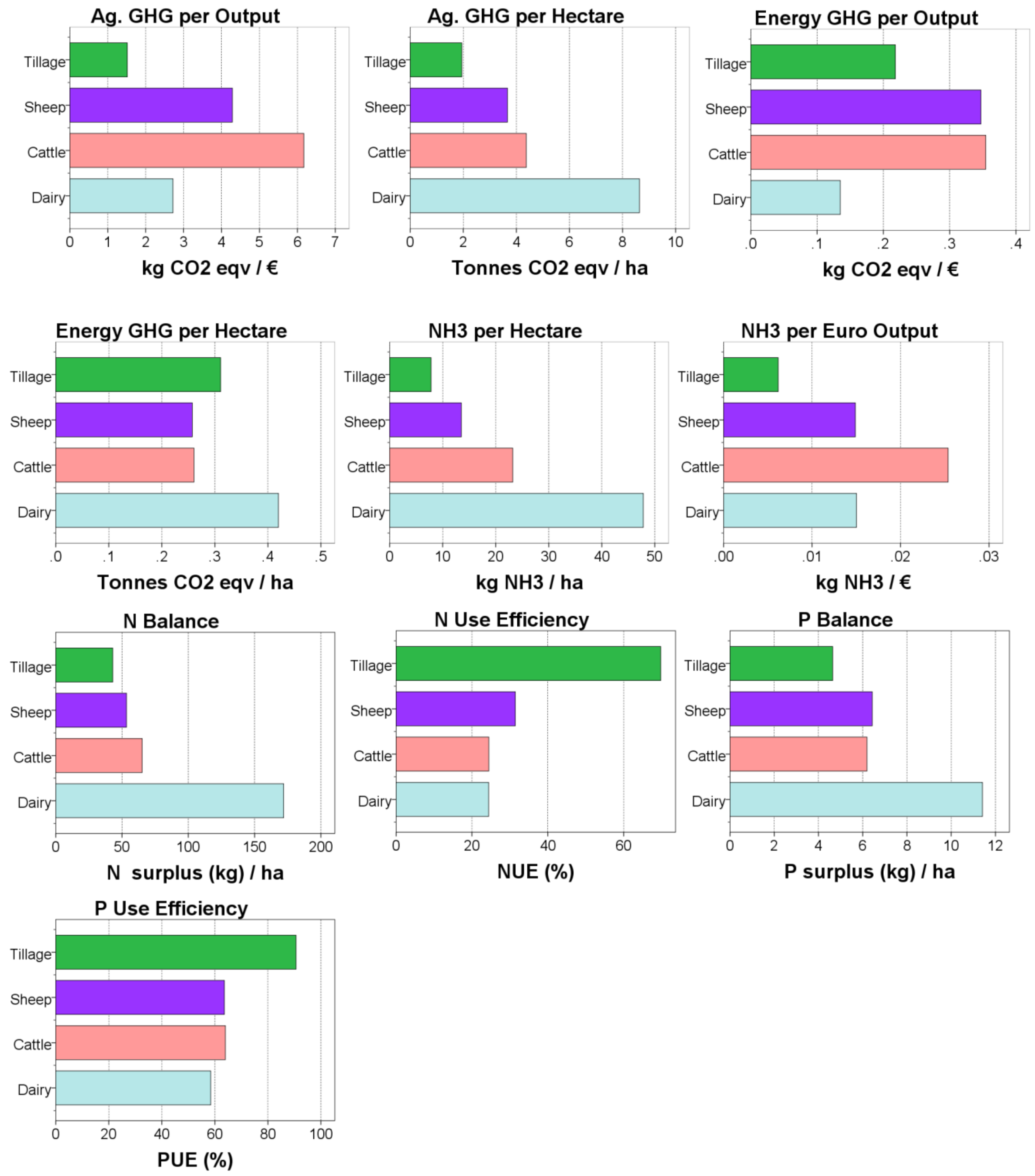
Environmental Indicators: The environmental sustainability of farms is more difficult to compare directly across different farm systems, as the indicators are more directly linked with the type of farming undertaken and different outputs produced. More detail can be revealed by comparing within farm type variations (see previous section), but some shared environmental indicators across different farm types are presented in Figure 98.

Livestock farms have higher greenhouse gas emissions per hectare than tillage, this is expected due to the greater emissions associated with animals, especially ruminant systems. Per hectare, dairy farms show the largest emissions, significantly greater than any other system, due to the greater production intensity on these farms. Dairy emissions are a function of greater stocking rates, more energy intensive diets for dairy cows and more use of chemical fertilisers than the other livestock systems. In terms of kg of GHG emitted per Euro of output generated, cattle and sheep farms had much higher emission levels due to the greater value/volume of output associated with dairying systems.

In common with GHG emissions, ammonia emissions per hectare were significantly higher on dairy farmers compared to all other systems in 2017. Cattle farms had the next highest level of emissions (although half that of dairy farms) followed by sheep and tillage farms. In terms of ammonia (NH_3) emission per Euro of market output generated, cattle farm emitted the highest level of ammonia (due to the generally lower levels of output) followed jointly by dairy and sheep farms. Tillage farms have the lowest level of ammonia emission per Euro of output generated due to the lower number of livestock on these farms.

Dairy farms have the largest N surplus per hectare due to the greater levels of livestock production intensity per hectare in this system. In terms of the input-output accounting nitrogen use efficiency (NUE) metric, dairy is similar to the other livestock systems, while tillage farms have greater nitrogen use efficiency on average. It should be noted, however, that this analysis excludes tillage farms with manure imports. Dairy farms had the highest farm gate level P balances, significantly higher than those of the cattle, sheep and tillage systems. However, this metric should be interpreted with caution as reference to a soil test is required to establish optimal P balance on farms and such soil test data are not available for farms in the NFS. P use efficiency was highest on tillage farms, which was higher than that observed across all of the livestock systems, which were on average at a similar level.

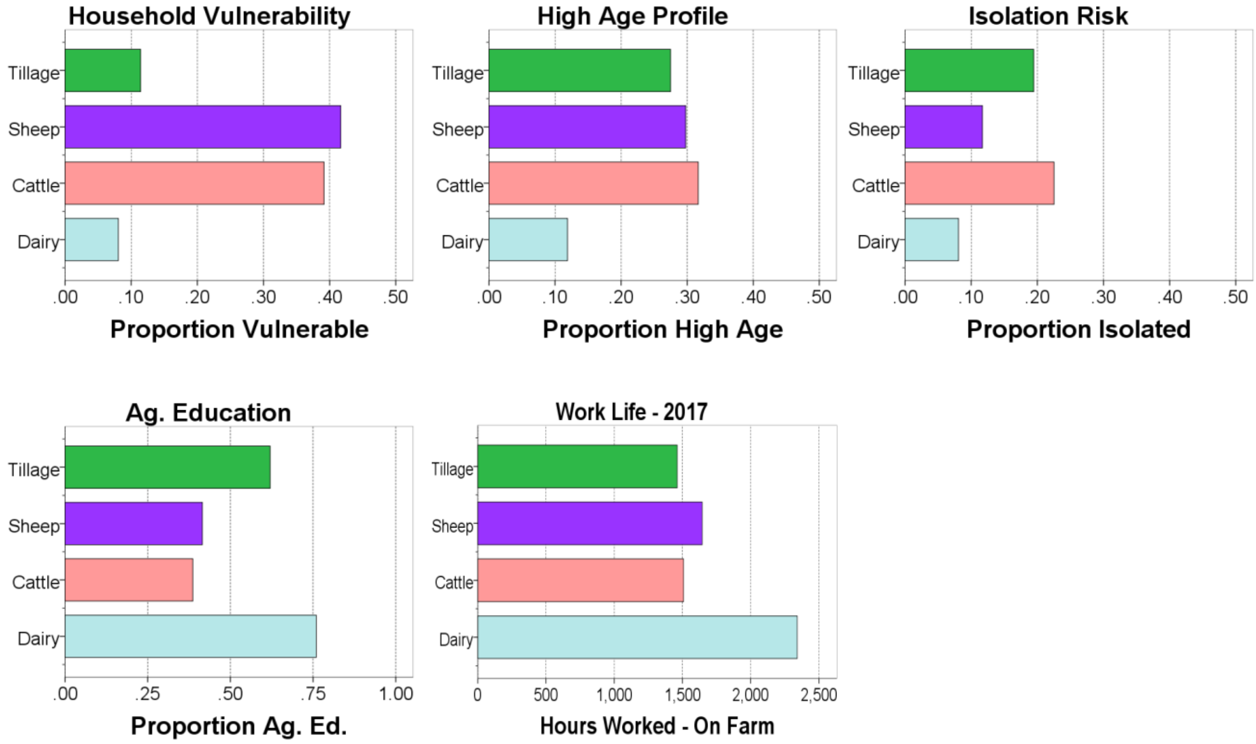
Figure 98: Environmental Sustainability: Farm System Comparison 2017 (average per system)



Social Indicators: Comparing the social sustainability of different farm types (in Figure 99) shows a similar overall trend to the economic performance indicators in Figure 89, with dairy and tillage farms distinct from cattle and sheep systems, but with some notable exceptions. The greater labour intensity of dairying is illustrated by the longer hours worked, although it should be noted that other farm systems are more likely to incur hours of off-farm employment, which if combined with hours worked on the farm would significantly increase total labour input by those farmers.

Given that there were lower levels of economic viability across cattle and sheep farms (see Figure 97) these systems were also more likely to have a more vulnerable household structure (non-viable with no off-farm employment within the household). Cattle and sheep farms were also more likely to have a high age profile, while cattle and tillage farms were more inclined to be farmed by farmers living alone, however, there was less variation for these than other social sustainability indicators. Dairy and tillage farmers were more likely to have attained agricultural education or training than cattle or sheep farmers, on average.

Figure 99: Social Sustainability: Farm System Comparison 2017 (average per system)



6. Time Series Comparisons with a three year rolling average: 2012-2017

Building on research presented in previously published sustainability reports (Hennessy et al., 2013; Lynch et al., 2016a), we can now begin to track changes in the evolution over time of farm-level sustainability indicators. The figures presented below highlight changes in indicator scores, with averages across all farm types. As short term input and output price volatility and weather events in a given year can occur and distort temporal trends, results below are presented on the basis of a three year rolling average (i.e. the result for 2012 is based on the average of the years 2010 to 2012 inclusive and is labelled as such). Annual average results for each indicator are also provided in Appendix 1.

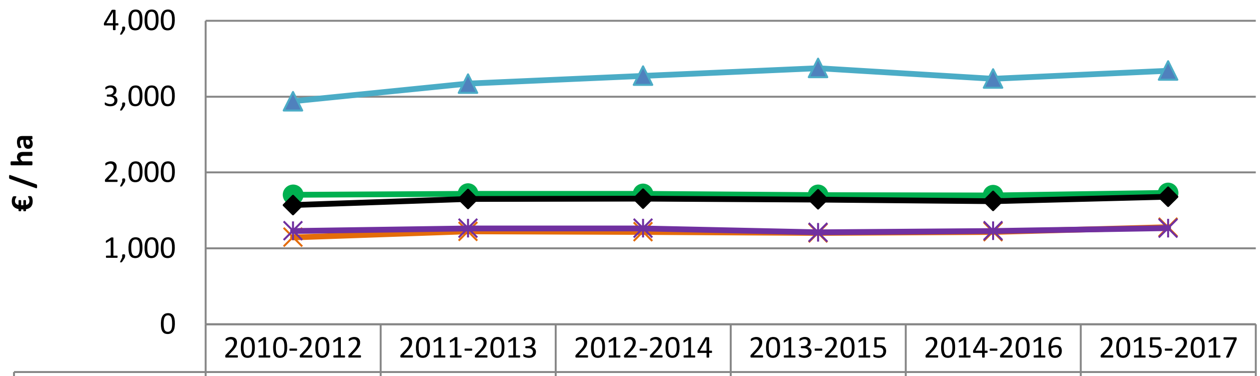
It is important to appreciate that some factors influencing the various indicator measures shown here are partially within the control of an individual farmer (e.g. input use efficiency) and hence may be improved by changes in farmer behaviour, while others factors are outside of an individual farmer's control (e.g. some farm output prices, weather conditions, soil quality). Since farming is influenced by weather conditions, which vary from year to year, and which therefore may affect the level of production or the level of input utilisation in a given year, this limits the inferences that can be drawn from apparent trends in a short-term time series. The reported values can thus be thought of as containing both the signal and noise components.

6.1 Economic sustainability indicators

Figure 100 shows that the value of economic return to land (gross output (€) per hectare) tended to increase over the study period. However, across individual farm systems, there are notable differences; dairy farms have significantly higher levels of output per hectare compared to all other systems. Tillage farmers were next highest ahead of cattle and sheep systems.

Dairy farm output per hectare peaked in 2017 due to high milk prices and expansion in volumes produced post-milk quota abolition. Output per hectare was highest on tillage farms at the start of the period and followed a mainly declining trend thereafter until 2017. Cattle and sheep output per hectare remained relatively static over the study period (at circa €1,200 per ha).

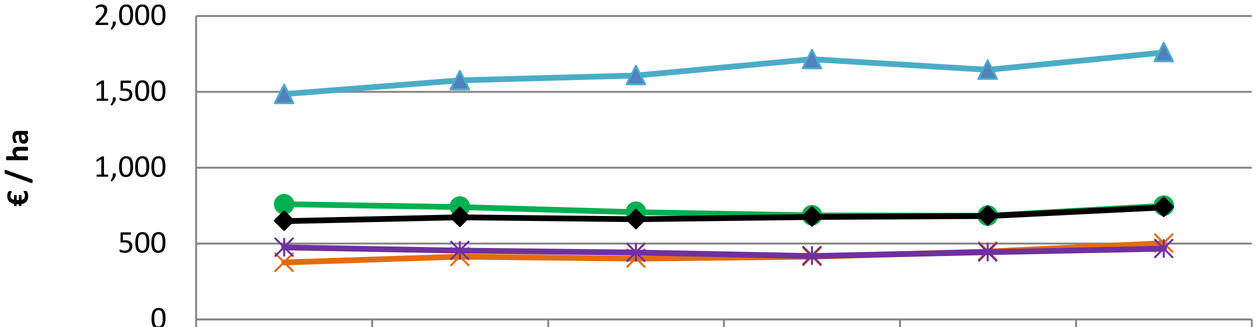
Figure 100: Economic Returns to Land: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	2,937	3,171	3,274	3,374	3,236	3,341
Cattle	1,145	1,223	1,218	1,203	1,217	1,279
Sheep	1,230	1,264	1,263	1,212	1,230	1,267
Tillage	1,705	1,719	1,718	1,702	1,698	1,730
All Farms	1,569	1,651	1,655	1,644	1,622	1,679

The profitability of land (gross margin per hectare) in dairying was again significantly higher than for all other systems and tended to increase over the years, significantly so at the end of the study period. Tillage farms again had the second highest gross margin per hectare. The lowest gross margins per hectare were returned by cattle and sheep farms which tended to be relatively static over the study period.

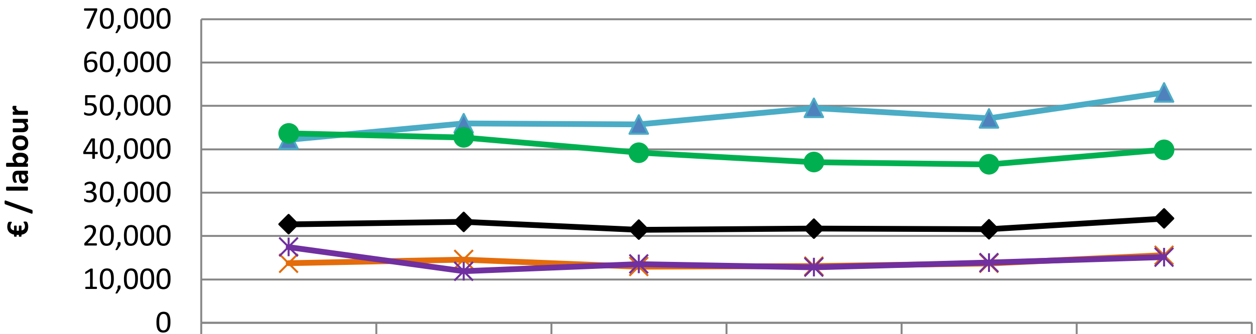
Figure 101: Profitability of Land: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	1,484	1,575	1,607	1,715	1,645	1,759
Cattle	375	413	401	413	448	501
Sheep	474	453	440	418	442	466
Tillage	759	741	707	685	682	748
All farms	648	674	660	676	682	738

Figure 102 reveals that comparisons of farm income per labour unit follow broadly similar trends as the gross output and gross margin per hectare indicators. However, the differences between farm types when income per labour unit are compared are not as pronounced as in the case of gross output and gross margin, with some adjustment to reflect different labour intensities of each production system. Returns to labour were significantly higher on dairy and tillage farms compared to cattle and sheep systems, due to the larger labour input on these farms.

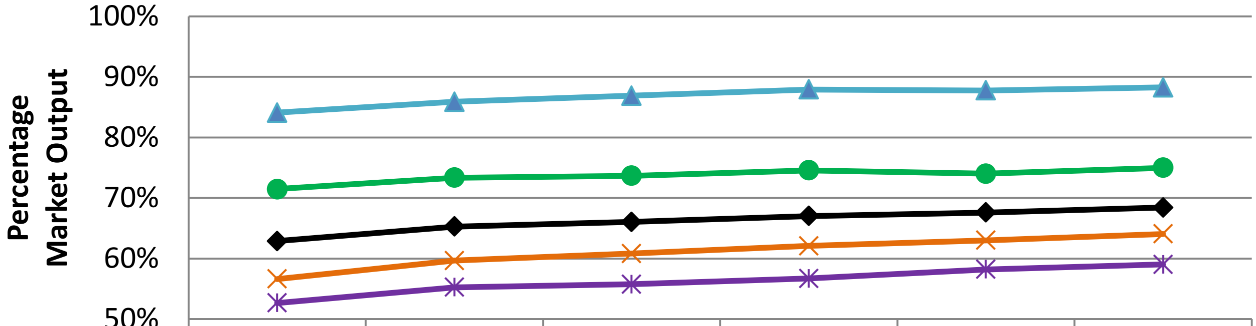
Figure 102: Productivity of Labour: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	42,229	45,998	45,731	49,544	47,118	53,066
Cattle	13,745	14,562	12,968	13,049	13,688	15,582
Sheep	17,453	11,879	13,545	12,787	13,892	15,144
Tillage	43,683	42,738	39,227	37,057	36,528	39,888
All Farms	22,696	23,241	21,450	21,695	21,565	24,049

Figure 103 illustrates that the average share of output derived from the market increased between 2012 and 2017 when measured using a three year rolling average from 63% to 69%. This is as a result of both a decrease in the value of direct payments, and an increase in market output. Dairying is the most market orientated of all the systems (84 to 88%) followed by tillage systems (71 to 75%). The market orientation of cattle systems increased from 57% at the start of the period to 64% at the end. A similar trend was evident for sheep systems where market orientation increased from 53% at the start of the period compared to 59% at the end of the period.

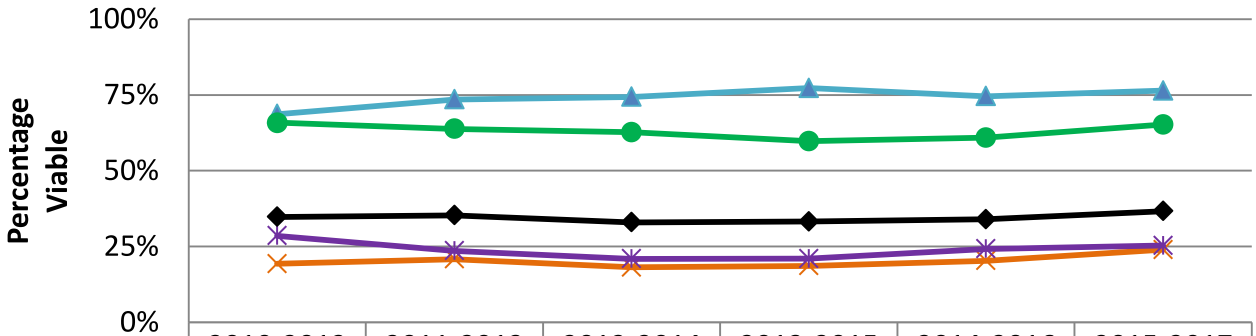
Figure 103: Percentage of Output Derived from Market: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	84%	86%	87%	88%	88%	88%
Cattle	57%	60%	61%	62%	63%	64%
Sheep	53%	55%	56%	57%	58%	59%
Tillage	71%	73%	74%	75%	74%	75%
All Farm	63%	65%	66%	67%	68%	68%

The same trends over time are also observed in terms of farm economic viability. Dairy and tillage systems have significantly higher levels of viability (60 to 76%) compared to cattle or sheep farms (19 to 25%) over the study period. Viability, as with the other economic indicators, was affected by sectoral output prices over the period.

Figure 104: Economic Viability: 3 year rolling average 2012-2017

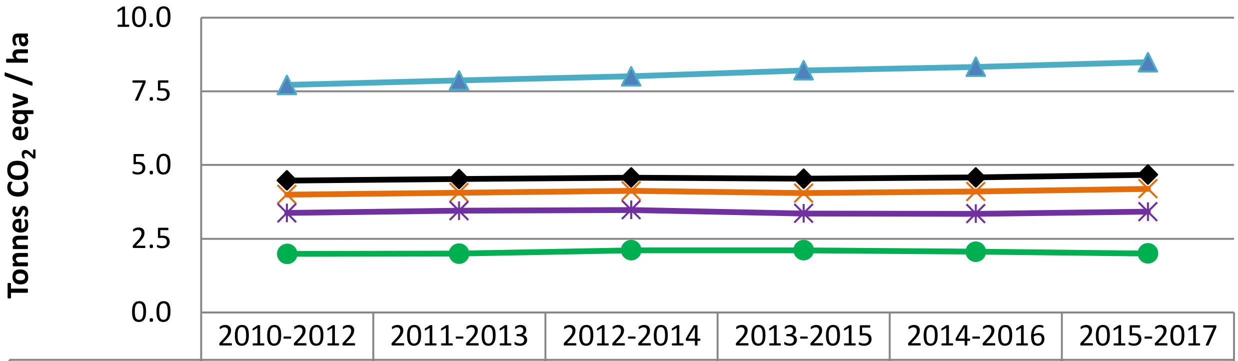


	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	69%	74%	74%	77%	75%	76%
Cattle	19%	21%	18%	19%	20%	24%
Sheep	29%	24%	21%	21%	24%	25%
Tillage	66%	64%	63%	60%	61%	65%
All Farm	35%	35%	33%	33%	34%	37%

6.2 Environmental sustainability indicators

Figure 105 illustrates that from a low in 2012 (4.5 tonnes CO_2 equivalent per hectare), agricultural GHG emissions per hectare have remained fairly stable between 2013 and 2017 across all farm systems (4.5 to 4.7 tonnes CO_2 equivalent per hectare). Due to the more intensive nature of production for dairy systems compared to all other grassland systems, agricultural GHG emissions per hectare are significantly higher. The main trends show an increase in dairy emissions per hectare (especially post milk quota abolition) and relative stability in emission intensity per hectare across the other systems.

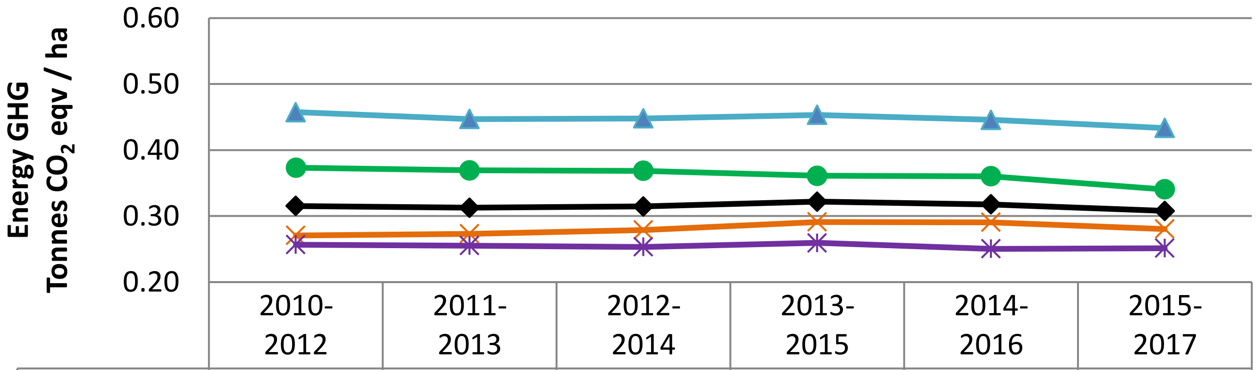
Figure 105: Agricultural Greenhouse Gas Emissions per hectare: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	7.7	7.9	8.0	8.2	8.3	8.5
Cattle	4.0	4.1	4.1	4.0	4.1	4.2
Sheep	3.4	3.4	3.5	3.4	3.3	3.4
Tillage	2.0	2.0	2.1	2.1	2.1	2.0
All Farms	4.5	4.5	4.6	4.5	4.6	4.7

Figure 106 indicates that energy based GHG emission generally remained stable over the study period. Higher emissions were prevalent across dairy farms.

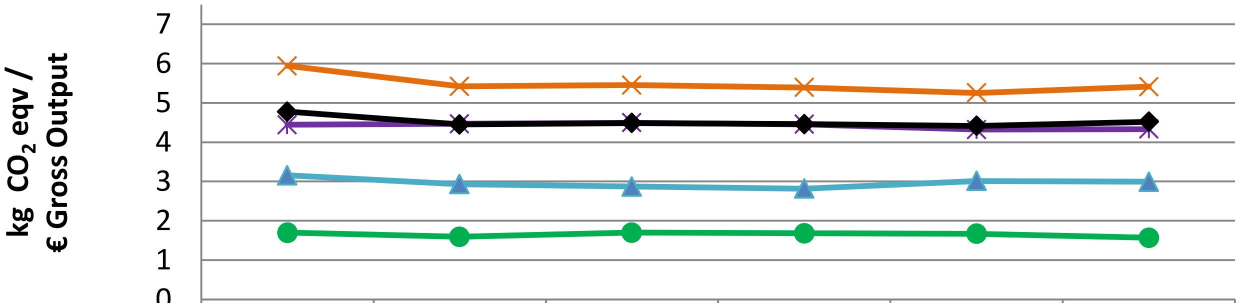
Figure 106: Energy Greenhouse Gas Emissions per hectare: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	0.46	0.45	0.45	0.45	0.45	0.43
Cattle	0.27	0.27	0.28	0.29	0.29	0.28
Sheep	0.26	0.26	0.25	0.26	0.25	0.25
Tillage	0.37	0.37	0.37	0.36	0.36	0.34
All Farms	0.32	0.31	0.31	0.32	0.32	0.31

Figure 107 illustrates that agricultural GHG emissions per euro of gross output generated have declined post 2012 and remained stable thereafter across all systems on a three year rolling average basis. Emissions per Euro of output generated are significantly higher across cattle and sheep farms over the years considered. These results are reflective of the greater financial return available from dairying and the lower emissions associated with non-livestock orientated tillage systems. The increase in dairy emissions per hectare is not reflected in emissions per € output, reflecting the fact that there has been substantial variability in milk prices over the years considered.

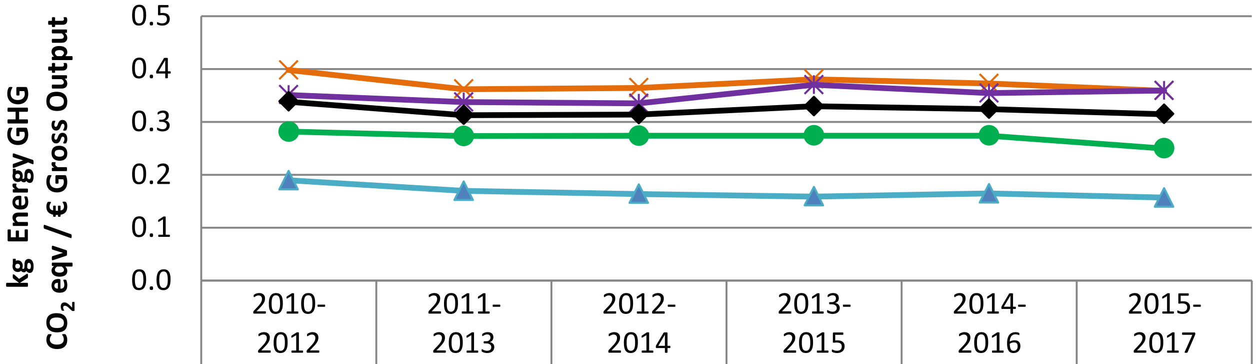
Figure 107: Agricultural GHG Emissions per Euro output: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	3.2	2.9	2.9	2.8	3.0	3.0
Cattle	5.9	5.4	5.5	5.4	5.3	5.4
Sheep	4.4	4.5	4.5	4.5	4.3	4.3
Tillage	1.7	1.6	1.7	1.7	1.7	1.6
All Farms	4.8	4.5	4.5	4.5	4.4	4.5

Figure 108 illustrates energy based GHG emissions per € of market based gross output. Results follow a similar pattern to that of agricultural based emissions where energy emissions per Euro of output are significantly higher across cattle and sheep farms over the study period compared to dairying. Across all farm systems, energy emissions per Euro of output shoed a declining trends of the study period.

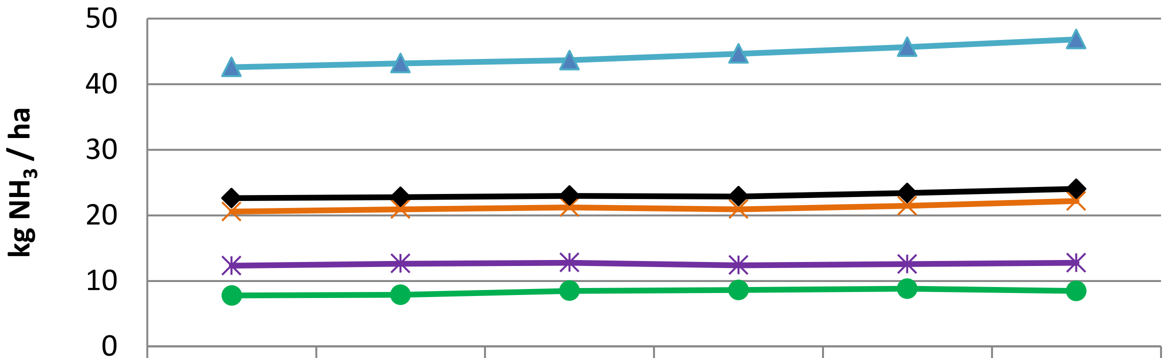
Figure 108: Energy GHG Emissions per Euro output: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	0.19	0.17	0.16	0.16	0.16	0.16
Cattle	0.40	0.36	0.36	0.38	0.37	0.36
Sheep	0.35	0.34	0.33	0.37	0.35	0.36
Tillage	0.28	0.27	0.27	0.27	0.27	0.25
All Farms	0.34	0.31	0.31	0.33	0.32	0.31

Figure 109 illustrates that across all farms that ammonia (NH_3) emissions per hectare were relatively static between the start and middle of the study period before increasing toward the end of the study period on a three year rolling average basis. Again due to the more intensive nature of production, NH_3 emissions per hectare are significantly higher for dairy systems compared to all other grassland systems and especially tillage. The main trends show an increase in average dairy farm emissions per hectare (especially post milk quota abolition) and relative stability in emission intensity per hectare across the other systems, except for cattle farms where an increase in per hectare emissions was evident towards the end of the study period.

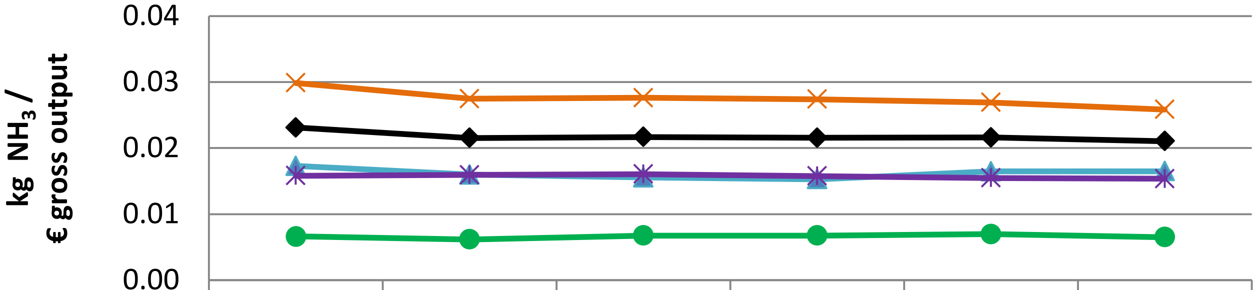
Figure 109: kg of Ammonia Emissions per hectare: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	42.61	43.18	43.66	44.66	45.67	46.85
Cattle	20.57	20.93	21.23	20.94	21.43	22.17
Sheep	12.31	12.64	12.78	12.38	12.55	12.75
Tillage	7.79	7.86	8.48	8.60	8.80	8.46
All Farms	22.62	22.78	22.99	22.88	23.39	24.03

Figure 110 illustrates NH_3 emissions per Euro of market based gross output. Results indicate that emissions per Euro of output were significantly higher on cattle farms compared to all other systems over the study period. This is a function of the low levels of output across these cattle farms. Dairy and sheep farms had very similar levels of ammonia emission per Euro of output generated (due to high output value and low levels of emissions respectively). Tillage farms had the lowest emissions per Euro of market based output generated.

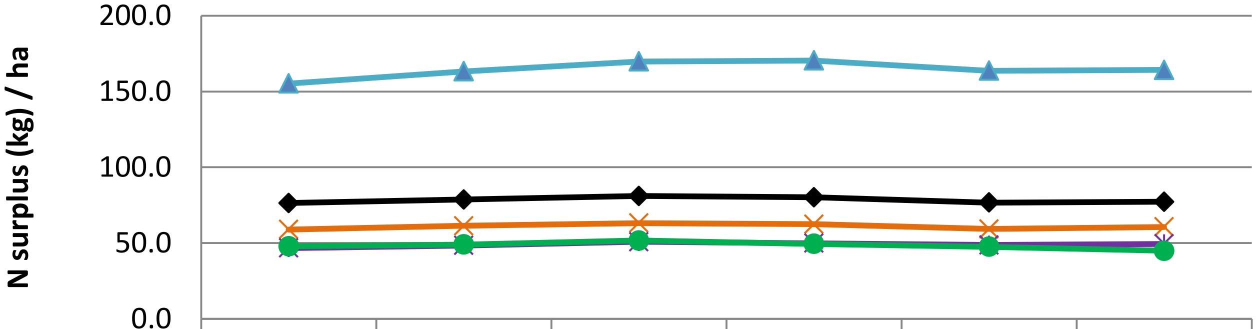
Figure 110: Ammonia Emissions per Euro Output: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	0.017	0.016	0.016	0.015	0.016	0.016
Cattle	0.030	0.027	0.028	0.027	0.027	0.026
Sheep	0.016	0.016	0.016	0.016	0.015	0.015
Tillage	0.007	0.006	0.007	0.007	0.007	0.006
All Farms	0.023	0.022	0.022	0.022	0.022	0.021

Figure 111 illustrates that nitrogen surpluses per hectare peaked mid study period for livestock farms and declined thereafter. Across all farm systems, N balance per hectare was slightly higher at the end versus the start of the study period. Again due to the more intensive nature of production, N surpluses were significantly higher for dairy farms compared to all other systems. Due to the non-livestock orientated nature of production on tillage farms, N surpluses were on average lowest across these farms over the study period. N surpluses are affected by a range of factors some within and some outside the farmer's control, such as variability in the weather. Higher N surplus years tended to be allied to poorer annual weather conditions.

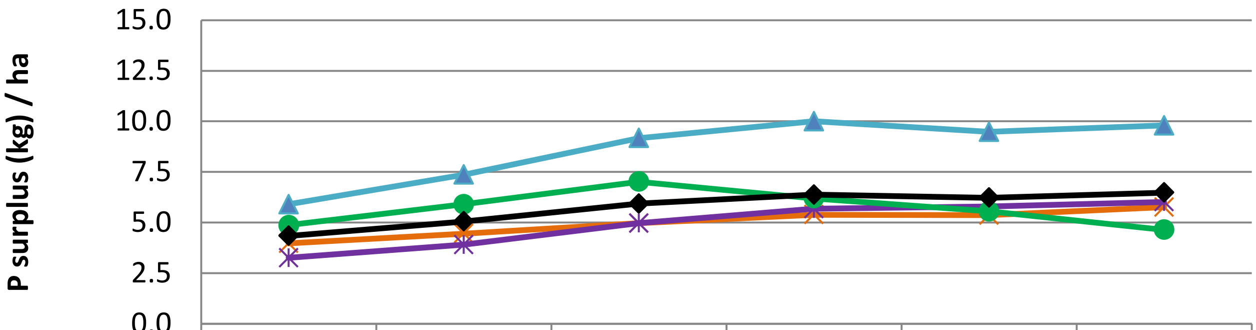
Figure 111: Nitrogen Balance per ha: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	155.3	163.3	169.8	170.4	163.7	164.2
Cattle	59.0	61.4	63.2	62.5	59.3	60.6
Sheep	46.7	48.4	50.8	49.9	48.8	49.4
Tillage	47.9	49.0	51.7	49.5	47.5	44.9
All Farms	76.4	78.7	81.1	80.2	76.7	77.2

Figure 112 illustrates that P balances tended to increase over the study period. P surpluses were significantly higher on dairy farms compared to all other systems post-2013. It should also be noted that P fertiliser allowances were increased in 2014 following regulatory changes, which allow more P to be applied to fields with sub-optimal soil P levels. Farm gate level P balances must be interpreted with care, since establishing the optimal balance requires a soil test. Farmers are allowed to run significant farm gate level surpluses if soil P status is sub optimal (deficient). In 2017, Teagasc analysed a total of 45,227 soil samples comprising of dairy, drystock and tillage enterprises (Teagasc, 2018). Results indicate that 60% of samples taken from dairy farms, 67% taken from drystock farms and 56% taken from tillage farmer were P deficient (at either index 1 or 2 for phosphorus).

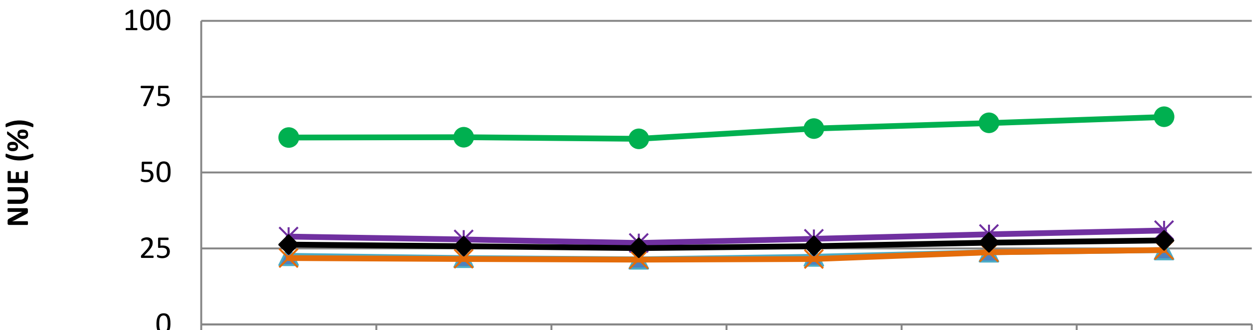
Figure 112: Phosphorus Balance per ha: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	5.9	7.4	9.2	10.0	9.5	9.8
Cattle	4.0	4.5	5.0	5.4	5.4	5.8
Sheep	3.3	3.9	5.0	5.7	5.8	6.0
Tillage	4.9	5.9	7.0	6.2	5.6	4.6
All Farms	4.3	5.1	5.9	6.4	6.2	6.5

Figure 113 illustrates that across all farm systems N use efficiency (NUE) (N outputs / N inputs) has generally increased over the years when examined on a rolling three year rolling average basis. Dairy and cattle farmers tended to have the lowest NUE over the study period, although NUE was seen to improve slightly between the start and end of the study period. Tillage NUE was generally significantly higher than all other systems due to the mainly non livestock nature of this system.

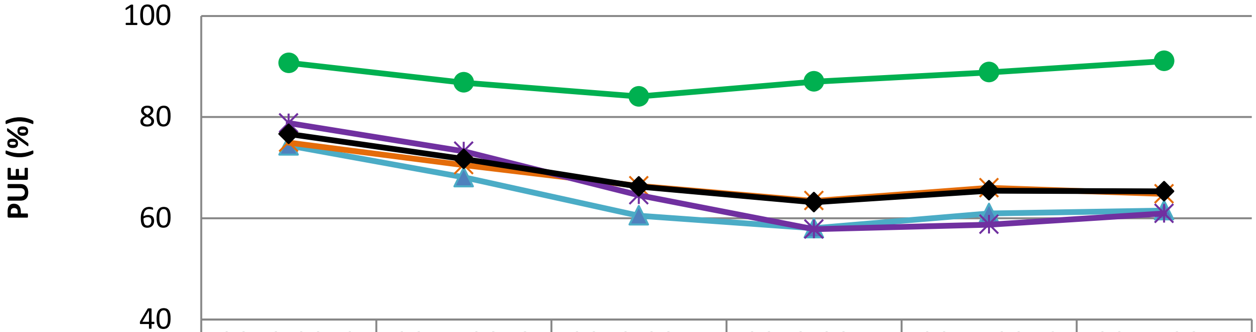
Figure 113: Nitrogen Use Efficiency: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	22.6	21.9	21.4	22.3	23.7	24.5
Cattle	21.8	21.6	21.3	21.5	23.7	24.5
Sheep	28.9	28.0	26.8	28.1	29.7	31.0
Tillage	61.6	61.6	61.1	64.5	66.3	68.3
All Farms	26.2	25.7	25.2	25.8	26.9	27.6

Figure 114 illustrates that across all farm systems P use efficiency (P outputs / P inputs) have generally declined between the start and end of the study period on a three year rolling average basis. Again it should also be noted that P fertiliser allowances were increased in 2014 following regulatory changes, which allow more P to be applied to fields with sub-optimal soil P levels. Farm gate level PUE must be interpreted with care, since establishing true PUE requires a soil test.

Figure 114: Phosphorus Use Efficiency: 3 year rolling average 2012-2017

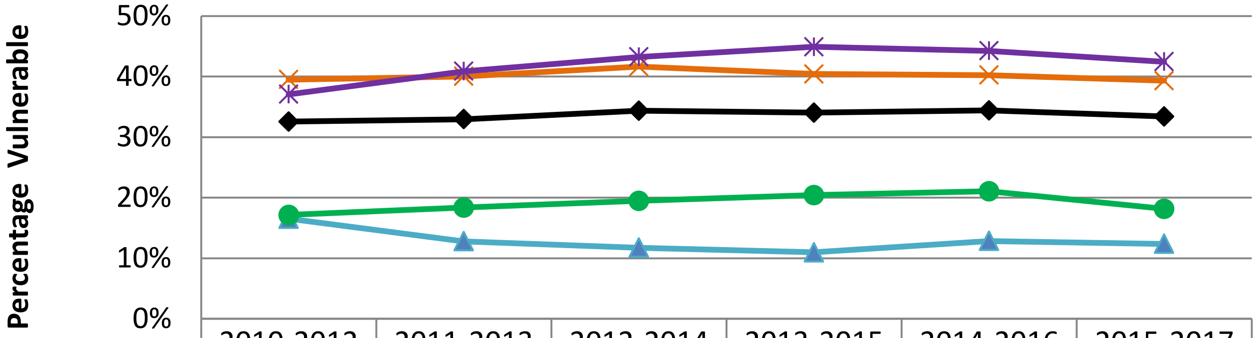


	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	74.4	68.1	60.6	58.0	61.0	61.6
Cattle	75.0	70.5	66.4	63.4	66.0	64.8
Sheep	78.8	73.2	64.6	57.8	58.8	60.9
Tillage	90.7	86.8	84.1	87.0	88.8	91.1
All Farms	76.7	71.7	66.3	63.2	65.5	65.3

6.3 Social Sustainability Indicators

Figure 115 shows that the rate of vulnerability (non-viable and no off-farm employment) of farming households has remained stable over the 2012-2017 period across all systems on a three year rolling average basis at between 33 and 34%. Dairying and tillage systems tended to have significantly lower levels of household vulnerability than cattle and sheep systems.

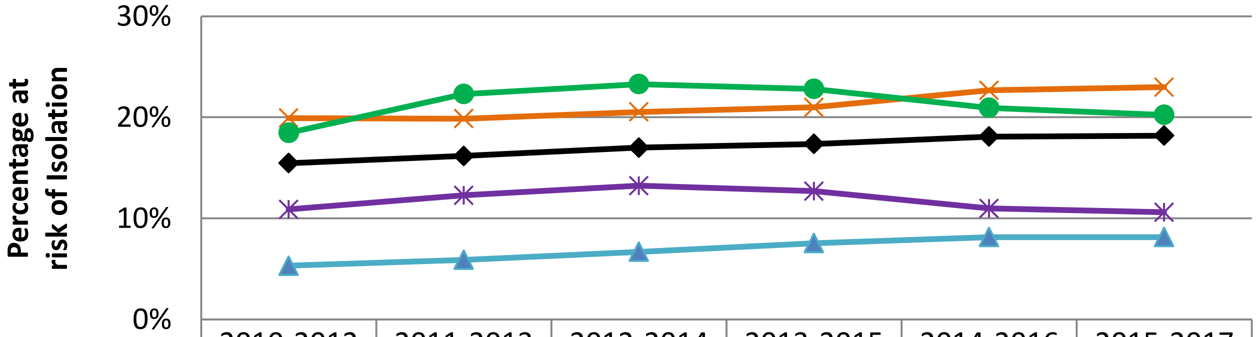
Figure 115: Farm Household Vulnerability: 3 year rolling average 2012-2017



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	17%	13%	12%	11%	13%	12%
Cattle	40%	40%	42%	40%	40%	39%
Sheep	37%	41%	43%	45%	44%	42%
Tillage	17%	18%	19%	20%	21%	18%
All Farms	33%	33%	34%	34%	34%	33%

Figure 116 shows that the percentage of farmers at risk of isolation increased from the start (15%) to the end (18%) of the study period across all systems on a three year rolling average basis. Isolation risk tended to be higher on tillage and cattle farms compared to dairy and sheep based systems.

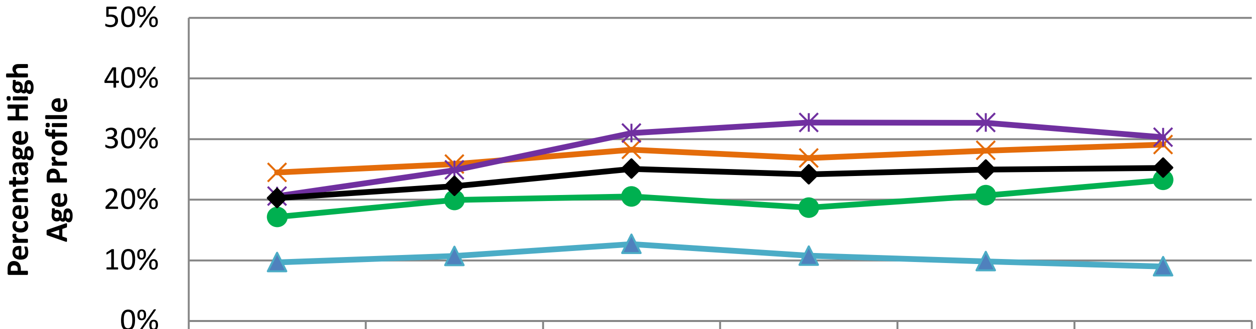
Figure 116: Isolation Risk: 3 year rolling average 2012-2017 (average per system)



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	5%	6%	7%	8%	8%	8%
Cattle	20%	20%	21%	21%	23%	23%
Sheep	11%	12%	13%	13%	11%	11%
Tillage	18%	22%	23%	23%	21%	20%
All Farms	15%	16%	17%	17%	18%	18%

Figure 117 shows that the percentage of all farms with a high age profile increased between the start and end of the study period (20% to 25%) when measured on a three year rolling average basis. Dairy farms tended to have the lowest age profile across all the farm systems (9 to 13%), compared to other systems which tended to be double this rate.

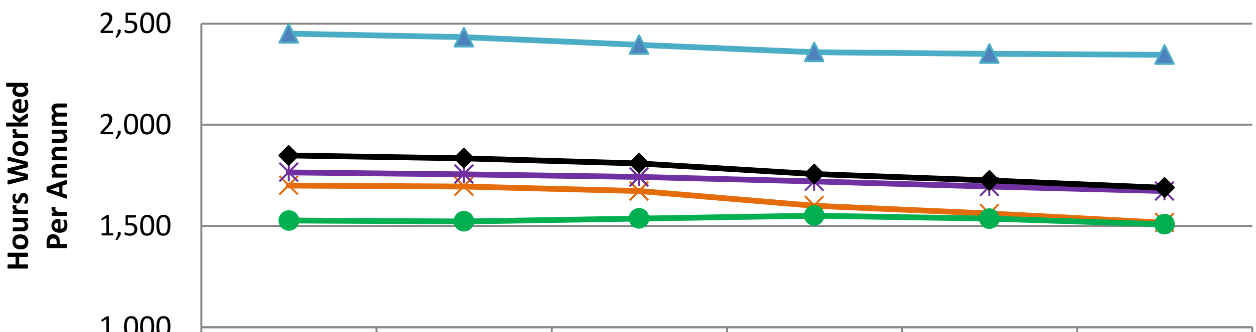
Figure 117: High Age Profile: 3 year rolling average 2012-2017 (average per system)



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	10%	11%	13%	11%	10%	9%
Cattle	24%	26%	28%	27%	28%	29%
Sheep	21%	25%	31%	33%	33%	30%
Tillage	17%	20%	21%	19%	21%	23%
All Farm	20%	22%	25%	24%	25%	25%

Figure 118 shows that the hours worked on-farm per annum declined slightly across all farm types between 2012 and 2017 when measured on a three year rolling average basis. However, it is not clear to what extent this decline in hours worked on farm may or may not be matched by an increase in time engaged in off-farm employment. This caveat should be noted when using this measure of work/life balance. Hours worked on farm per annum were significantly higher on dairy farms, compared to all other farm systems.

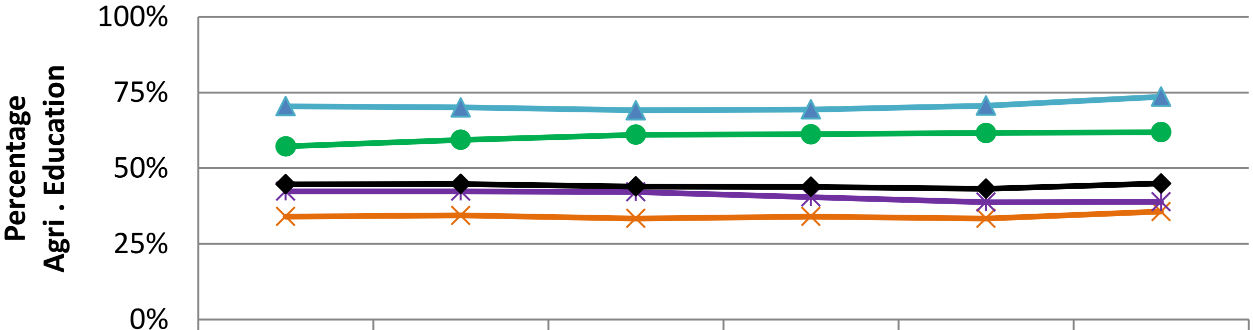
Figure 118: Hours Worked Per Annum: 3 year rolling average 2012-2017 (average per system)



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	2,451	2,432	2,395	2,359	2,351	2,347
Cattle	1,700	1,696	1,672	1,601	1,562	1,516
Sheep	1,765	1,756	1,742	1,720	1,695	1,673
Tillage	1,528	1,523	1,537	1,551	1,536	1,509
All Farms	1,848	1,835	1,810	1,756	1,725	1,689

Figure 119 indicates that the percentage of famers who have received some form of agricultural education has remained consistent for the period 2012-2017 on a three year rolling average basis at between 43% and 45%. Significantly higher levels of formal agricultural education were prevalent among dairy and tillage farmers compared to cattle and sheep farms.

Figure 119: Formal Agricultural Education: 3 year rolling average 2012-2017 (average per system)



	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017
Dairy	70%	70%	69%	69%	71%	74%
Cattle	34%	34%	33%	34%	33%	36%
Sheep	42%	42%	42%	40%	39%	39%
Tillage	57%	59%	61%	61%	62%	62%
All Farms	45%	45%	44%	44%	43%	45%

6.4 Environmental Emissions Intensity Trends

The following section examines the trends in environmental efficiency of production for the main products produced on livestock farms (milk, beef, sheep meat). Results are again reported on the basis of a three year rolling average (e.g. the 2010-2012 results is the average of 2010, 2011 and 2012). Results for individual years are reported in the appendices on a farm system basis.

Results presented in Figure 120 indicate that kg of CO_2 equivalent per kg of FPCM followed a declining trend between 2012 and 2017 on a three year rolling average basis. Additional milk output in the post milk quota era has been produced at lower level of emissions intensity.

Figure 120: Ag. GHG Emissions per kg FPCM: 2012-2017 (IPCC approach) 3 year rolling average – Dairy Farms

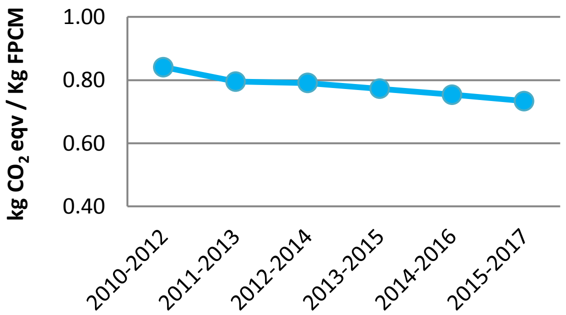


Figure 121 indicates that kg of CO_2 equivalent per kg of live-weight beef produced on cattle farms also tended to follow a declining trends, especially towards the end of the study period. A similar trend was also observed for agriculture based GHG emissions in sheep meat production on sheep farms. Figure 122 indicates a steady declining trend in terms of kg of CO_2 emitted per kg of live-weight sheep produced between 2012 and 2017 on a three year rolling average basis.

Figure 121: Ag. GHG Emissions per kg live-weight beef produced: 2012-2017 (IPCC approach) 3 year rolling average – Cattle Farms

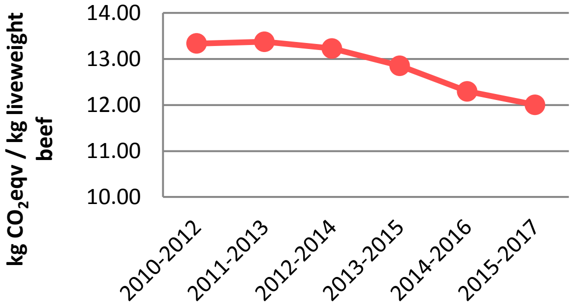
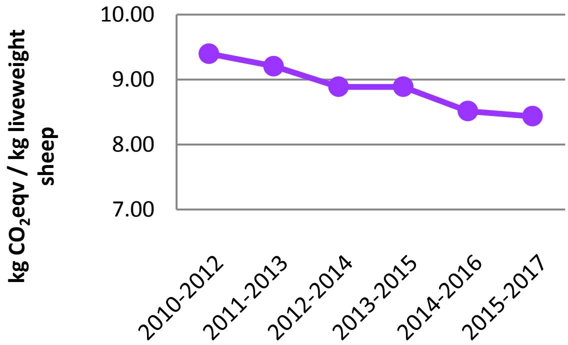
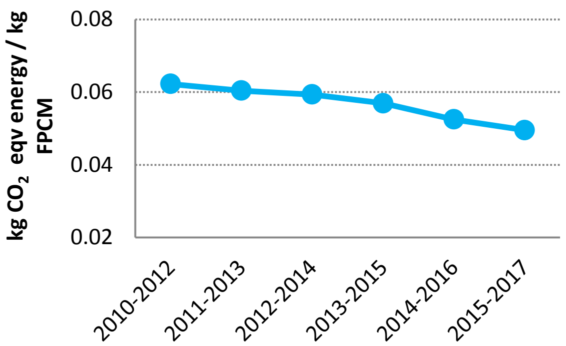


Figure 122: Ag. GHG Emissions per kg live-weight sheep produced: 2012-2017 (IPCC approach) 3 year rolling average – Sheep Farms



Energy based emissions may be affected by the weather in any given year, if for example extra heating is required for a cold winter, or wet conditions requiring extra movement of the herd. Results presented in Figure 123 indicate a gradual decline in GHG emission derived from electricity and fuel associated with milk production between 2012 and 2017 on a three year rolling average basis, especially in the period between 2015 and 2017. This again indicates that additional kg of FPCM has been produced at a lower emissions intensity between the start and end of the study period.

Figure 123: Energy use related GHG emissions per kg FPCM: 2012-2017 (IPCC approach) 3 year rolling average – Dairy Farms



Energy based CO_2 emissions related to the production of live-weight beef on cattle farms was relatively static over the study, with a slight decline toward the end of the study period as illustrated in Figure 124.

Energy based GHG emission from the production of live-weight sheep was also relatively static over the 2012-17 period except for a slight increase in the mid-study period, followed by a return to previous levels as illustrated in Figure 125.

Figure 124: Energy use related GHG emissions per kg live-weight beef produced: 2012-2017 (IPCC approach) 3 year rolling average – Cattle Farms

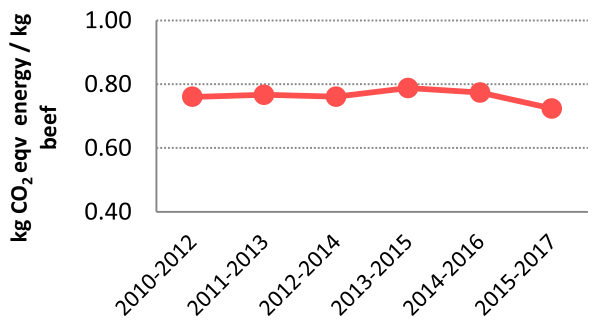
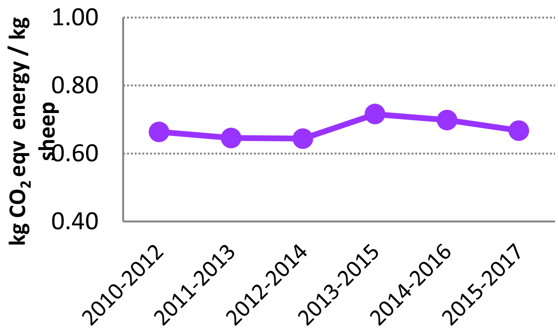
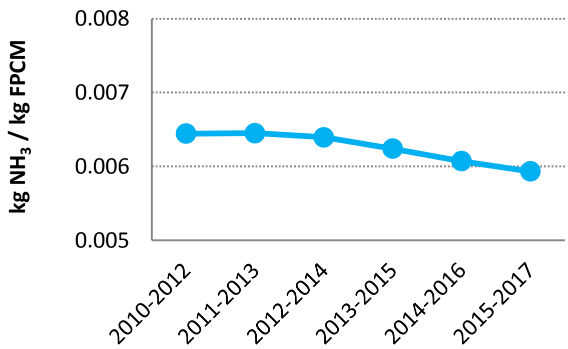


Figure 125: Energy use related GHG emissions per kg live-weight sheep produced: 2012-2017 (IPCC approach) 3 year rolling average – Sheep Farms



Similar to GHG's, the ammonia emissions intensity of milk production tended to follow a declining trend over the 2012 to 2017 period on a three year rolling average basis as outlined in Figure 126. More milk is being produced at a lower level of ammonia emissions intensity at the end of the study period.

Figure 126: Ammonia emissions per kg FPCM: 2012-2017 3 year rolling average – Dairy Farms



On a three year rolling average basis ammonia emissions per kg of live-weight beef produced on cattle farms was relatively static over the majority of the study period before a slight decline was seen at the end as seen in Figure 127. This pattern was repeated for ammonia emissions per kg of live-weight sheep meat produced on sheep farms as illustrated in Figure 128.

Figure 127: Ammonia emissions per kg live-weight beef produced: 2012-2017 3 year rolling average – Cattle Farms

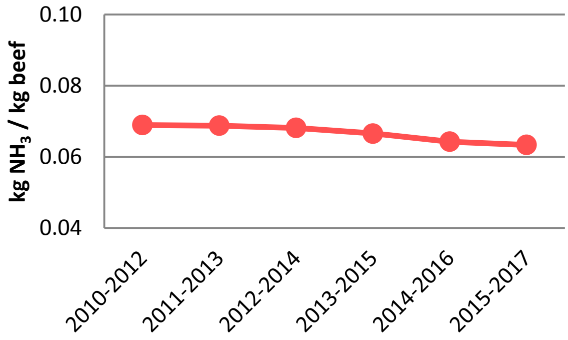


Figure 128: Ammonia emissions per kg live-weight sheep produced: 2012-2017 3 year rolling average – Sheep Farms

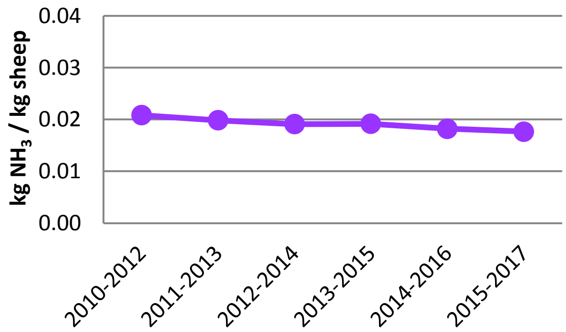


Figure 129 illustrates the trend on dairy farms in terms of kg of FPCM produced per kg of N surplus (excess of N input over outputs) on a three year rolling average basis. The graph shows a decline in the mid study period followed by a rising trend to the end of the period. This indicates that more milk is produced per kg of nitrogen surplus at the end of the study period.

Figure 129: kg of FPCM produced per kg of N surplus: 2012-2017: 3 year rolling average – Dairy Farms

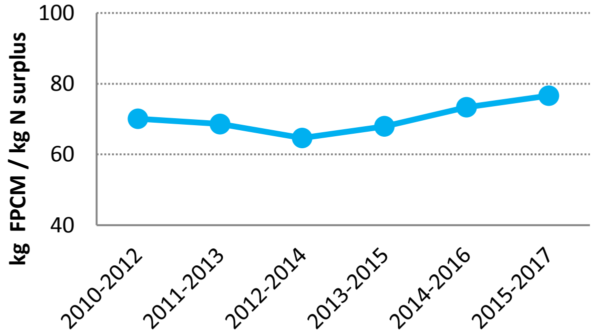
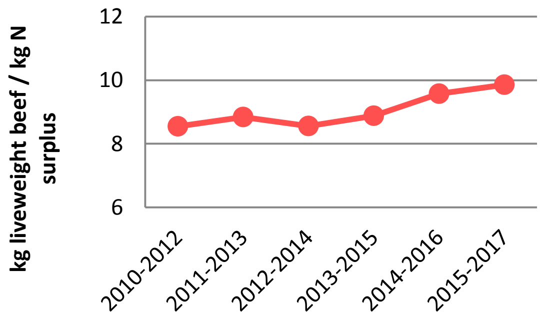


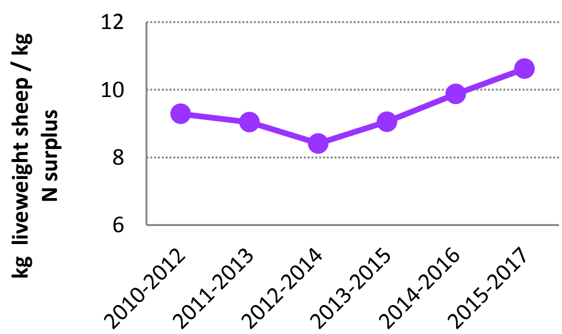
Figure 130 shows the trend per kg of live-weight beef produced per kg of N surplus. Results indicate a relatively static trend at the start of the study period followed by a slight increased at the end, based on a three year rolling average. This suggests that more live-weight beef is being produced per kg of N surplus at the end of the study period.

Figure 130: kg of live-weight beef produced per kg of N surplus: 2012-2017 3 year rolling average – Cattle Farms



Results for kg of live-weight sheep meat produced per kg of N surplus on sheep farms are presented in Figure 131. Results suggest a declining trend at the start of the study period, followed by an upward trajectory at the end of the study period on a three year rolling average. Again indicating that more live-weight sheep are being produced per kg of N surplus at the end of the study period

Figure 131: kg of live-weight sheep produced per kg of N surplus: 2012-2017 3 year rolling average – Sheep Farms



7. National Cross Validation on Carbon Footprint of Milk Production

Using the more holistic LCA approach (including both agricultural and energy based emissions) the Teagasc NFS data has been used (since 2013) in conjunction with the Moorepark developed LCA model (O'Brien et al., 2014). Results of this LCA approach indicate that the carbon footprint of Irish milk production (CO_2 equivalent per kg of FPCM produced) has declined between 2015 and 2017 on a rolling three year average basis, both on a weighted farm and national aggregate basis (results weighted by milk supply). These results in terms of kg CO_2 equivalent per kg of FPCM are consistent with other nationally based results obtained using a similar LCA methodological approach and farm level data collected and published as part of the Bord Bia Sustainable Dairy Assurance Scheme (SDAS) (Bord Bia, Forthcoming) as outlined below.

Figure 132: GHG Emission per kg FPCM (LCA Approach) – 3 year rolling nationally weighted farm average

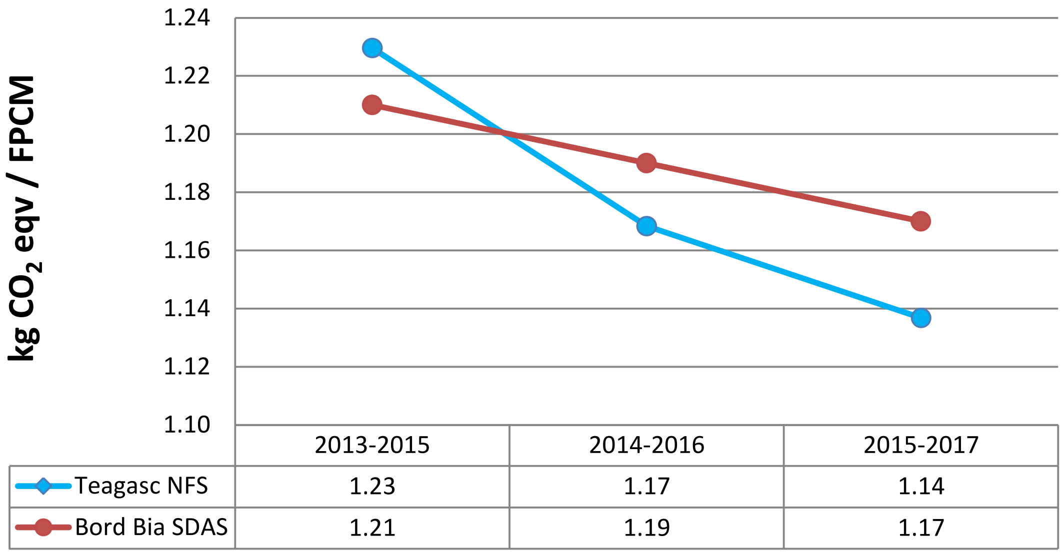
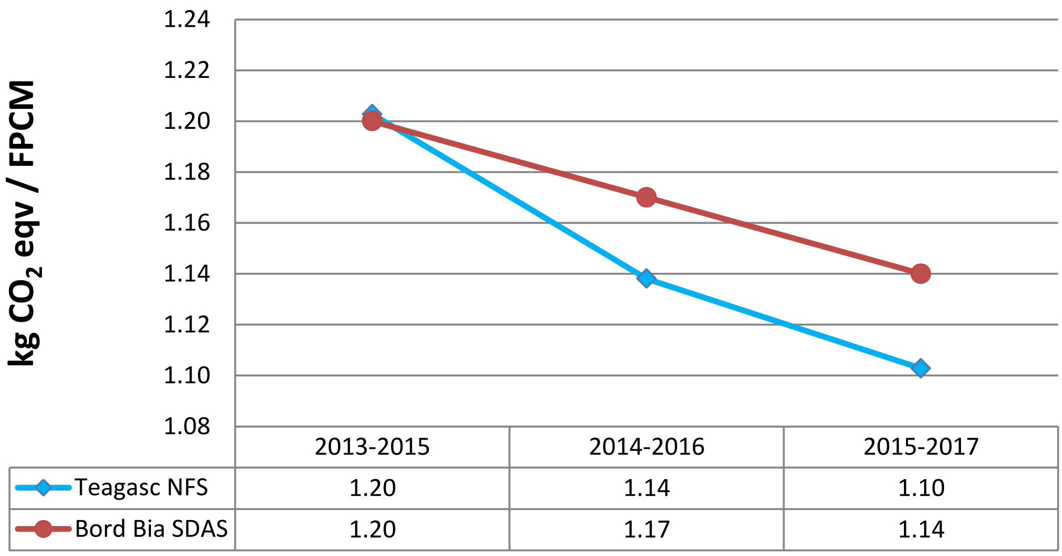


Figure 133: GHG Emission per kg FPCM (LCA Approach) – 3 year rolling average weighted by milk supply.



8. On-going and Future work

The Teagasc National Farm Survey sustainability indicator set is a powerful tool with which to assess the actual performance of Irish farms across a range of areas and allows detailed comparisons between and within farm systems. This report builds on the research reported in previously published sustainability reports (Hennessy et al., 2013; Lynch et al., 2016a) and shows the changes in relevant indicators through time. Additional indicators around ammonia emissions and the sustainable use of phosphorus have been added in this edition of the Teagasc NFS Sustainability report. The indicator set reported will continue to evolve and will demonstrate changes in the multiple dimensions of sustainability across a nationally representative sample of farms in Ireland over time. The data required to ensure the continued refinement of such metrics is continually under review. To that end, efforts are currently being made to strengthen the social and environmental indicators in particular. As such, two important environmental aspects not yet included are currently being considered as outlined below.

Life-Cycle Analysis Model for Beef Production

Measuring GHG emissions and carbon footprints for beef farms is more challenging than for dairy farms. The system of production on dairy farms is more homogeneous than on beef farms and the volume of the principal output (milk) can easily be recorded. In addition, there are more limited movements of animals onto and from dairy farms. By contrast there are a range of different systems on beef farms and movements of animals onto and from farms can be quite diverse depending on the system in operation. In addition, the output of the farm (live-weight gain) can be hard to capture as it is not directly observed. However, an updated LCA model for beef production is being developed by Teagasc colleagues in the Animal and Grassland Research and Innovation Programme and the Teagasc NFS data collection schedule will be expanded to enable the development of this approach.

Biodiversity

Farms may not only be producing food, but also providing appropriate habitats for wildlife. The provision of habitats can in turn provide benefits on the farm itself through the provision of ecosystem services such as pollination as well as contributing to the wider set of environmental public goods produced by agriculture. Agricultural production is thus involved in the production of an environment that can be appreciated by local communities and tourists as well as having its own intrinsic value. However, one of the concerns associated with the intensification of agricultural production is that wildlife and native flora may be negatively impacted, resulting in irrevocable biodiversity loss. Biodiversity is therefore an important component of farm performance, but can usually only reliably be assessed by detailed on-farm surveys which are beyond the current scope and resources of the Teagasc NFS. However, funding has been obtained to investigate the potential of remote mapping and ground truthing methods of farmland habitat biodiversity measurement for a representative portion of NFS farms. The inclusion of biodiversity metrics is becoming increasingly desirable in quantitative measurements of sustainability by key stakeholders, consumers, producers and policymakers.

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Glossary of Terms

CO_2 equivalent: For reporting purposes all non-carbon dioxide (CO_2) emissions are converted to CO_2 equivalents using appropriate global warming potentials for CH_4 and N_2O which are respectively 25 and 298 times greater than CO_2.

Direct Costs: Costs directly incurred in the production of a particular enterprise, e.g., fertilisers, seeds and feeding stuffs.

Fat and Protein Corrected Milk (FPCM): This is the functional unit used for carbon foot printing dairy output on farm. It adjusts kg/litres of milk to allow for the level of milk solids produced which is standardized to 4% fat and 3.3% true protein per kilogramme of milk.

Greenhouse Gases (GHG): The amount of greenhouse gas emissions (CO_2, N_2O, CH_4) associated with the production of a specific type of agricultural produce, expressed as kg CO_2 equivalent per kg of produce (e.g. per kg beef, milk).

Gross Output: Gross output for the farm is defined as total sales less purchases of livestock, plus value of farm produce used in the house, plus receipts for hire work, services, fees etc. It also includes net change in inventory, which in the case of cows, cattle and sheep is calculated as the change in numbers valued at closing inventory prices. All non-capital grants, subsidies, premiums, headage payments are included in gross output in this report.

Gross Margin: Gross output minus direct costs.

Labour Unit: One labour unit is defined as at least 1,800 hours worked on the farm by a person over 18 years of age. Persons under 18 years of age are given the following labour unit equivalents:

16-18 years: 0.75
14-16 years: 0.50

Please note: An individual cannot exceed one labour unit even if he/she works more than 1,800 hours on the farm.

Life Cycle Analysis: An alternative method to the IPCC approach to measuring carbon is the Life-Cycle Assessment approach which accounts for emissions through the entire food production supply chain.

Nitrogen balance: (per hectare farmed), is used as an indicator of the potential magnitude of nitrogen surplus which reflects the risk of nutrient losses to water bodies all other things being equal. It is calculated on the basis of N inputs less N outputs on a per hectare basis at the farm gate level.

Nitrogen use efficiency: is used to highlight the proportion of N retained in the farm system (N outputs / N inputs). This is a generic measure allowing comparison across disparate farm types at the farm gate level.

Phosphorus balance: (per hectare farmed), is used as an indicator of the potential magnitude of phosphorus surplus which may result in nutrient losses to water bodies all other things being equal. It is calculated on the basis of P inputs less P outputs on a per hectare basis at the farm level.

Phosphorus use efficiency: is used to highlight the proportion of P retained in the farm system (P outputs / P inputs). This is a generic measure allowing comparison across different farm types.

Appendix 1

Table 5: Sustainability Indicator results for Dairying Farms 2012-2017

Indicator	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***
Economic Sustainability Metrics			€			
Economic return per hectare	2,983	3,436	3,404	3,283	3,021	3,720
Profitability per hectare	1,388	1,667	1,767	1,710	1,457	2,111
Productivity of labour	37,923	48,468	50,803	49,363	41,188	68,646
			percentage			
Market orientation	85	88	88	88	87	90
Viability	67	77	80	75	69	85
Social Sustainability Metrics						
Household vulnerable	16%	10%	9%	13%	16%	8%
Isolation	5%	7%	8%	8%	8%	8%
High age profile	12%	12%	14%	6%	9%	12%
Hours worked	2,437	2,395	2,354	2,329	2,370	2,341
Agricultural education	70%	70%	67%	71%	74%	76%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	426.8	447.0	450.5	464.9	490.6	502.5
of which dairy	246.5	265.2	268.7	285.9	302.6	311.6
cattle	177.4	178.9	179.3	176.5	185.7	188.8
sheep	1.5	1.3	1.3	1.4	1.2	1.3
other	1.3	1.6	1.2	1.1	1.0	0.9
energy use	24.1	24.3	24.9	24.6	22.8	22.9
			tonnes CO_2 eqv per ha			
Ag GHG Emissions	7.7	8.1	8.2	8.3	8.5	8.6
Energy GHG Emissions	0.44	0.44	0.46	0.46	0.42	0.42
			kg CO_2 eqv			
GHG Emissions per kg milk	0.77	0.79	0.78	0.74	0.75	0.73
GHG Emissions per kg FPCM	0.79	0.80	0.78	0.73	0.74	0.72
GHG Emissions per € output	3.09	2.74	2.78	2.94	3.33	2.72
Energy Emissions per kg FPCM	0.06	0.06	0.06	0.05	0.05	0.05
Energy Emissions eqv per kg milk	0.06	0.06	0.06	0.05	0.05	0.05
GHG Emissions per kg FPCM (LCA)	n/a	1.31	1.24	1.14	1.13	1.14
			tonnes NH_3 per farm			
Total farm average NH3 emissions	2.37	2.45	2.47	2.57	2.76	2.82
of which dairy	1.77	1.89	1.92	2.02	2.10	2.18
cattle	0.31	0.27	0.26	0.25	0.28	0.27
sheep	0.00	0.00	0.00	0.00	0.00	0.00
chemical fertiliser	0.29	0.29	0.29	0.30	0.38	0.37
			kg NH_3			
NH_3 emissions per hectare	42.6	44.1	44.3	45.6	47.1	47.8
NH_3 emissions per Euro output	0.0169	0.0148	0.0150	0.0161	0.0184	0.0150
NH_3 emissions per kg milk	0.0064	0.0065	0.0064	0.0065	0.0063	0.0059

NH_3 emissions per kg FPCM	0.0062	0.0063	0.0063	0.0063	0.0062	0.0059
			kg per ha			
N Balance per hectare	154.0	185.0	170.3	155.9	164.8	171.9
P Balance per hectare	6.5	10.6	10.4	9.0	9.0	11.4
			percentage			
N use efficiency	22.3	19.7	22.2	25.0	24.0	24.4
P use efficiency	71.3	53.6	56.8	63.8	62.4	58.4
			Per kg of N Surplus			
Kg FPCM	68.7	59.2	66.1	78.3	75.3	76.0

Table 6: Sustainability Indicator results for Cattle Farms 2012-2017

Indicator	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Economic Sustainability Metrics			€			
Economic return per hectare	1,234	1,269	1,150	1,189	1,312	1,336
Profitability per hectare	425	402	374	463	507	533
Productivity of labour	14,786	12,893	11,225	15,029	14,809	16,909
			percentage			
Market orientation	60%	62%	61%	64%	64%	64%
Viability	22%	18%	14%	24%	23%	25%
Social Sustainability Metrics						
Household vulnerable	41%	42%	41%	38%	42%	39%
Isolation	21%	19%	22%	22%	24%	23%
High age profile	29%	27%	29%	25%	31%	32%
Hours worked	1,689	1,682	1,646	1,474	1,566	1,508
Agricultural education	41%	42%	41%	38%	42%	39%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	146.8	147.3	140.1	131.2	138.7	141.2
of which dairy	0.0	0.0	0.0	0.0	0.0	0.0
cattle	142.0	142.5	135.7	127.4	134.6	137.6
sheep	4.3	4.4	4.1	3.6	3.7	3.3
other	0.5	0.5	0.3	0.3	0.4	0.3
energy use	9.4	9.8	9.5	9.5	8.5	8.1
			tonnes CO_2 eqv per ha			
Ag GHG Emissions	4.1	4.2	4.1	3.8	4.4	4.4
Energy GHG Emissions	0.26	0.28	0.29	0.30	0.29	0.26
			kg CO_2 eqv			
Ag. GHG Emissions per kg live-weight beef	13.3	13.5	12.8	12.2	11.8	11.9
Ag. GHG Emissions per € output	5.2	5.4	5.7	5.1	5.0	6.2
Energy Emissions per kg live-weight beef	0.77	0.78	0.77	0.81	0.61	0.60
			tonnes NH_3 per farm			
Total farm average NH3 emissions	0.75	0.75	0.71	0.68	0.73	0.74
of which dairy	0.00	0.00	0.00	0.00	0.00	0.00
cattle	0.71	0.70	0.67	0.64	0.68	0.69
sheep	0.01	0.01	0.01	0.00	0.00	0.00
chemical fertiliser	0.04	0.05	0.04	0.04	0.04	0.04
			kg NH_3			
NH_3 emissions per hectare	21.00	21.69	20.97	20.14	23.16	23.20
NH_3 emissions per Euro output	0.0267	0.0276	0.0288	0.0260	0.0261	0.0254
NH_3 emissions per kg live-weight beef	0.0688	0.0695	0.0661	0.0641	0.0627	0.0633
			kg per ha			
N Balance per hectare	55.9	72.4	61.3	53.6	63.0	65.2
P Balance per hectare	4.2	5.7	5.0	5.4	5.6	6.2

	percentage					
N use efficiency	22.1	19.5	22.4	22.6	23.1	24.2
P use efficiency	70.1	61.6	67.5	61.2	69.3	64.0
	Per kg of N Surplus					
kg Live weight beef	9.5	7.8	8.4	10.4	9.8	9.2

Table 7: Sustainability Indicator results for Sheep Farms 2012-2017

Indicator	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Economic Sustainability Metrics			€			
Economic return per hectare	1,289	1,236	1,265	1,134	1,291	1,375
Profitability per hectare	484	361	475	417	435	545
Productivity of labour	16,394	10,951	13,289	14,122	14,266	17,043
			percentage			
Market orientation	54%	56%	57%	57%	61%	60%
Viability	24%	15%	24%	24%	24%	27%
Social Sustainability Metrics						
Household vulnerable	40%	44%	46%	45%	42%	41%
Isolation	13%	14%	13%	11%	9%	12%
High age profile	23%	33%	37%	28%	33%	30%
Hours worked	1,766	1,749	1,710	1,700	1,675	1,644
Agricultural education	41%	44%	41%	36%	39%	42%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	134.9	135.1	132.7	123.1	134.2	139.3
of which dairy	1.3	0.9	0.8	1.2	0.0	1.7
cattle	69.3	70.9	72.4	64.5	73.0	72.5
sheep	63.9	62.9	59.1	57.1	60.9	64.7
other	0.4	0.4	0.4	0.3	0.4	0.4
energy use	9.4	9.3	9.7	9.9	7.9	8.7
			tonnes CO_2 eqv per ha			
Ag GHG Emissions	3.4	3.6	3.5	3.1	3.5	3.7
Energy GHG Emissions	0.25	0.25	0.25	0.27	0.22	0.26
			kg CO_2 eqv			
Ag. GHG Emissions per kg live-weight sheep produced	9.2	9.2	8.4	9.0	8.1	8.2
Ag. GHG Emissions per € output	4.4	4.8	4.2	4.3	4.4	4.3
Energy Emissions per kg live-weight sheep produced	0.62	0.62	0.69	0.84	0.56	0.60
			tonnes NH_3 per farm			
Total farm average NH3 emissions	0.50	0.51	0.51	0.47	0.52	0.53
of which dairy	0.00	0.00	0.00	0.00	0.00	0.00
cattle	0.35	0.35	0.37	0.33	0.38	0.38
sheep	0.11	0.11	0.10	0.09	0.10	0.10
chemical fertiliser	0.04	0.04	0.05	0.04	0.05	0.05
			kg NH_3			
NH_3 emissions per hectare	12.42	13.01	12.91	11.20	13.53	13.51
NH_3 emissions per Euro output	0.0158	0.0171	0.0153	0.0149	0.0162	0.0149
NH_3 emissions per kg live-weight sheep	0.020	0.019	0.018	0.020	0.017	0.016
			kg per ha			
N Balance per hectare	45.2	55.8	51.4	42.4	52.5	53.4
P Balance per hectare	3.8	5.3	5.8	5.9	5.6	6.5

	percentage					
N use efficiency	28.0	24.7	27.7	32.1	29.3	31.5
P use efficiency	78.9	57.8	57.1	58.6	60.6	63.6
	Per kg of N Surplus					
kg liveweight sheep	9.0	7.7	8.5	10.7	10.1	10.7

Table 8: Sustainability Indicator results for Tillage Farms 2012-2017

Indicator	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Economic Sustainability Metrics			€			
Economic return per hectare	1,833	1,684	1,638	1,784	1,671	1,734
Profitability per hectare	825	679	618	757	671	817
Productivity of labour	45,490	37,940	34,252	38,978	36,355	44,330
			percentage			
Market orientation	74%	74%	73%	77%	73%	76%
Viability	71%	57%	61%	62%	60%	74%
Social Sustainability Metrics						
Household vulnerable	17%	21%	20%	20%	23%	11%
Isolation	22%	26%	22%	21%	21%	19%
High age profile	20%	22%	20%	15%	28%	28%
Hours worked	1,498	1,570	1,544	1,540	1,525	1,462
Agricultural education	62%	61%	60%	62%	62%	61%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	136.2	138.1	137.8	137.4	132.5	125.1
of which dairy	0.0	0.0	0.0	0.0	0.0	0.0
cattle	96.9	97.9	100.0	99.7	89.8	89.2
sheep	10.2	11.5	8.6	8.4	7.2	7.3
other	29.0	28.7	29.2	29.3	35.5	28.6
energy use	23.7	26.0	25.4	23.3	23.3	19.3
			tonnes CO_2 eqv per ha			
Ag GHG Emissions	2.1	2.1	2.1	2.1	1.9	1.9
Energy GHG Emissions	0.4	0.4	0.4	0.3	0.4	0.3
			tonnes NH_3 per farm			
Total farm average NH3 emissions	0.58	0.56	0.59	0.62	0.61	0.52
of which dairy	0.00	0.00	0.00	0.00	0.00	0.00
cattle	0.47	0.46	0.49	0.49	0.45	0.43
sheep	0.01	0.01	0.01	0.01	0.01	0.01
chemical fertiliser	0.09	0.08	0.10	0.11	0.15	0.08
			kg NH_3			
NH_3 emissions per hectare	8.71	7.91	8.82	9.07	8.50	7.82
NH_3 emissions per Euro output	0.0066	0.0061	0.0076	0.0065	0.0068	0.0062
			kg per ha			
N Balance per hectare	51.8	52.4	50.8	45.2	46.6	43.0
P Balance per hectare	6.8	6.9	7.4	4.3	5.0	4.6
			percentage			
N use efficiency	57.7	61.7	63.8	67.8	67.4	69.8
P use efficiency	84.0	84.2	84.0	92.9	89.7	90.6

Table 9: Sustainability Indicator results for All Farms 2012-2017

Indicator	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Economic Sustainability Metrics			€			
Economic return per hectare	1,635	1,706	1,623	1,605	1,638	1,793
Profitability per hectare	657	657	666	703	676	835
Productivity of labour	22,222	21,413	20,714	22,958	21,024	28,164
			percentage			
Market orientation	65%	67%	66%	68%	68%	69%
Viability	35%	32%	32%	36%	34%	40%
Social Sustainability Metrics						
Household vulnerable	34%	34%	35%	33%	36%	32%
Isolation	17%	17%	18%	18%	19%	18%
High age profile	24%	25%	27%	21%	27%	28%
Hours worked	1831	1819	1780	1670	1724	1674
Agricultural education	45%	45%	42%	44%	43%	47%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	198	201	196	190	200	204
of which dairy	48.0	49.8	49.4	51.6	53.5	55.3
cattle	133.4	133.8	130.6	124.1	130.6	132.8
sheep	13.7	13.9	12.8	12.1	12.5	12.9
other	3.2	3.2	2.9	2.7	3.1	2.6
energy use	13.5	13.9	13.7	13.4	12.1	11.6
			tonnes CO_2 eqv per ha			
Ag GHG Emissions	4.5	4.7	4.6	4.4	4.8	4.8
Energy GHG Emissions	0.3	0.3	0.3	0.3	0.3	0.3
			tonnes NH_3 per farm			
Total farm average NH3 emissions	1.01	1.01	0.99	0.98	1.05	1.06
of which dairy	0.35	0.36	0.36	0.37	0.38	0.39
cattle	0.55	0.54	0.52	0.50	0.54	0.54
sheep	0.02	0.02	0.02	0.02	0.02	0.02
chemical fertiliser	0.09	0.09	0.09	0.09	0.11	0.11
			kg NH_3			
NH_3 emissions per hectare	22.75	23.25	22.94	22.42	24.78	24.88
NH_3 emissions per Euro output	0.0213	0.0216	0.0223	0.0209	0.0218	0.0204
			kg per ha			
N Balance per hectare	73.6	89.5	80.1	71.0	79.1	81.7
P Balance per hectare	4.8	6.7	6.4	6.1	6.2	7.1
			percentage			
N use efficiency	25.9	23.6	25.9	27.7	27.1	28.1
P use efficiency	72.8	61.1	64.9	63.5	68.0	64.5