Teagasc National Farm Survey 2020 Sustainability Report

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Any errors or omissions remain the responsibility of the authors.

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Abbreviations

CH_4	Methane
CO_2	Carbon dioxide
CO_2 e	Carbon dioxide equivalent
CSO	Central Statistics Office
ESD	EU Effort Sharing Decision
FPCM	Fat and protein corrected milk
GHG	Greenhouse gases
GM	Gross Margin
GWP	Global Warming Potential
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
PUE	Phosphorus use efficiency

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.

Executive Summary

This report provides the latest available information on farm sustainability performance in Ireland, based on detailed analysis of data collected through the Teagasc National Farm Survey. Economic, Social and Environmental Sustainability are measured for Dairy, Cattle, Sheep and Tillage farms in 2020. The report also includes time series results extending back into the last decade, allowing an assessment of how farm sustainability has changed over time.

Economic sustainability

- Consistent with the established trend, Dairy remains the powerhouse. Average **economic returns** in Dairy tend to be multiples of those in the other farm systems
- When allowance is made for the amount of labour required in different systems and income is expressed on a per labour unit basis, on average Dairy and Tillage both considerably outperform the drystock sectors
- For 2020, the economic performance of the average sheep farm improved, reflecting the higher lamb prices in this sector

Social sustainability

- Again reflecting established trends, Dairy continues to have stronger **social sustainability** performance relative to other farm systems. Dairy tends to have a lower **isolation risk**, with fewer households having a **high age profile** in comparison with other farm systems.
- However, in terms of **labour input**, on average the main dairy farm operator works significantly more **hours per year** than the farm operator in the other farm systems. Even when time spent working off farm is combined with time spent working on-farm, the labour input of dairy farm operators tends to exceed that of other farm systems.

Environmental sustainability

a) Green-house gas emissions

- **Dairy**: **Total farm GHG emissions** on the average dairy farm increased in 2020, largely due to an increase in the average herd size. However, **GHG emissions per hectare** on dairy farms remained relatively stable, as the average dairy farm area increased. The **GHG emissions intensity of milk production** (CO_2 per kilogramme of Fat and Protein Corrected Milk) improved. Effectively this means that the average kilogramme of milk was produced with a lower carbon footprint. However, this improvement in GHG emissions intensity was offset by a higher volume of milk produced on the back of a larger average herd size. Hence, farm level GHG emissions increased on dairy farms in 2020.
- **Non-Dairy Systems: Farm level GHG emissions** on sheep and tillage farms remained stable in 2020. Farm level emissions on cattle farms declined slightly. Per hectare emissions generally remained stable across these systems.
- **Agriculture as a whole:** The decline in cattle GHG emissions offset the increases in dairy farm emissions.

b) Ammonia emissions

- Positive developments are evident. On average, **ammonia emissions** showed some decline in 2020 relative to preceding years, across all systems on a farm and per hectare basis. It is notable that, on average, ammonia emissions fell even on dairy farms in 2020 in spite of their increase in output.
- The driver of reduced ammonia emissions is the increased adoption of low emissions slurry spreading. In aggregate terms, 36% of all slurry applied used a LESS (low emission slurry spreading) approach in 2020, compared to just 16% in 2019.

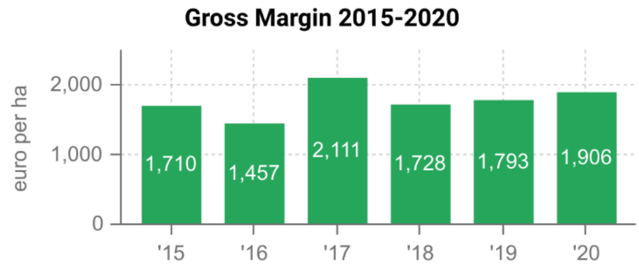
c) Nitrogen balance and use efficiency

- **N surpluses** declined and **N use efficiency** tended to improve in 2020. These metrics tend to significantly influenced by weather conditions although improved N management on farms also plays a role.

Dairy: Economic and Social Sustainability

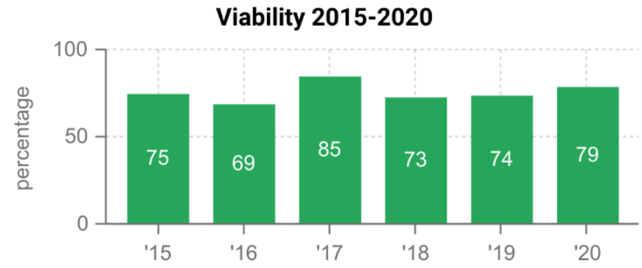
Gross Margin per ha 2020

€1,906



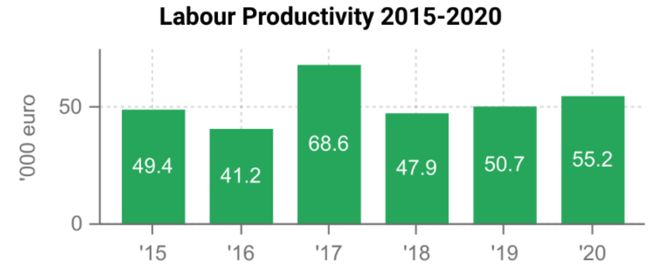
Viability 2020

79%



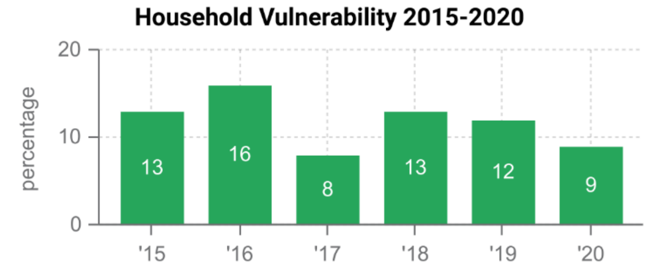
Productivity of Labour Unit 2020

€55,271



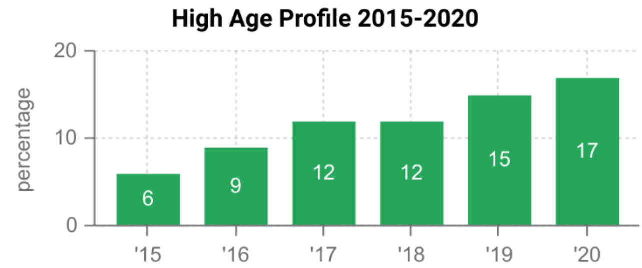
Household Vulnerability 2020

9%



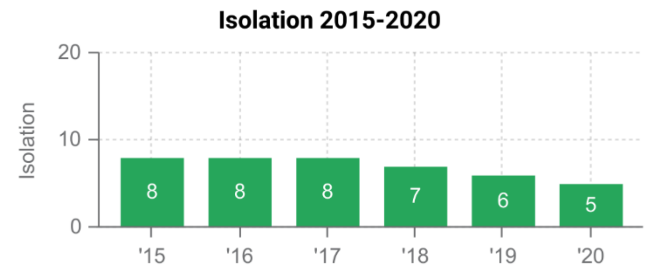
High Age Profile 2020

17%



Isolation 2020

5%

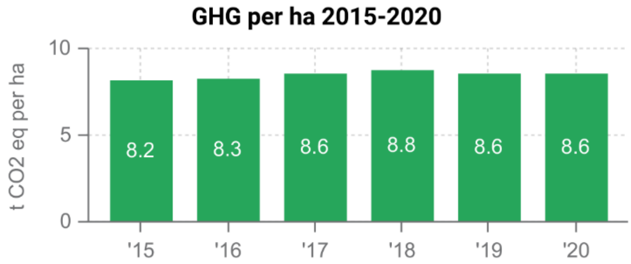


Source: Teagasc National Farm Survey

Dairy: Environmental Sustainability

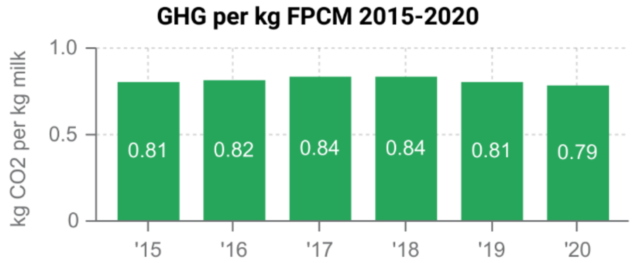
CO2 eq per ha 2020

8.6



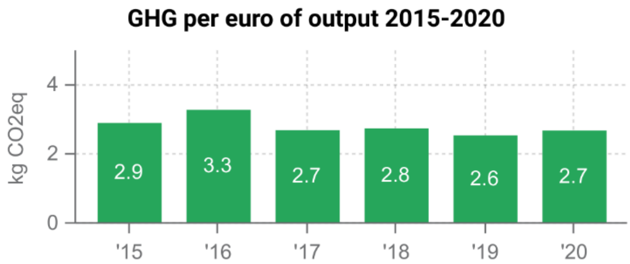
CO2 Eq per kg FPCM 2020

0.79



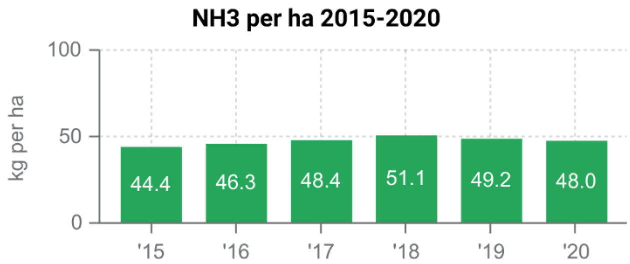
CO2 Eq per euro of output 2020

2.7



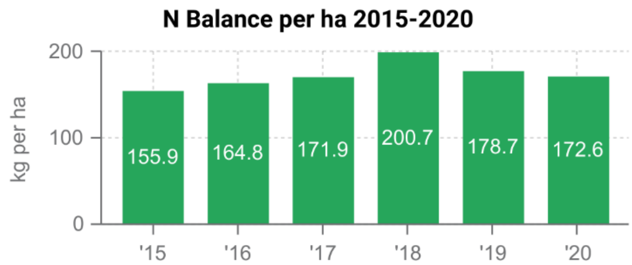
NH3 kg per ha 2020

48



N Balance kg per ha 2020

173

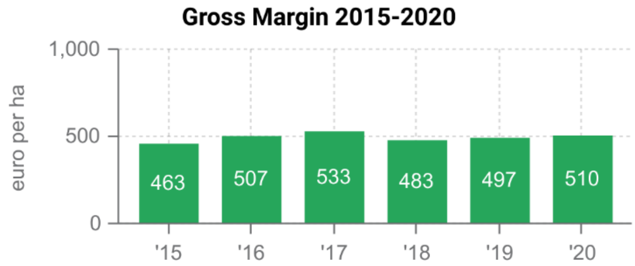


Source: Teagasc National Farm Survey

Cattle: Economic and Social Sustainability

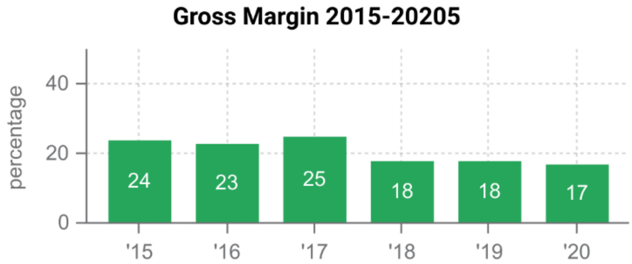
Gross Margin per ha 2020

€510



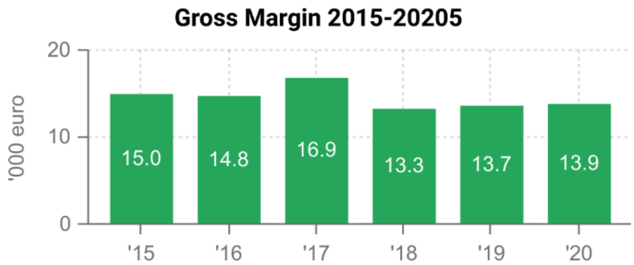
Viability 2020

17%



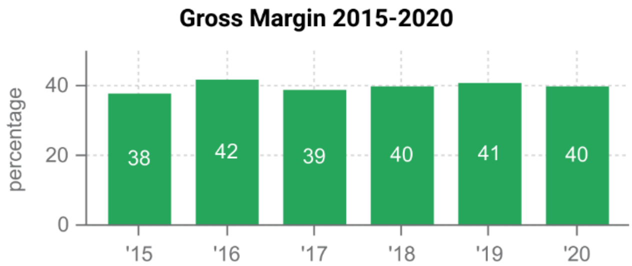
Productivity of Labour Unit 2020

€13,888



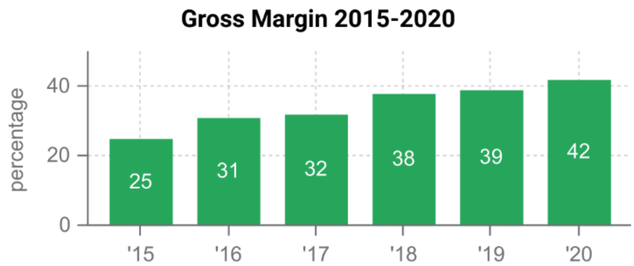
Household Vulnerability 2020

40%



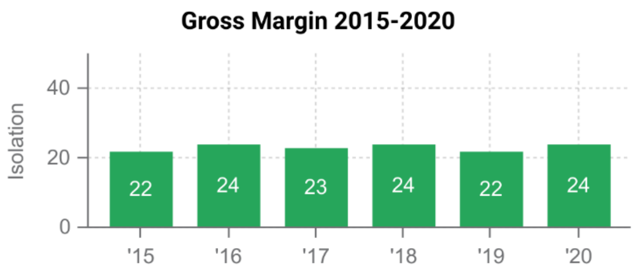
High Age Profile 2020

42%



Isolation 2020

24%

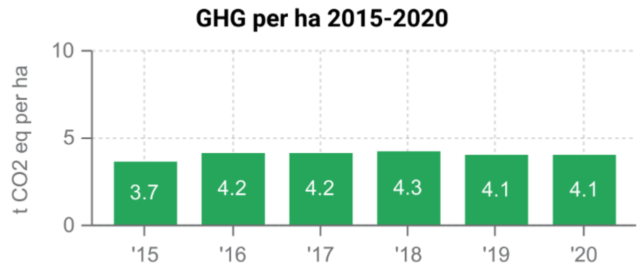


Source: Teagasc National Farm Survey

Cattle: Environmental Sustainability

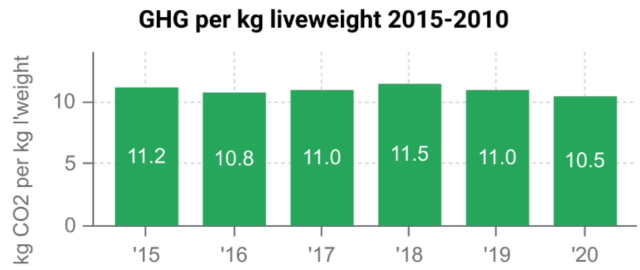
CO2 eq per ha 2020

4.1



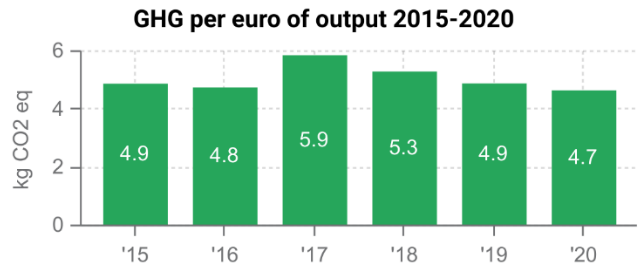
CO2 eq per kg of liveweight 2020

10.5



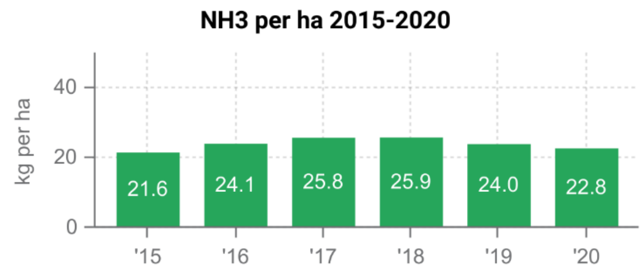
CO2 per euro of output 2020

4.68



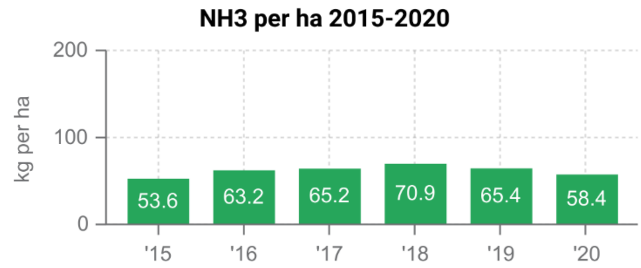
NH3 kg per ha 2020

22.8



N Balance kg per ha 2020

58.4

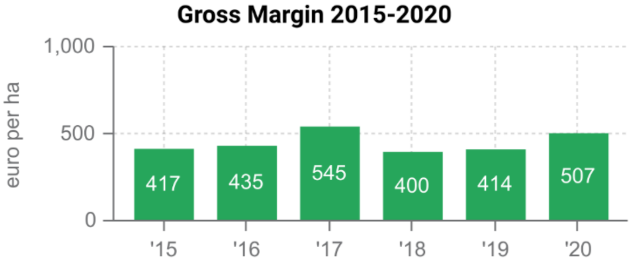


Source: Teagasc National Farm Survey

Sheep: Economic and Social Sustainability

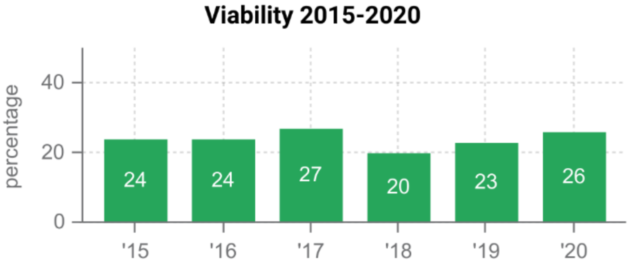
Gross Margin per ha 2020

€507



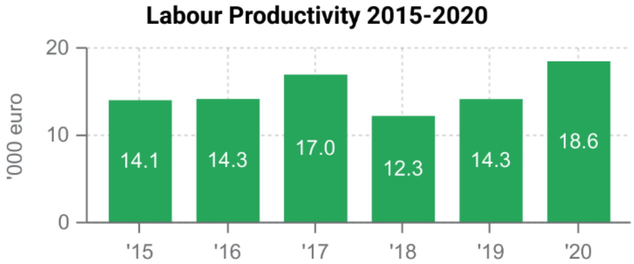
Viability 2020

26%



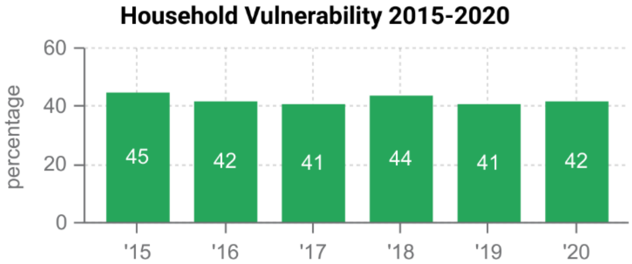
Productivity of Labour 2020

€18,568



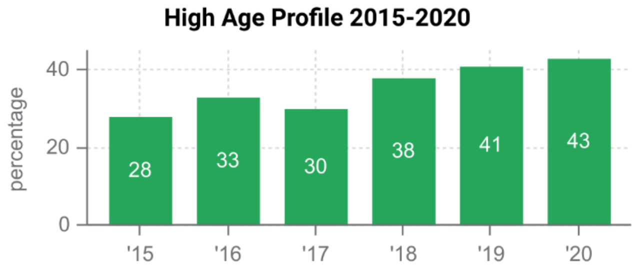
Household Vulnerability 2020

42%



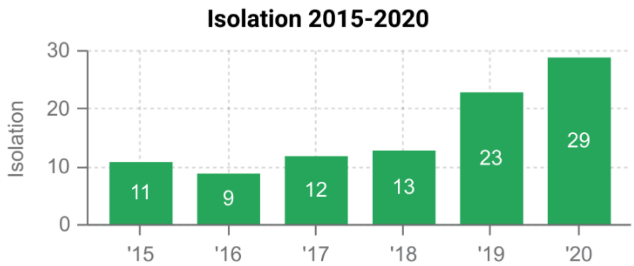
High Age Profile 2020

43%



Isolation 2020

29%

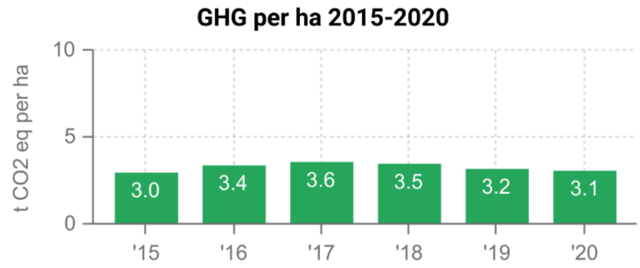


Source: Teagasc National Farm Survey

Sheep: Environmental Sustainability

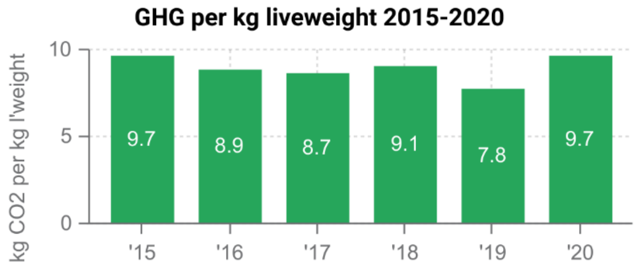
CO2 eq per ha 2020

3.1



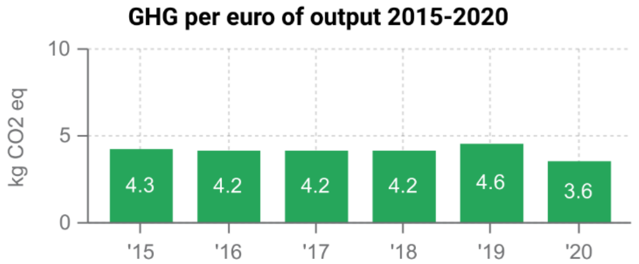
CO2 per kg liveweight 2020

9.7



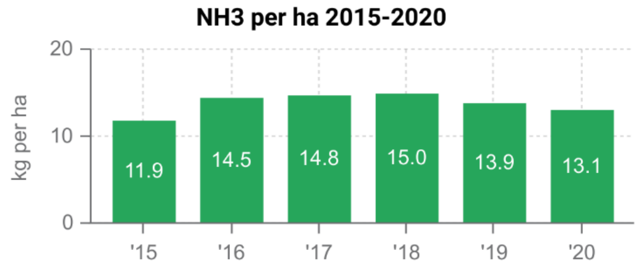
CO2 per euro of output 2020

3.6



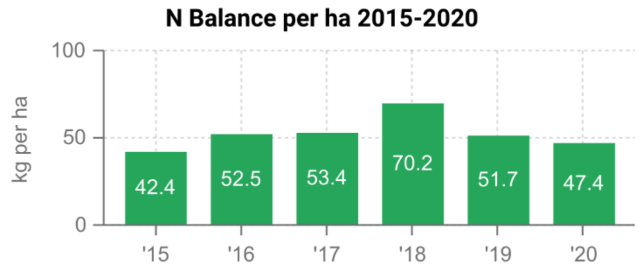
NH3 kg per ha 2020

13.1



N Balance kg per ha 2020

47.4

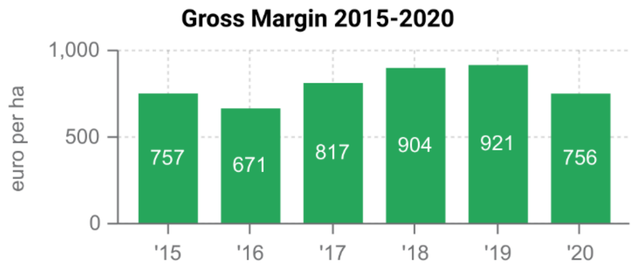


Source: Teagasc National Farm Survey

Tillage: Economic and Social Sustainability

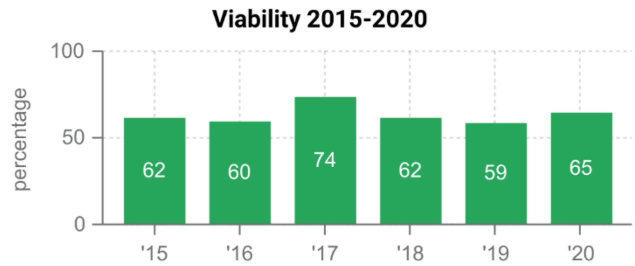
Gross Margin per ha 2020

€756



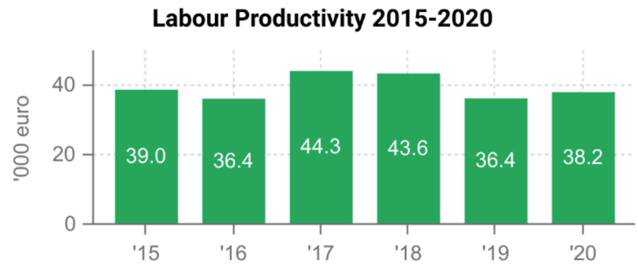
Viability 2020

65%



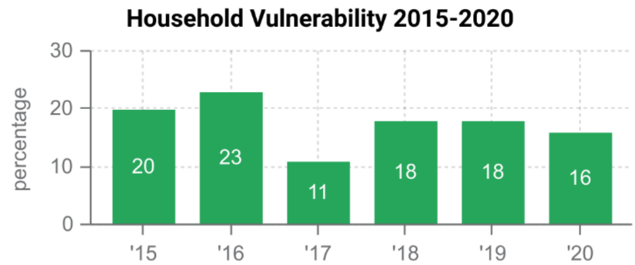
Productivity of Labour Unit 2020

€38,225



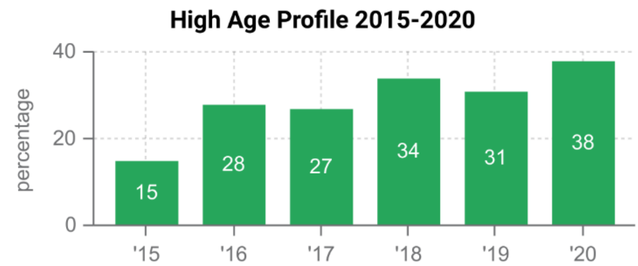
Household Vulnerability 2020

16%



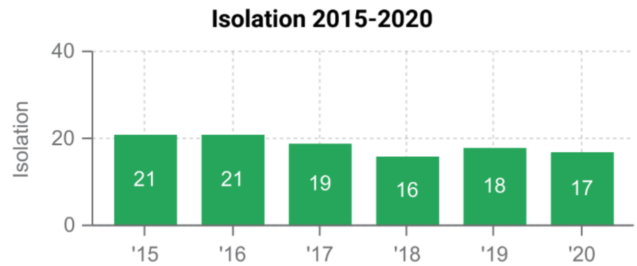
High Age Profile 2020

38%



Isolation 2020

17%

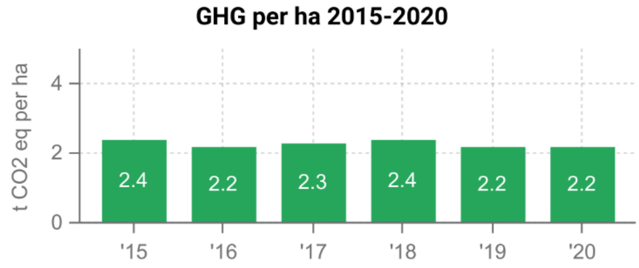


Source: Teagasc National Farm Survey

Tillage: Environmental Sustainability

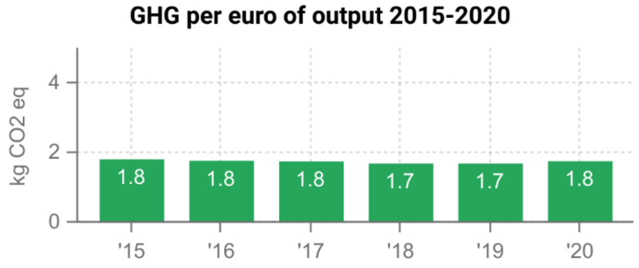
CO2 eq per ha 2020

2.2



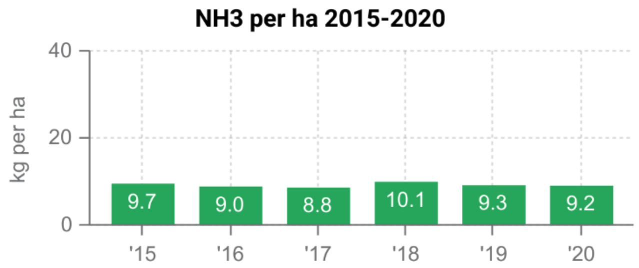
CO2 eq per euro of output 2020

1.8



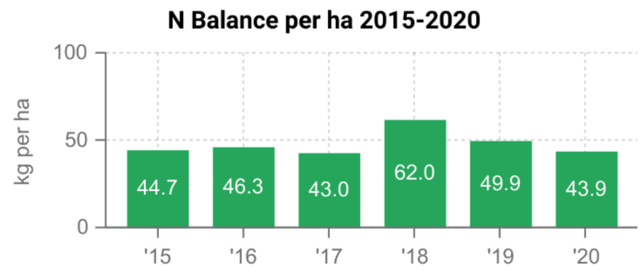
NH3 kg per ha 2020

9.2



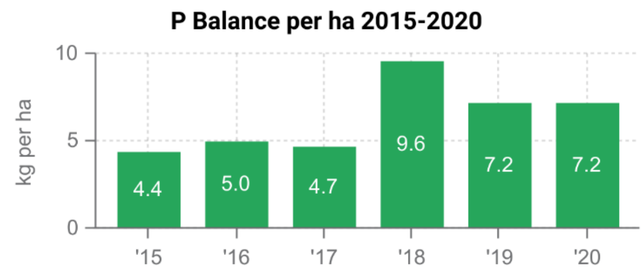
N Balance kg per ha 2020

43.9



P Balance kg per ha 2020

7.2



Source: Teagasc National Farm Survey

1 Introduction - Agricultural Sustainability

Humanity faces a grand challenge in trying to feed a growing human population, while minimising the environmental impacts of food production, especially in the context of climate change, deteriorating water quality and biodiversity loss. To sustainably feed a growing global population, agricultural output must be increased without influencing the capacity for future production or compromising the environment. This is the overarching objective of the EU Farm to Fork Strategy published in May 2020 (European Commission, 2020).

Since the publication of the previous Sustainability Report for 2019, there have been significant developments in environment policy in Ireland, including legislation requiring a 51% reduction in greenhouse gas emissions by 2030 and a requirement to protect and restore biodiversity. A Climate Action Plan 2021 has been published, which sets out emissions reductions targets for the various sectors.

Agricultural systems are complex and tend to have multiple objectives and wide-reaching effects, which must be considered holistically. To measure and track the diverse elements of Irish farm systems, 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 elements, which may vary through time and space. While Irish agriculture is dominated by grassland systems, production systems are heterogeneous, which substantial variations between farms in terms of farm size, stocking rates and input usage. Relevant indicators which capture this diversity are required 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. Ireland is at the forefront in Europe in the development and use of sustainability metrics for agriculture.

Deriving a sustainability indicator set is difficult, as it requires detailed, accurate and consistent farm-level measurements and data across a wide range of physical, socioeconomic and demographic farm attributes. The Teagasc National Farm Survey (NFS) has evolved in response to the changing needs of stakeholders to provide such a dataset. The NFS is a nationally representative sample of approximately 900 farms across Ireland. Data from the Teagasc NFS represent the Irish component of the European Union's Farm Accountancy Data Network (FADN) dataset[1]. However, the data collected in the Teagasc NFS surpasses the requirements of FADN, giving the Teagasc NFS dataset much more capacity to measure and track developments in agricultural sustainability. The Teagasc NFS collects data on an ongoing basis, with the results published annually. A weighting system, produced by the Central Statistics Office (CSO), reflective of the national farm population is applied to the data from the individual NFS farms. In this way, national level representation is achieved in terms of size and farm type for the principal farm systems in Ireland. This is important to ensure that aggregations of farm types can be made at an appropriate scale (for example, based on farm system type). It also means that the survey results are capable of accurately highlighting synergies and/or trade-offs between different indicators, depending on how farms are managed.

The Teagasc NFS is based on a nationally representative stratified random sample, which is selected annually in conjunction with the CSO. Each farm is assigned a weighting factor so that the results of the survey are representative of the national population of farms (91,367 farms are represented in this report for 2020). Within the Teagasc NFS, farms are classified into major farming systems according to the standardised EU typology as set down by European Commission regulations and applied by the EU FADN (a more detailed explanation and the correspondence between the farm systems used in the NFS and the farm types set out in the EU farm typology can be found in the Teagasc National Farm Survey Report (Donnellan et al., 2020). This report presents results for the four dominant farm systems in Ireland, namely, dairy, cattle, sheep and tillage.

As the required data are produced on an annual basis, it is possible to generate and compare indicators over time. As methodologies are updated and data requirements evolve to reflect scientific developments, the entire time series of sustainability metrics can be updated accordingly. This is evident in the time-series analysis for key indicators presented in the report which are revised to reflect recognised developments in the measurement of sustainability. It

[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 91,367 farms are represented in this study for 2020. A small farm survey is conducted periodically to assess position on smaller farms (Dillon et al., 2017).

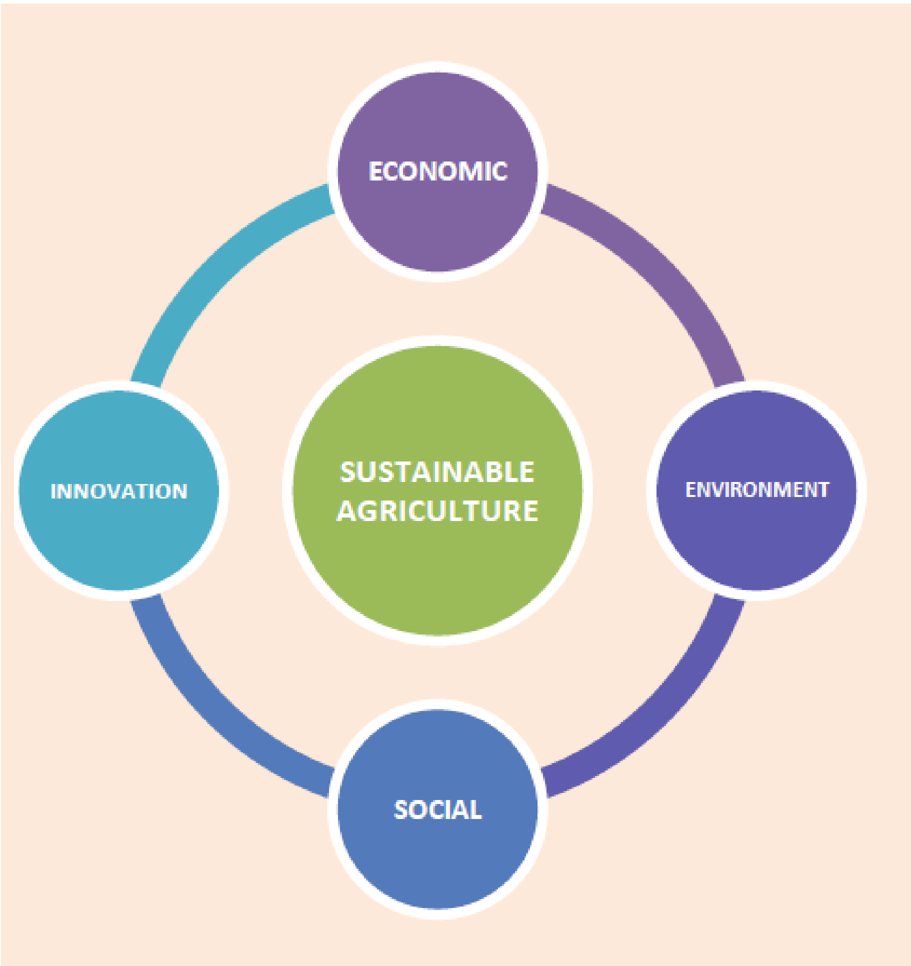
is expected that, based on scientific advances and emerging areas of interest (e.g.in both a scientific and policy context), the sustainability indicator set will continue to evolve to maximise its relevance. The aim is that as indicator methodologies develop, they will still be capable of being generated using Teagasc NFS data, ensuring an on-going accurate inter-temporal assessment of the sustainability performance of Irish farm systems. Furthermore, as the NFS is part of the EU FADN, there is scope for comparative analysis with the sustainability performance of farms in other EU Member States. Indeed, the EU Farm to Fork strategy (EU Commission, 2020) proposes to develop the EU FADN into a Farm Sustainability Data Network (FADN), with a view to collecting data on sustainability indicators and reporting these in a common framework across the EU. The Teagasc NFS is leading the way on this as evidenced by this report.

3 Description of Sustainability Indicators

The indicators described here follow on those published in previous Teagasc sustainability reports (Hennessy et al., 2013; Lynch et al., 2016; Buckley et al., 2019; Buckley & Donnellan, 2020a; Buckley & Donnellan 2020b). Updates presented here reflect methodological refinements, as well as additional data on agricultural activities on Irish farms collected and published by the Teagasc NFS. In particular, it should be noted that in this report for the farming year 2020, there have been methodological developments in the estimation of greenhouse gas and ammonia emissions since the publication of the report covering 2019. For this reason, the historical time series for some of the sustainability indicators presented in the current report will differ from those presented in earlier Teagasc Sustainability reports (Buckley et al., 2019; Buckley & Donnellan, 2020a; Buckley & Donnellan 2020b). This approach to revising historic sustainability indicators is to ensure they reflect our current scientific knowledge. It mirrors the approach used by the Environmental Protection Agency (EPA) in national inventory reporting and therefore is consistent with international best practice.

As depicted in Figure 1 and described in the following section, the Teagasc Sustainability Report's indicators are grouped into four categories: **economic, environmental, social** and **innovation**.

Figure 3-1: Sustainability Overview



3.1 Economic Indicators

Economic viability is essential to ensure that a farm system can sustain itself and that farming families are compensated adequately for owned capital and labour employed. At a national level, agriculture is an important component of the Irish economy. The NFS is well equipped to generate economic indicators. Its origins derive from the need to submit data on economic farm performance to the European Commission through the EU FADN, primarily to aid in the understanding of the effectiveness of the Common Agricultural Policy. The economic sustainability indicator set is, therefore, relatively comprehensive and (relatively unconstrained by issues relating to data availability) designed to cover a range of important economic measures. The following economic indicators are presented in the report:

Table 3.1: 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	%
Family Farm Income	Family Farm Income per hectare	€ / hectare

a) Economic Return to Land

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

b) Profitability of Land

The profitability of a farm is measured as the **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 the labour of farm family members, which is generally unpaid and therefore in not classified as a production cost, and hired labour, which in accounting terms does represents a production cost to the farm. The return on unpaid family labour is measured as **family farm income per unpaid family labour unit**. For consistency in measurement of farm labour input across the EU, one 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 per person, even where an individual works more than 1,800 hours). Labour unit equivalents of 0.75 and 0.5 are used for individuals aged 16-18 years and 14-16 years respectively.

d) Economic Viability

The **economic viability** of a farm business is measured by a **binary variable**. A farm is defined as viable if family labour is remunerated at greater than or equal to the minimum wage as set down in the under the National Minimum Wage Act, 2000 (as outlined by Government of Ireland, 2021a) and there is also sufficient income generated by the farm 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 gross output (€) that is derived from the market** (generally the sales value of the farm's outputs which can referred to as **market based gross output**), as opposed to grants and subsidies, which are treated as a non-market based gross output of the farm.

f) Family Farm Income

Family Farm Income (FFI) is the return from farming for farm family labour, land and capital. It is a function of gross output plus subsidies less total net expenses.

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 covering 65.6% of the State's land area (World Bank, 2020). Hence, the environmental sustainability of agriculture is key to achieving national level objectives relating to the environment. The current set of NFS based environmental indicators focus on **greenhouse gas (GHG) emissions**, **ammonia emissions**, **nitrogen** and **phosphorus use**. Indicators that are currently under development include, metrics relating to **biodiversity** and these will be included in future Teagasc sustainability reports once the relevant scientific work needed to establish indicators and consistently collect the related data has concluded. Progress relating to some of this work has been hampered by restrictions around the COVID-19 pandemic.

Table 3.2: Overview of Environmental Indicators

Indicator	*Measure*	*Unit*
Ag. GHG emissions per farm	Absolute GHG emissions per farm	Tonnes CO_2 equivalent / farm
Ag. GHG emissions per hectare	Absolute 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
NH_3 emissions per farm	Absolute NH_3 emissions per farm	Tonnes NH_3 equivalent / farm
NH_3 emissions per hectare	Absolute NH_3 emissions per hectare	Tonnes NH_3 equivalent / hectare
NH_3 emissions per kg of output	NH_3 emissions efficiency	kg NH_3 equivalent / kg output *AND* kg NH_3 / € output
N balance	N transfer risk	kg N surplus / ha^{-1}
N use efficiency	N retention efficiency	% N outputs / N inputs
N surplus per kg of output	N emissions efficiency	kg N surplus / kg output
P balance	P transfer risk	kg P surplus / ha^{-1}
P use efficiency	P retention efficiency	% P outputs / P inputs

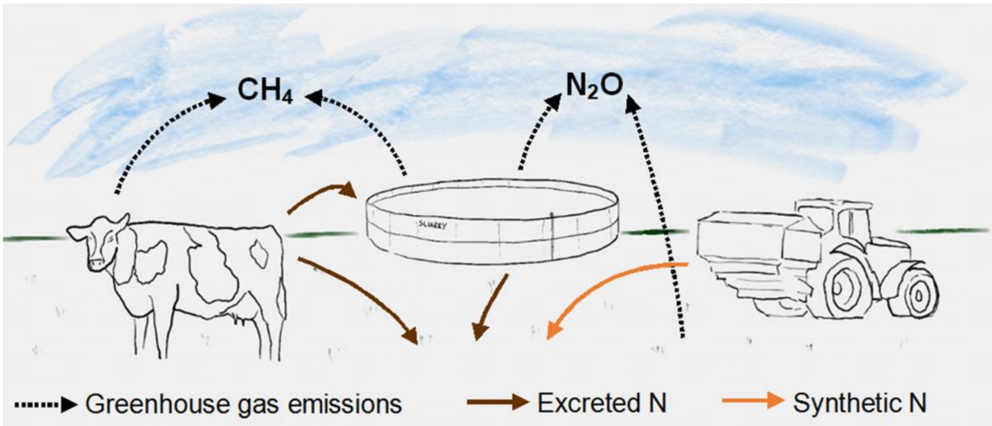
3.2.1 Greenhouse gas emissions

To minimise the extent and impact 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 37.1% of the national emissions total in 2020 (EPA, 2021a). The agricultural sector must reduce its emissions in the context of Ireland's commitment to reduce national GHG emissions. The Climate Action and Low Carbon Development (Amendment) Act 2021 (Government of Ireland, 2021b) sets down a net-zero greenhouse gas emissions target by 2050 for the state. Under the Climate Action Plan 2021, agriculture has a sectoral target of between a 21-30% reduction by 2030 (Government of Ireland, 2021c). Maintaining or even increasing food production will be very difficult, while at the same time reducing aggregate emissions (Breen et al., 2010).

Intergovernmental Panel on Climate Change (IPCC) Methodology*:* The GHG emissions indicators in this report are in the first instance calculated following the IPCC methodology accounting conventions and Irish emission factors as employed in the 2020 National Inventory Report for Ireland (Duffy et al., 2021). The three main agricultural GHG 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. **Carbon dioxide (CO_2)** emissions associated with **crop residues**, **liming** and **urea application** are also included in the analysis presented in this report.

A complicating factor inherent in a **farm based** approach to emissions measurement, (as opposed to a **national aggregate** emissions inventory approach), is that some animals move between farms via inter-farm sales as part of the agricultural production process. Accordingly, an animal inventory approach is used here, 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 a particular farm. For reporting purposes, all non-carbon dioxide (CO_2) emissions are converted to **CO_2 equivalents (CO_2e)** using appropriate global warming potentials (GWP) for CH_4 and N_2O which are respectively 25 and 298 times greater than the GWP of CO_2.

Figure 3-2: An illustration of some of the major agricultural greenhouse gas emissions



Emissions resulting from on-farm fuel and electricity use are considered independently of the IPCC's agricultural emissions category, as they are recognised under 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, 2021; SEAI, 2021)) and by applying national level emissions factors to these quantities.

Using the IPCC methodology, the main indicators developed include:

a. **Total agricultural emissions 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:** derived so that the total emissions of the farm can be decomposed into components relating to each of the farm's main agricultural outputs (milk, cattle or sheep live-weight and crop outputs).
c. **Agricultural greenhouse gas emissions per unit of hectare & € output:** In addition, agricultural based GHG emissions per € of output and per hectare are used to illustrate GHG emissions that are generated on farms with dissimilar levels of agricultural output.
d. **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 GHG emissions are considered separately from agricultural GHG emissions.

Methodological Update

Updated emissions factors in line with national inventory accounting methodology have been applied in the areas of animal nitrogen excretion rates, enteric fermentation and manure management based emissions factors.

Greater granularity around farm management activity data in now available across NFS farms on a longitudinal basis. This includes individual farm level data on grazing and housing periods, storage of manure, timing of manure application and method of manure application to land.

A benefit of the greater granularity in the calculation of emissions is that it allows a more accurate allocation between enterprises based on associated activity levels (e.g. emissions associated with Dairy are linked to dairy cows). Where emissions cannot be directly associated with an enterprise (e.g. liming), then they are allocated based on gross output of the relative farm enterprises.

LCA Methodology: An alternative method to the **IPCC approach** of measuring GHG emissions is the **Life Cycle Assessment (LCA) 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 when it leaves the farm. 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.

Relative to the territorial IPCC approach, 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 it was only possible to conduct a carbon LCA based footprint analysis of milk production using

NFS data. The Teagasc Dairy LCA model was used for this analysis (O'Brien et al., 2014; Herron et al., 2021). This model, which is accredited by the National Carbon Trust (UK) underpin the carbon footprint results from the Bord Bia Sustainable Dairy Assurance Scheme (SDAS). The system boundaries of this 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 Dairy LCA model using NFS data is that the Teagasc NFS is nationally representative of Irish milk production and thus reflects the full spectrum of dairy farming conditions in the country and as such allows for the production of a nationally representative LCA based carbon footprint measure.

As with the other indicators presented in this report, emphasis should not be placed on the absolute level of the carbon footprint measure, since this can be the subject of ongoing revision. Of greater relevance is the direction in which the indicator evolves over time. The main objective of this research is to establish indicators through which progress in sustainability performance can be documented and evaluated.

Methodological Update

The Teagasc Dairy LCA model has also been updated from version 3 to version 4. For an overview of the update please refer to (Herron et al., 2021).

3.2.2 Ammonia

Ammonia (NH_3) is an air pollutant contributing to **eutrophication** and **acidification** of terrestrial and aquatic ecosystems. It is also an **indirect source** of a potent greenhouse gas **nitrous oxide** (Sutton et al., 1992). 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 NH_3. Within the EU, NH_3 emissions are regulated through the National Emissions Ceiling (NEC) Directive (EU, Commission 2016). Over 99.4% of Ireland's NH_3 emissions originate within agriculture, principally from animal waste and the application of synthetic fertilisers (EPA, 2021b). The fact that NH_3 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. From 2020, Ireland has an NH_3 ceiling of 112.2 kilotonnes per annum, representing a 1% NH_3 reduction relative to the 2005 level. A further reduction target of 5% relative to the 2005 level (to a ceiling of 107.6 kilotonnes per annum) is to be achieved by 2030. The national inventory accounting methodology as applied by the Environmental Protection Agency (Duffy et al., 2021) in conjunction with activity data from the NFS is used for estimating NH_3 emission indicators across different farm systems in this report, the main indicators developed include:

a. **Total agricultural ammonia emissions per farm**: with emissions also disaggregated to show the emissions originating from different farm enterprises (dairy, cattle, sheep and fertilisers).
b. **Ammonia emissions per unit of output/hectare:** derived so that the total NH3 emissions of the farm can be decomposed into components relating to each of the farm's main agricultural outputs (milk, cattle or sheep live-weight and crop outputs). In addition, NH3

emissions per € of output and per hectare are used to illustrate emissions that are generated on farms with dissimilar levels of agricultural output.

3.2.3 Nutrient Use Efficiency

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 the farms output, which would include milk, crops, wool, manures exported and livestock sold (including livestock for slaughter). Imports are comprised of fertilisers applied, feeds purchased, livestock brought onto the farm and imported organic manures. 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.

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.

c. **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.
d. **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 temporal comparisons at the farm gate level.
e. **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).

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** (PUE) is used to highlight the proportion of P retained in the farm system (P outputs / P inputs). This is a generic measure allowing temporal comparisons at the farm gate level.

3.3 Social Indicators

A farm will only be sustainable if employment in agriculture can provide a suitable economic return for the labour employed, 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 new entrants to farming with fewer younger people 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 a viable farming sector are also important in **maintaining employment** and **social well-being** in the broader rural community. The design of social sustainability indicators is subjective in nature and further work is required to improve the farmer, animal and community well-being aspects of social sustainability measurement within the Teagasc NFS. Based on the data currently available from the NFS, the following indicators are reported:

Table 3.3: 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
Hours worked on-farm	Farm work load of farmer	Hours worked on the farm
Total hours worked	Work load of farmer	Total hours worked on and off-farm

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 (e.g. willingness to adopt new technologies).

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**.

e) Hours worked on farm

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**.

f) Total Hours worked

This indicator is the **number of hours worked** by the farmer **on and off the farm**. This **includes** hours worked in **off-farm employment**.

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 arise from the **adoption of** established and newly developed **management techniques**. Hence, it is important to measure uptake of such innovations to ensure that evolving science and knowledge is being translated into actual farmer 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, and also reflect **farmer membership in groups** which may be positively associated with increased adoption of broader innovations. The majority of the innovation indicators are scored as **binary variables**, either where a specific technology or practice is used or where a farmer is a member of the given group. Innovation indicators can be especially useful when evaluated in conjunction with those relating to economic performance, as they will highlight the benefits of specific technologies or behaviours.

Table 3.4: 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*	Break Crop
Protected urea use	Protected urea use	Protected urea use	
Reseeding	Reseeding	Reseeding	
Low emission slurry spreading	Low emission slurry spreading		
Milk Recording			

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

Dairy innovation indicators

- ***Discussion group membership*** was selected as indicating the degree of interaction farmers have with farm extension services and their peers. This is reported in binary (yes/no) format.
- ***Liming*** **and** ***Reseeding*** were identified as important practices in grassland management. This is reported in binary (yes/no) format.
- ***Spring slurry spreading*** (spreading at least 50% of total slurry between January and April) was identified as an important practice to minimise nutrient losses to the

environment and maximise grass production. This is reported in binary (yes/no) format.

- ***Protected urea fertiliser use*** is associated with lower greenhouse gas emissions compared to Calcium Ammonium Nitrate (CAN). Protected urea is also associated with lower ammonia emissions compared to conventional straight urea fertiliser formulations and greater nitrogen recovery for agronomic purposes. This is reported as the proportion of chemical N applied in protected urea form.
- ***Low emission slurry spreading*** low emission slurry spreading or LESS (trailing shoe, trailing hose or injection methods) increases nitrogen retained in slurry and reduces the need for chemical fertiliser, as well as reducing nitrogen losses to the environment. This is reported as the proportion of farm slurry applied using LESS techniques.
- ***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. This reported is in binary (yes/no) format.

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 the degree of interaction with extension services and peers. This is reported in binary (yes/no) format.
- ***Liming*** **and** ***Reseeding*** were identified as important practices in grassland management. This is reported in binary (yes/no) format.
- ***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. This is reported in binary (yes/no) format.
- ***Protected urea fertiliser use*** is associated with lower greenhouse gas emissions compared to Calcium Ammonium Nitrate (CAN). It is also associated with lower ammonia emissions compared to straight urea fertiliser formulations and greater nitrogen recovery for agronomic purposes. This is reported as the proportion of chemical N applied in protected urea form.
- ***Low emission slurry spreading*** low emission slurry spreading or LESS (trailing shoe, trailing hose or injection methods) increases nitrogen retained in slurry and reduce the need for chemical fertiliser, as well as reducing nitrogen losses to the environment. This is reported as the proportion of farm slurry applied using LESS techniques.

Tillage innovation indicators

- ***Discussion group membership*** was selected as indicating the degree of interaction with extension services and peers. This is reported in binary (yes/no) format.
- ***Liming*** was identified as important practices in arable production. This is reported in binary (yes/no) format.

- ***Growing a main break crop*** (oilseed rape, peas, beans, linseed) was identified as best practice for tillage farms for disease and pest control. This is reported in binary (yes/no) format.

4 Interpretation of Sustainability Indicator Results

The main diagrams used to represent sustainability indicator results are provided below. Boxplots are used to display continuous data and allow the visualisation of the statistical distribution of the results for the population represented. The boxplots used here show the 10th, 25th, 50th, 75th and 90th percentiles of the NFS sample's population weighted distribution. An annotated hypothetical example is shown in Figure 4-1 below, using data on gross margin per hectare for dairy farms. The value of the percentiles reflect the distribution of results. For example, the 50th percentile (the median) in Figure 4-1 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 4-2 below. To reflect how a given (non-economic) indicator relates to the economic performance of a farm, for most indicators, farms are segmented by performance into a top, middle and bottom performing third, where performance is based on gross margin per hectare. This is also demonstrated in the example in Figure 4-2, 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 4-1: Example Boxplot Gross Margin € per hectare

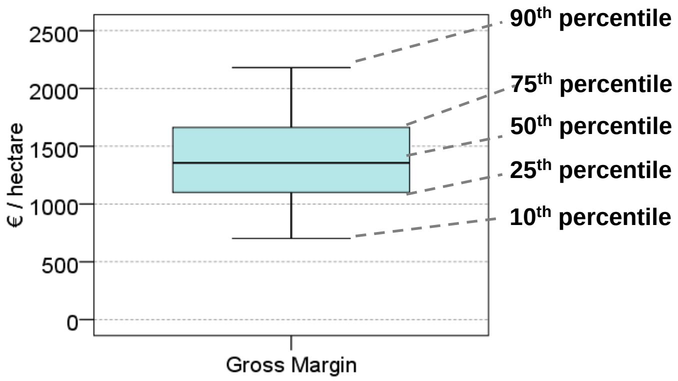
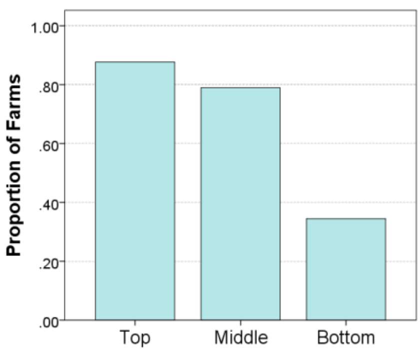


Figure 4-2: Example Bar Chart Proportion of farms

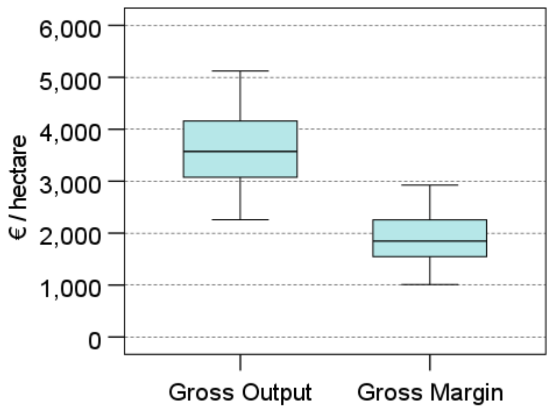


5 Dairy Farm Sustainability 2020

Economic Sustainability Indicators

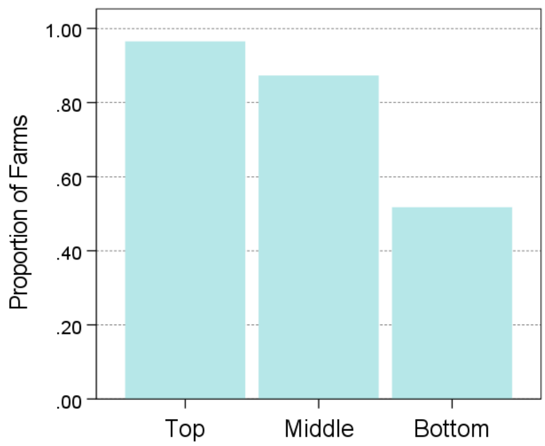
In 2020, the average dairy farm output per hectare was €3,695, and the average market based gross margin per hectare was €1,906. Median values were slightly lower than the average, as shown in Figure 5-1.

Figure 5-1: Economic Return and Profitability of Land: Dairy Farms



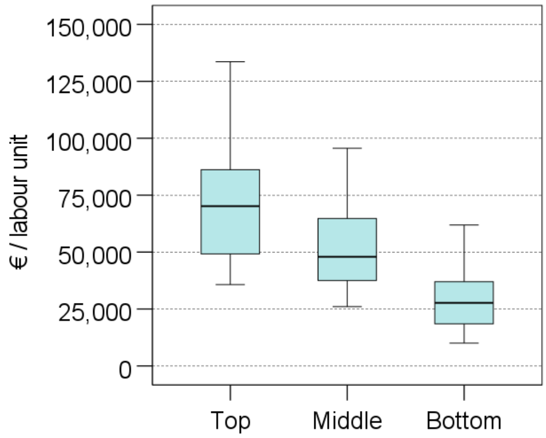
Overall 79% of dairy farms were economically viable in 2020. This ranged from 97% for the top third of economic performing dairy farms to 52% for the bottom third, as illustrated in Figure 5-2.

Figure 5-2: Economic Viability: Dairy Farms



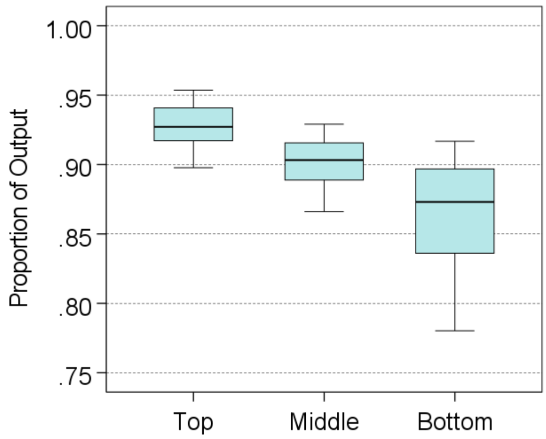
Average income per labour unit (unpaid family labour) for dairy farms in 2020 was €55,271. Average incomes per labour unit were €80,664, €55,776 and €29,834 for the top, middle and bottom performing farm cohorts respectively. However, there was a large range in the return to labour for dairy farms, especially for the higher performing farms, as shown in Figure 5-3.

Figure 5-3: Productivity of Labour: Dairy Farms



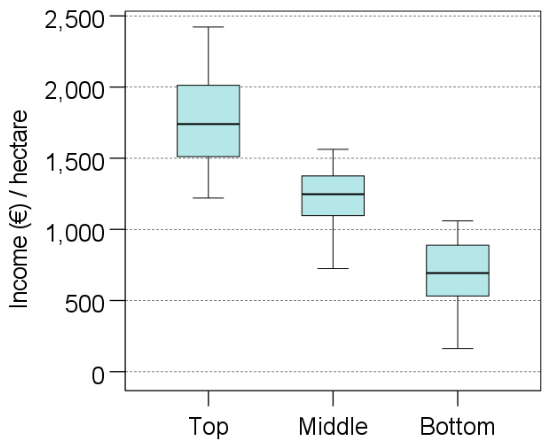
On average, dairy farms derived 90% of gross output directly from the market in 2020. The degree of market orientation was highest for the top third of dairy farms and the range was largest among the bottom third, as illustrated in Figure 5-4.

Figure 5-4: Market Orientation: Dairy Farms



For the full dairy farm population, there was a large range of income per hectare across all three groups as seen in Figure 5-5. The average family farm income per hectare on dairy farms was €1,248 in 2020. Within subcategories, the average income ranged from €1,838 from the top performing cohort to €677 for the bottom performers in economic terms.

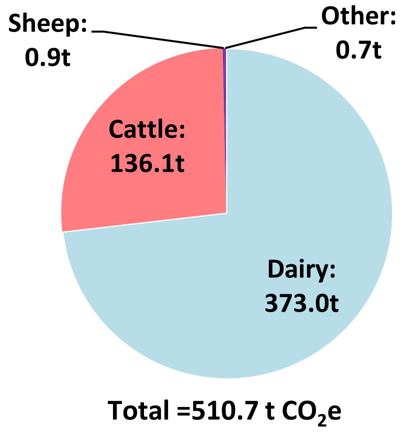
Figure 5-5: Family Farm Income per hectare: Dairy Farms



Environmental Sustainability Indicators

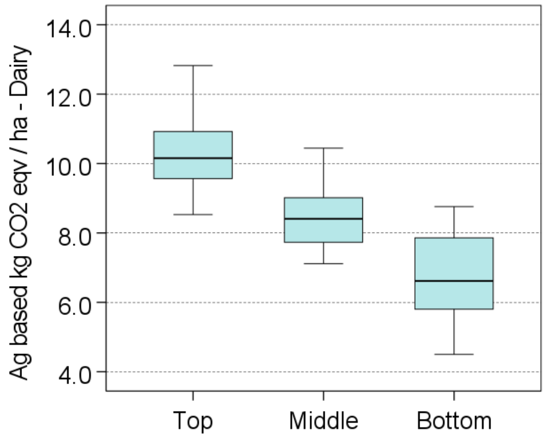
Figure 5-6 indicates that the average dairy farm produced 510.7 tonnes of agricultural GHG emissions (in CO_2 equivalent) in 2020. It should be noted that this measure is based on the IPCC definition of agricultural emissions. At 73%, most dairy farm emissions were from milk based output. A further 26.7% was allocated to beef production on these farms (this would include emissions from cull cows and calf sales and transfers). The remaining emissions, less than 1%, were associated with sheep and arable production on dairy farms.

Figure 5-6: Agricultural GHG Emissions for the average Dairy Farm



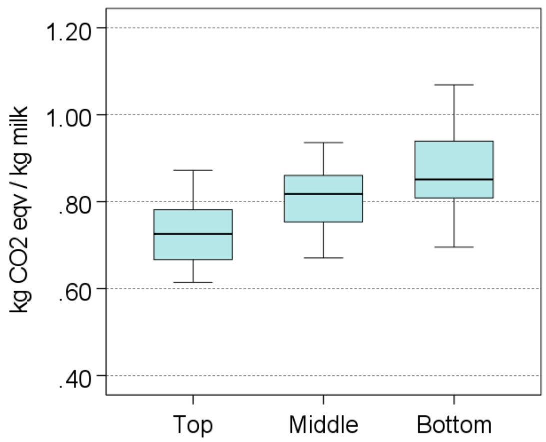
The average dairy farm emitted 8.61 tonnes of CO_2 equivalent per hectare. The better performing dairy farms in an economic sense tended to operate at higher intensities and this is reflected in their higher emissions of GHG per hectare, as shown in Figure 5-7.

Figure 5-7: Agricultural GHG Emissions per hectare: Dairy Farms



When emissions allocated to dairy output are expressed per kilogramme of milk output, the average dairy farm emitted 0.81 kg CO_2 equivalent per kg of milk produced.[2] Figure 5-8 shows that those farms with a better economic performance also tended to have the lowest emissions intensity per kg of milk produced.

Figure 5-8: Agricultural GHG Emissions per kg of milk: Dairy Farms

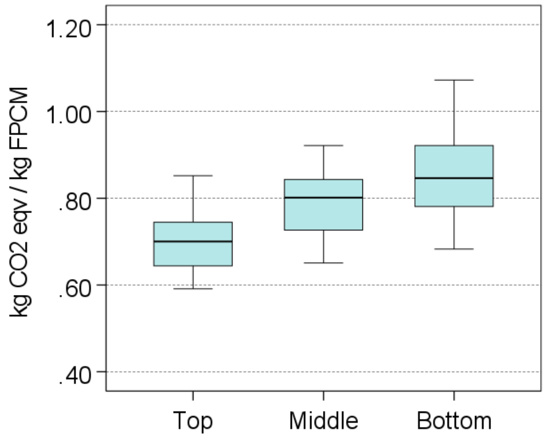


Emissions allocated to dairy output are also expressed per kg of fat and protein corrected milk (FPCM), which is standardized to 4% fat and 3.3% true protein per kg of milk. The average farm emitted 0.79 kg CO_2 equivalent per kg of FPCM produced. Figure 5-9 also shows that those farms with better economic

[2] Convert kg to litre by multiplying by 1.03

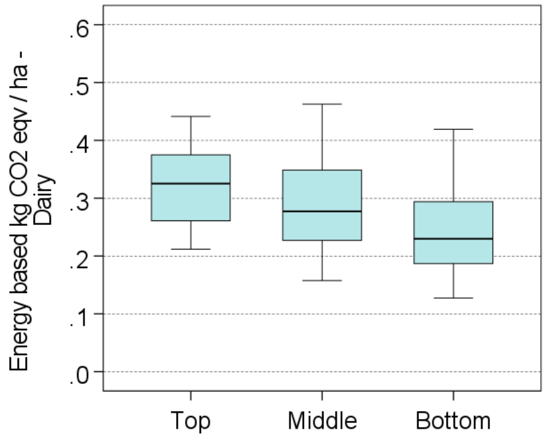
performance also have lower emissions intensity per kg of FPCM produced.

Figure 5-9: Agricultural GHG Emissions per kg of FPCM: Dairy Farms



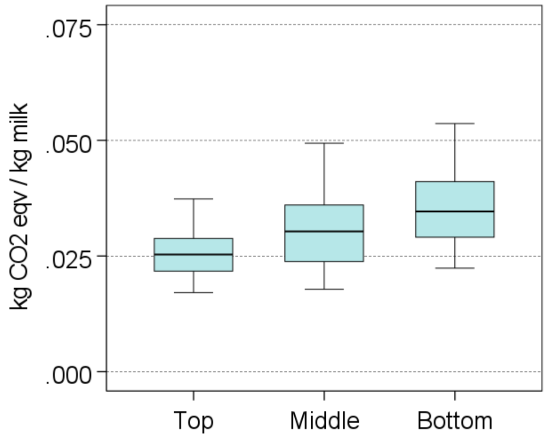
The average dairy farm emitted 0.31 tonnes of energy based CO_2 equivalent per hectare. The better performing dairy farms in an economic sense tended to operate at higher intensities and this is reflected in their higher emissions of energy based GHG per hectare, as shown in Figure 5-10.

Figure 5-10: Energy use related GHG Emissions per kg of Milk: Dairy Farms



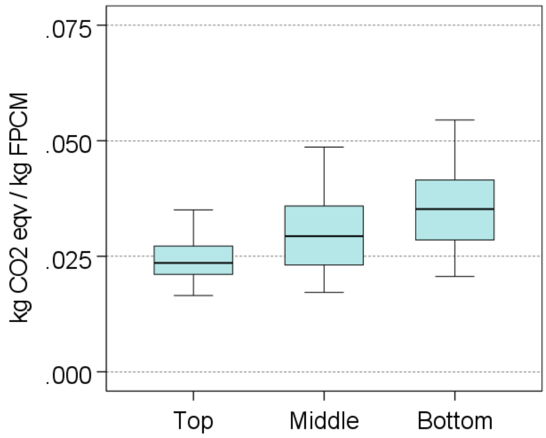
The average energy based GHG dairy farm emissions were 0.0335 kg CO2 equivalent per kg of milk in 2020. Figure 5-11 indicates that, similar to agricultural based GHG emissions intensity of milk production, lower energy based GHG emissions per kg of milk produced is evident among farms with better economic performance.

Figure 5-11: Energy use related GHG Emissions per kg of Milk: Dairy Farms



The average energy based GHG emissions were 0.0328 kg CO2 equivalent per kg of FPCM produced as shown in Figure 5-12. This indicator again shows that the top economic performers were more efficient in terms of FPCM produced per kg of energy related CO2 emissions generated.

Figure 5-12: Energy GHG Emissions per kg of FPCM: Dairy Farms



Using the LCA approach (including both agricultural and energy based emissions) the average dairy farm carbon footprint of milk was 1.04 kg CO2 equivalent per kg of FPCM. Figure 5-13 again shows that lower emissions per kg of FPCM (on an LCA basis) was more prevalent among the group of higher economic performing dairy farms.

Figure 5-13: Total LCA based GHG emissions (Agriculture & Energy) per kg of FPCM: Dairy Farms

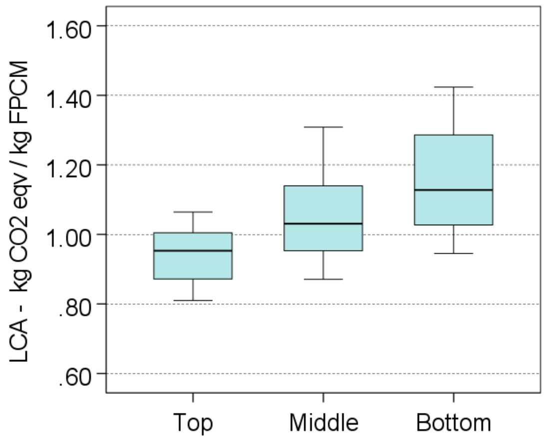
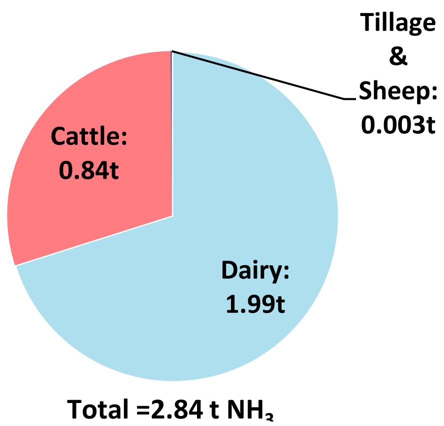


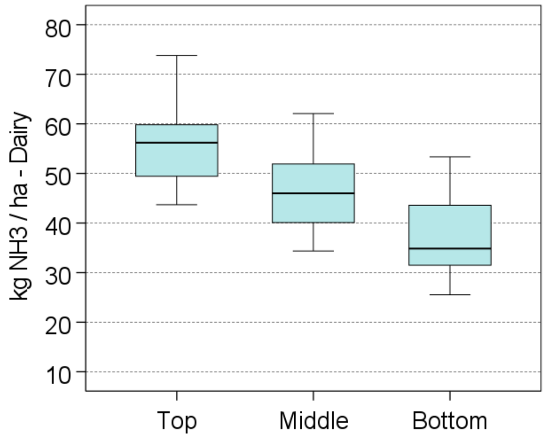
Figure 5-14 indicates that the average dairy farm produced approximately 2.84 tonnes of ammonia (NH_3) emissions in 2020. This calculation is based on an approach consistent with the EPA national inventory methodology. The majority of dairy emissions, 70%, were from milk based output, with 30% allocated to non milk producing animals and some minor arable production.

Figure 5-14: Total Ammonia Emissions for the average Dairy Farm



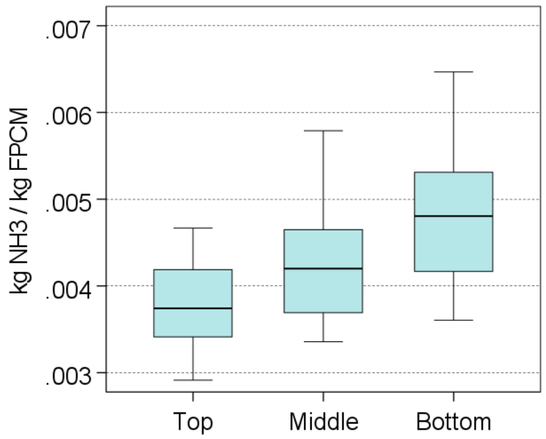
The average dairy farm emitted 48 kg of NH3 per hectare across the entire farm. Economically better performing farms tend to operate at higher intensities and this is reflected in higher emission of ammonia per hectare, as shown in Figure 5-15.

Figure 5-15: Ammonia Emissions kg per hectare: Dairy Farms



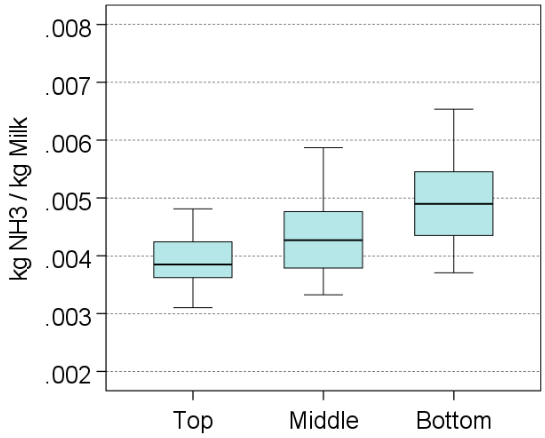
The average dairy farm emitted 0.0044 kg of NH_3 per kg of FPCM produced. Figure 5-16 again shows that the top economic performing dairy farms produced milk at a lower NH_3 emissions intensity compared to the middle and bottom cohorts.

Figure 5-16: Ammonia Emissions per kg of FPCM: Dairy Farms



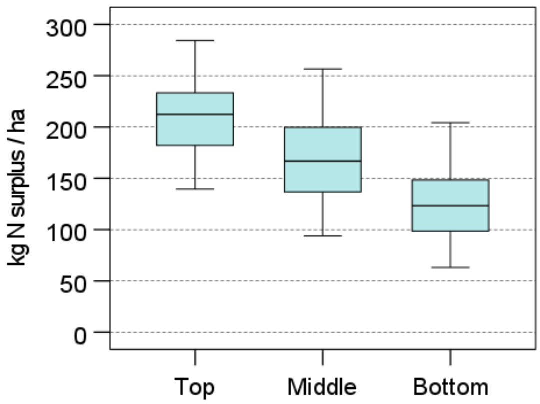
This result was replicated in the outcome on a kg of milk output basis, as shown in Figure 5-17. However, NH_3 per kg of milk was slightly higher at 0.0044.

Figure 5-17: Ammonia Emissions per kg of Milk: Dairy Farms



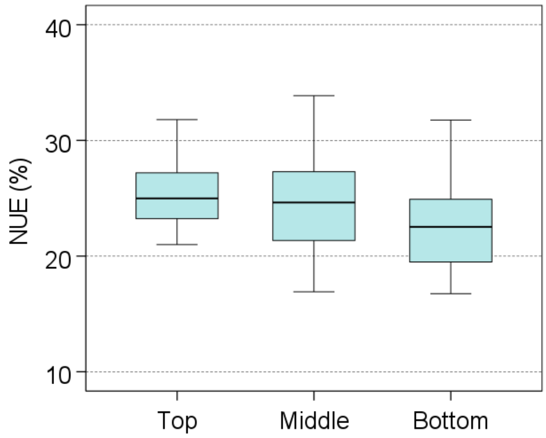
Nitrogen balance (excess of N inputs over outputs) averaged 172.6 kg N surplus per hectare across all dairy farms in 2020. Figure 5-18 indicates that higher N surpluses per hectare are associated with superior economic performance. This is due to the greater production intensity on economically better performing farms.

Figure 5-18: N Balance per ha: Dairy Farms



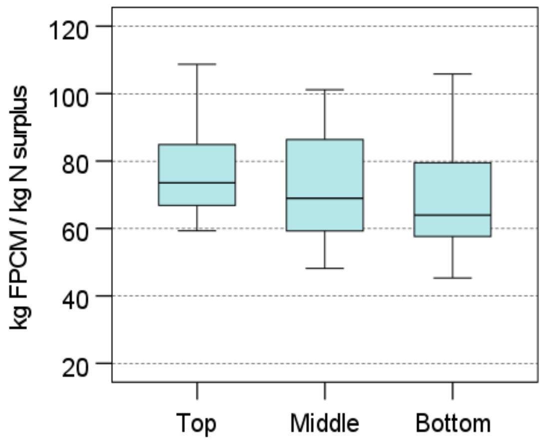
The average dairy farm had a NUE of 25.6% in 2020. Figure 5-19 demonstrates the slightly higher N use efficiency was evident among the better economic performing farmers, with the largest range prevalent among the middle and bottom cohorts.

Figure 5-19: N Use Efficiency: Dairy Farms



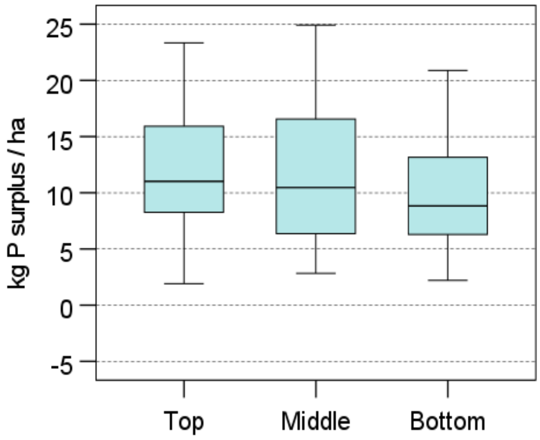
On average dairy farms produced 75.3 kg of FPCM per kg of surplus nitrogen. Figure 5-20 shows that higher NUE of milk production is linked to higher economic performance, with the top and middle cohorts producing more kg of FPCM per kg of surplus nitrogen.

Figure 5-20: NUE of Milk Production



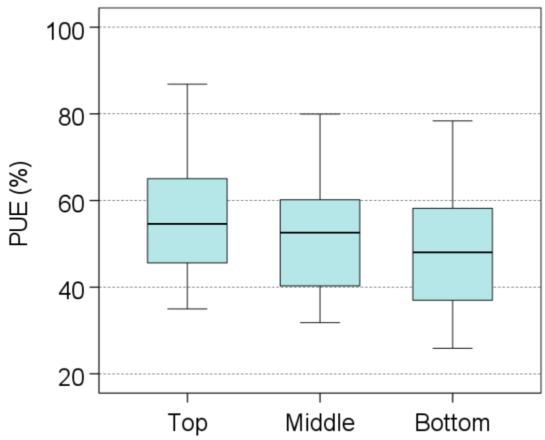
Phosphorus balance (excess of inputs over outputs) averaged 12.3 kg P surplus per hectare across all dairy farms in 2020. Figure 5-21 shows that there was a larger range of results, especially for the top and middle performing cohorts.

Figure 5-21: P Balance per ha: Dairy Farms



The average dairy farm had a P use efficiency of 54.9%. Figure 5-22 indicates higher P use efficiency was more prevalent among the better economic performing farmers.

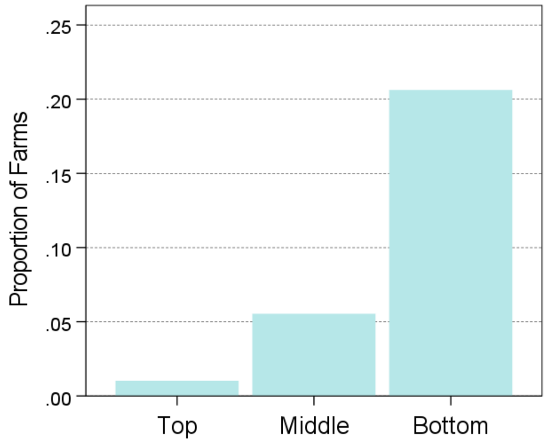
Figure 5-22: P Use Efficiency: Dairy Farms



Social Sustainability Indicators

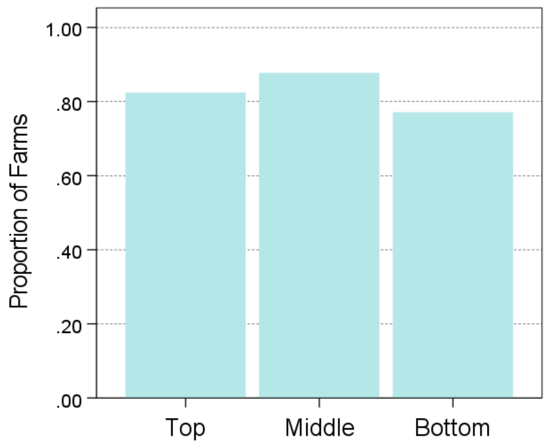
A minority of all dairy farm households, 9%, fell into the vulnerable category (non-viable and no off-farm employment). Figure 5-23 shows that there was a considerably larger proportion of households at risk among those farms with the lowest gross margin per hectare (21% among bottom third).

Figure 5-23: Household Vulnerability: Dairy



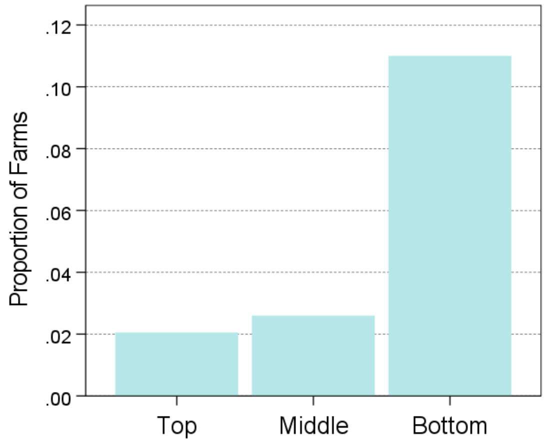
Overall, 82% of dairy farmers had received formal agricultural education of some description. Figure 5-24 shows that agricultural training rates were slightly higher across the middle and top performing cohorts.

Figure 5-24: Agricultural Education: Dairy



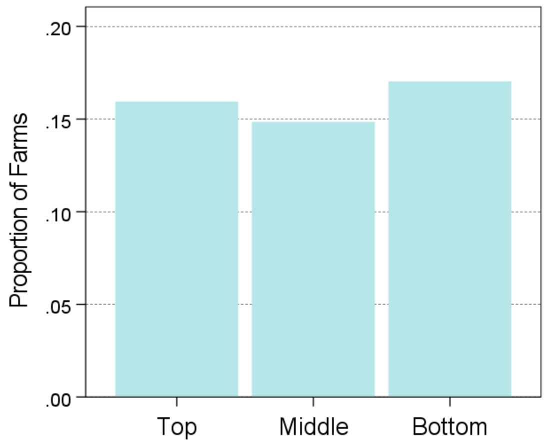
Only 5% of dairy farmers live alone and were thus classified as being at risk of isolation. Figure 5-25 indicates that the risk was lowest for the top economic preforming cohort.

Figure 5-25: Isolation Risk: Dairy Farms



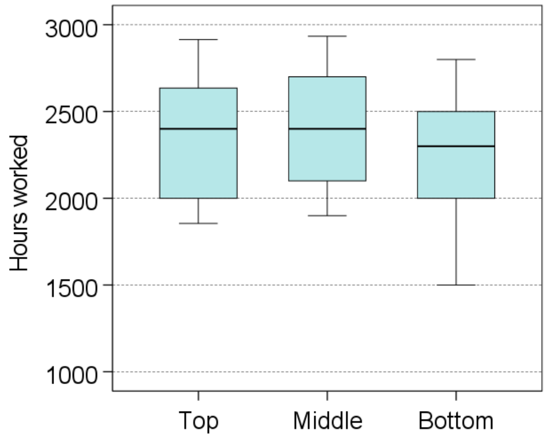
Across all dairy farms, 17% were identified as having a high age profile. Figure 5-26 shows that this was slightly higher for the weaker economic performing dairy farms.

Figure 5-26: High Age Profile: Dairy Farms



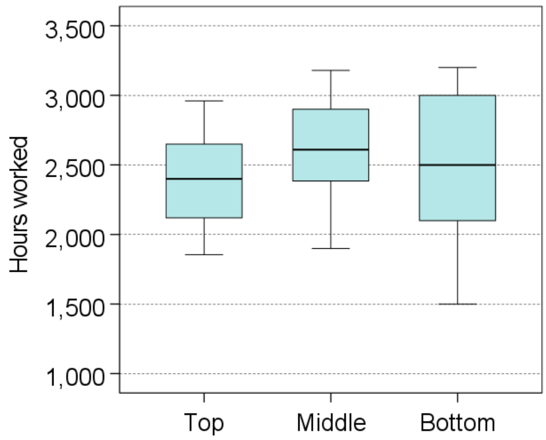
On average, dairy farmers worked 2,386 hours per year on-farm (approximately 45.9 hours per week). Figure 5-27 shows that the number of hours worked was highest for top and middle performing cohorts by economic performance. However, this figure does not take into consideration off-farm employment, or the share of hours worked by hired staff or other family members.

Figure 5-27: Hours Worked on farm: Dairy Farm Operator



On average, dairy farmers worked 2,575 hours per year between on and off-farm work (approximately 49.5 hours per week). Figure 5-28 shows that hours worked was highest for the middle and bottom performing cohorts by economic performance.

Figure 5-28: Total Hours Worked: Dairy Farm Operator

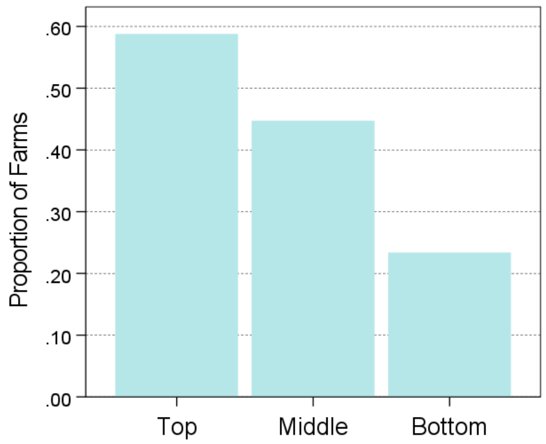


Dairy Innovation Indicators

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, use of low emission slurry spreading equipment, application of protected urea fertiliser, as well as liming & grassland reseeding rates.

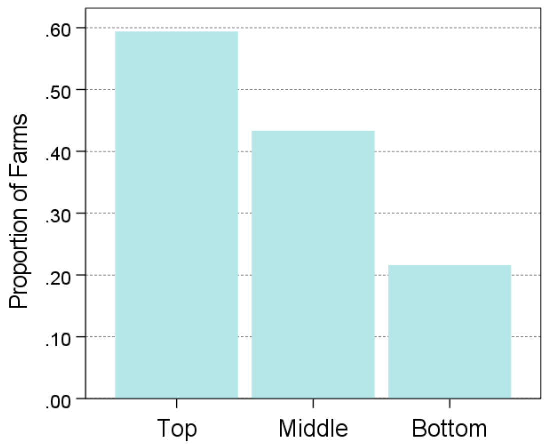
Figure 5-29 shows that those farms with better economic performance were more likely to use milk recording. Over 59% of the dairy farmers in the top group were milk recording, compared to 23% in the bottom group.

Figure 5-29: Milk Recording: Dairy Farms



Better economic performance was more prevalent among discussion group members. Membership rates were higher across the top economic performing group, at 60%, compared to 22% in the bottom cohort, as shown in Figure 5-30.

Figure 5-30: Discussion Group: Dairy Farms



The application of the majority of slurry in early spring was slightly higher across the top performing cohort at 59%, as shown in Figure 5-31. The middle and bottom cohorts had lower level of spring time slurry application at 45% and 51% respectively.

Figure 5-31: Spring Slurry: Dairy Farms

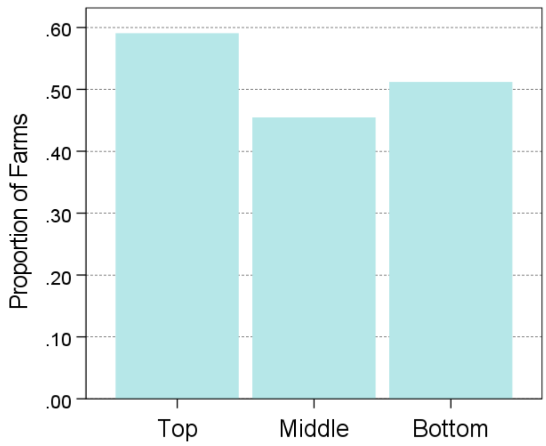
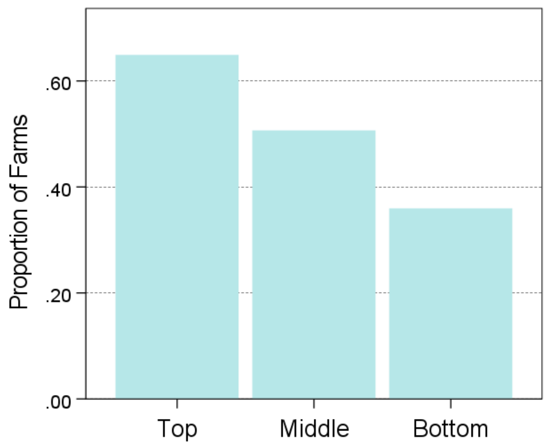


Figure 5-32 illustrates that volume of slurry applied by low emissions slurry spreading equipment. On average, nearly 51% of all slurry applied by dairy farmers was via low emission slurry spreading methods. This ranged from 65% for the top performing cohort to 36% for the bottom performing cohort.

Figure 5-32: Slurry applied by Low emissions slurry spreading methods: Dairy Farms



The percentage of total chemical nitrogen applied in the form of protected urea averaged 5% across all dairy farms. This ranged from 8% for the top performing cohorts to 2% for the bottom group as illustrated by Figure 5-33.

Figure 5-33 Protected Urea Use: Dairy Farms

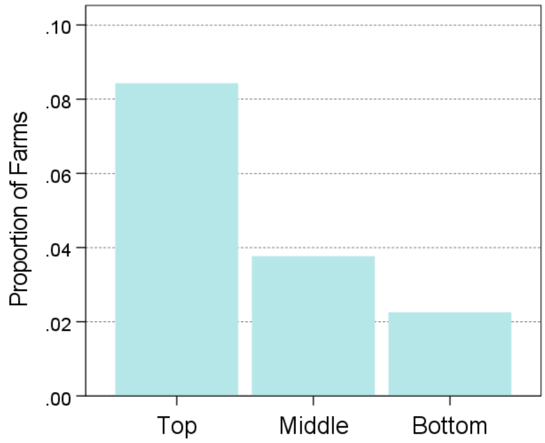


Figure 5-34 shows that liming was more prevalent among the better economic performers, with 48% of the top performing group engaging in this practice in 2020, compared to 24% for the bottom group.

Figure 5-34: Liming: Dairy Farms

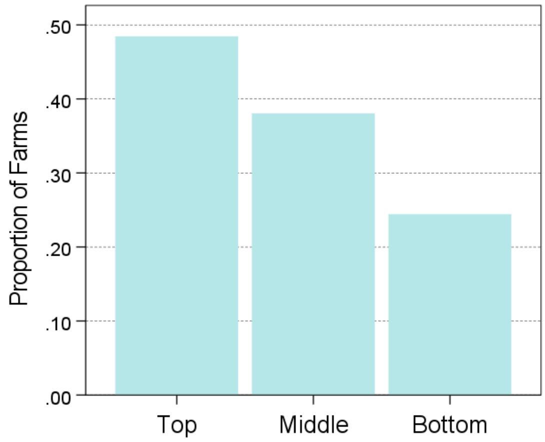
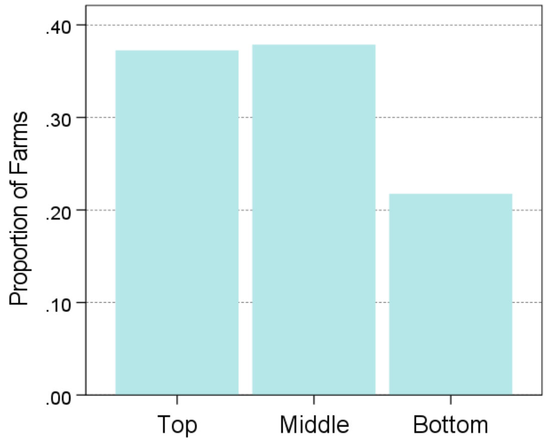


Figure 5-35 shows that reseeding was also more common among the better economic performing farms. A higher percentage of farmers in the top and middle groups (37-38%) engaged in reseeding of grassland compared to the bottom group (22%) in 2020.

Figure 5-35: Reseeding: Dairy Farms



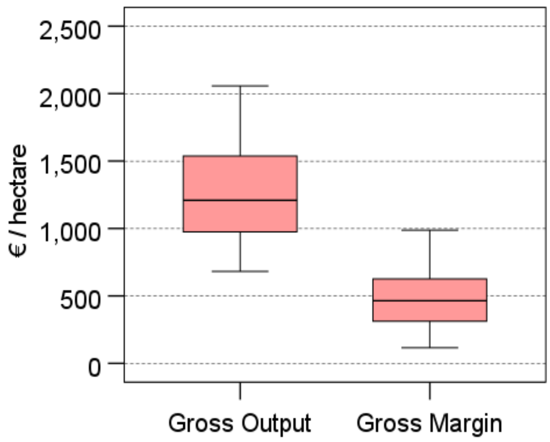
6 Cattle Farm Sustainability 2020

Cattle farms include both cattle rearing (mainly suckler based) and cattle finishing systems. Results for sustainability indicators in 2020 are presented below.

Economic Sustainability Indicators

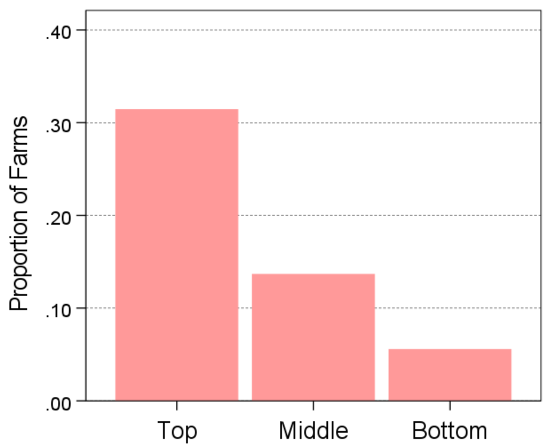
The average output per hectare for cattle farms was €1,327, and the average gross margin per hectare was €510 in 2020. There was a large range in farm economic performance, as shown in Figure 6-1.

Figure 6-1: Economic Return and Profitability of Land: Cattle Farms



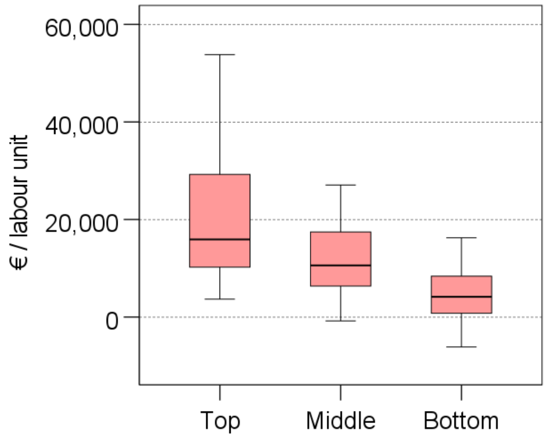
Only 17% of all cattle farms in the Teagasc NFS were defined as economically viable. As illustrated in Figure 6-2 the proportions deemed viable were 31%, 14% and 6% for the top, middle and bottom cohorts of farms by economic performance respectively.

Figure 6-2: Economic Viability: Cattle Farms



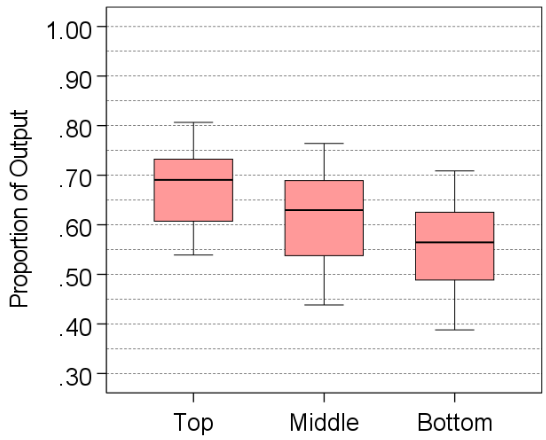
Across all cattle farms, the average income per labour unit was €13,888 in 2020. Figure 6-3 shows that this distribution was skewed by the top third of farms, which included a large number of relatively higher earners, with a mean income per labour unit of €24,104, compared with €11,879 and €5,275 for the middle and bottom cohorts of cattle farms respectively.

Figure 6-3: Productivity of Labour: Cattle



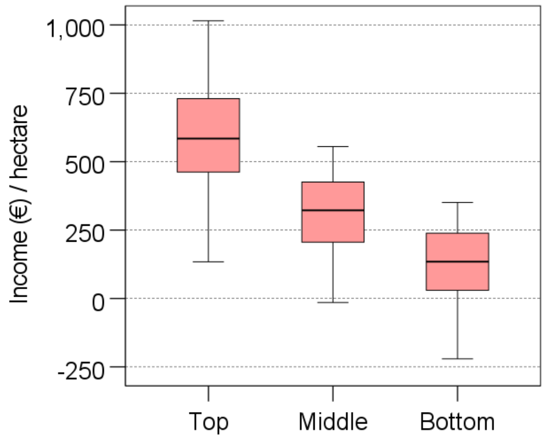
Market based output accounted for 62% of gross output across all cattle farms, with the remaining 38% accounted for by direct payment receipts. Figure 6-4 shows greater market orientation was exhibited across farms with better economic performance.

Figure 6-4: Market Orientation: Cattle Farms



The average family farm income per hectare on cattle farms was €331 in 2020. Across the subgroups, the average ranged from €609 for the top performing cohort to €105 for the bottom performers economically. Figure 6-5 shows significant ranges in income per hectare across the three groups, with negative income per hectare returned by a section of the middle and bottom performing cohort.

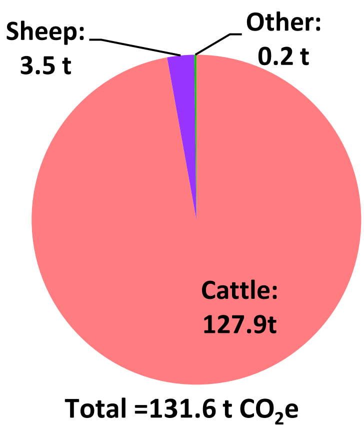
Figure 6-5: Family Farm Income per hectare: Cattle Farms



Environmental Sustainability Indicators

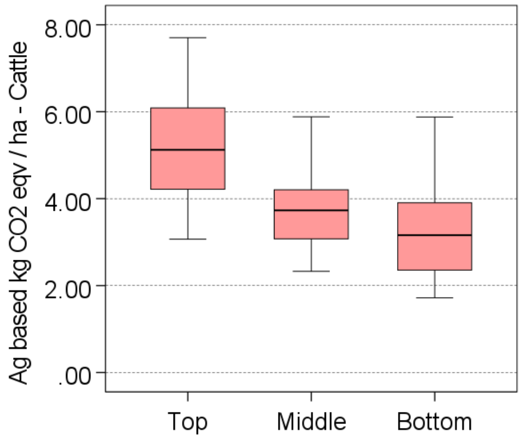
The average cattle farm produced 131.6 tonnes CO_2 equivalent of agricultural GHG emissions in 2020. Figure 6-6 shows that beef production was the principal source, generating 97.1% of these emissions. Sheep production was responsible for approximately 2.6% of total emissions on Irish cattle farms, and a very small proportion (less than 0.04%) was derived from other enterprises on these farms.

Figure 6-6: Agricultural GHG Emissions for the average Cattle Farm



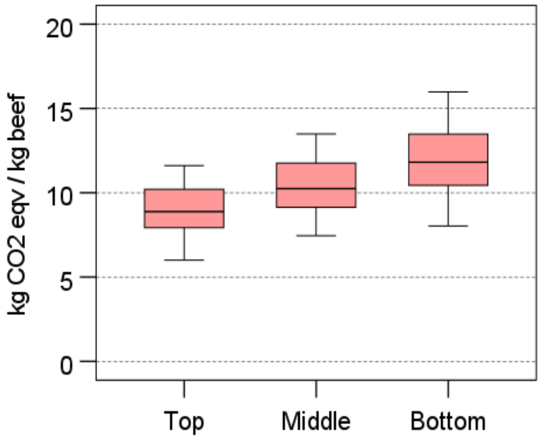
The average cattle farm emitted 4.1 tonnes of CO_2 equivalent of agriculturally generated GHG emissions per hectare in 2020. Emissions per hectare were higher for the more profitable cattle farms, which tended to be stocked at a higher intensity.

Figure 6-7: Agricultural GHG Emissions per hectare: Cattle Farms



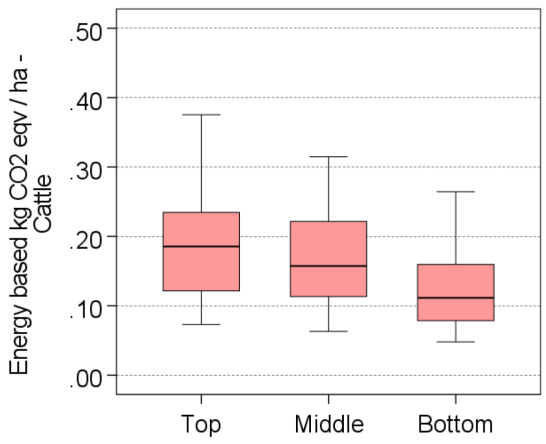
The emissions generated by cattle can be expressed in terms of their live-weight output (estimated using CSO price data). Figure 6-8 illustrates that there is a large range of emissions per kg of beef live-weight output. A positive association exists between emissions efficiency and economic performance. The top performing third of farms emitted, on average, 9.0 kg CO_2 equivalent per kg of live-weight beef produced, compared with 12.2 kg for the bottom performing third of cattle farms. The average level of GHG emissions across all farms was 10.5 kg CO_2 equivalent per kg beef of live-weight produced.

Figure 6-8: Agricultural GHG Emissions per kg live-weight beef produced: Cattle Farms



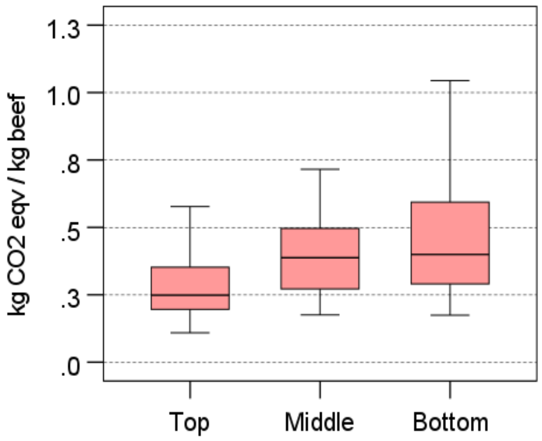
The average cattle farm emitted 0.18 tonnes of CO_2 equivalent of energy based GHG emissions per hectare in 2020 as seen in Figure 6-9. Emissions per hectare were higher for the more profitable cattle farms, which tended to be stocked at a higher intensity.

Figure 6-9: Energy GHG Emissions per hectare: Cattle Farms



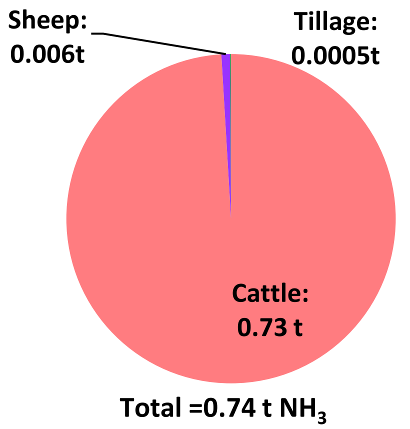
On average, energy based GHG emissions across all cattle farms was 0.43 kg of CO_2 equivalent per kg beef live-weight produced. Figure 6-10 illustrates that energy based GHG emissions per unit of product were also lower on farms with better economic performance. The top third produced an average of 0.32 kg CO_2 energy-based emissions per kg of live-weight beef produced, while for the bottom performing third this figure was 0.53 kg.

Figure 6-10: Energy use related GHG Emissions per kg live-weight beef: Cattle Farms



The average cattle farm emitted 0.74 tonnes of ammonia (NH_3). Over 98% of total NH_3 emissions were linked with beef production, the remainder reflected emissions from a sheep and tillage enterprise on cattle farms, as shown by Figure 6-11.

Figure 6-11: Total Ammonia Emissions for the average Cattle Farm



On average, cattle farms emitted 22.8 kg of NH3 per hectare in 2020. This ranged from 27.9 kg per hectare for the top performing cohort, to 18.9 per hectare for the bottom third, as shown by Figure 6-12. Emissions per hectare were higher for the more profitable cattle farms, which also tend to be stocked at a higher intensity.

Figure 6-12: Ammonia Emissions per hectare: Cattle Farms

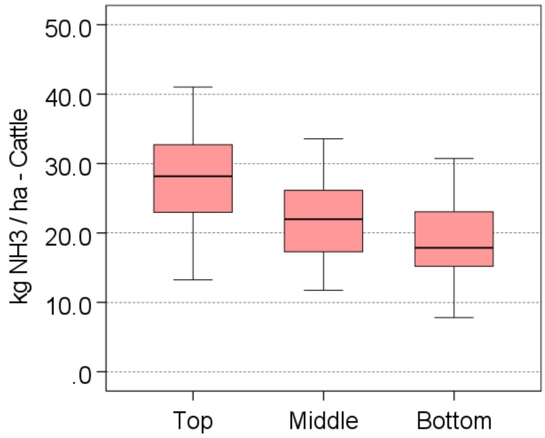


Figure 6-13 illustrates that, in terms of live-weight of beef produced, the more profitable cattle farmers have a lower level of ammonia emissions. There was a large range of results, especially for the bottom performing cohort of cattle farmers. On average, a kg of live-weight beef was produced at an intensity of 0.0617 kg of NH_3.

Figure 6-13: Ammonia Emissions per kg live-weight beef produced: Cattle Farms

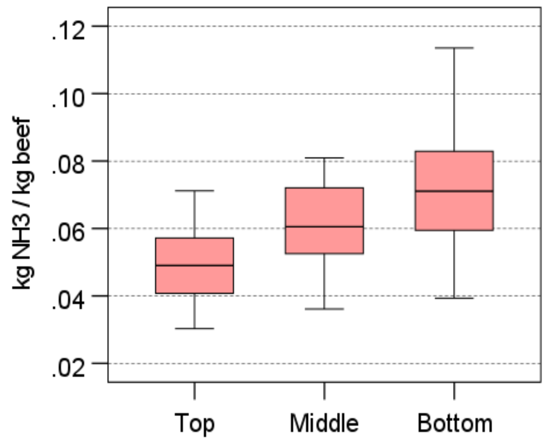
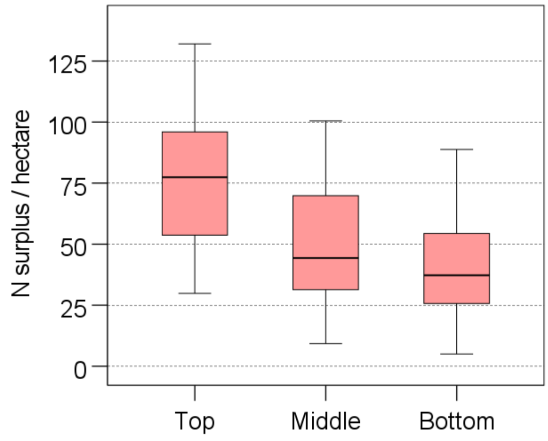


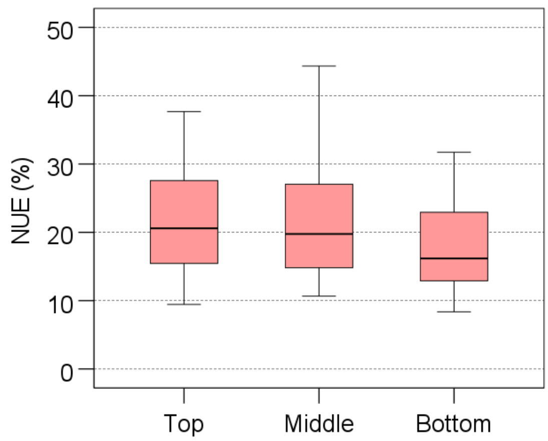
Figure 6-14 indicates that the nitrogen surplus per hectare tended to be higher on cattle farms that performed better economically. In general, these farms are operated more intensively. The top performing third of cattle farms had an average nitrogen surplus of 78.5 kg N per hectare, compared to 44 kg N per hectare for the bottom third of farms.

Figure 6-14: N Balance per ha: Cattle Farms



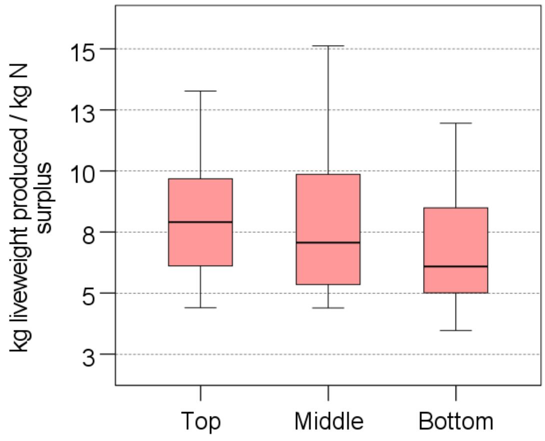
The average NUE across all cattle farms was 23.0%, but the range in NUE across the sample of cattle farms was significant, as shown in Figure 6-15. Despite the higher application rates, NUE tended to be higher on across the middle and top economic performing cohorts.

Figure 6-15: N Use Efficiency: Cattle Farms



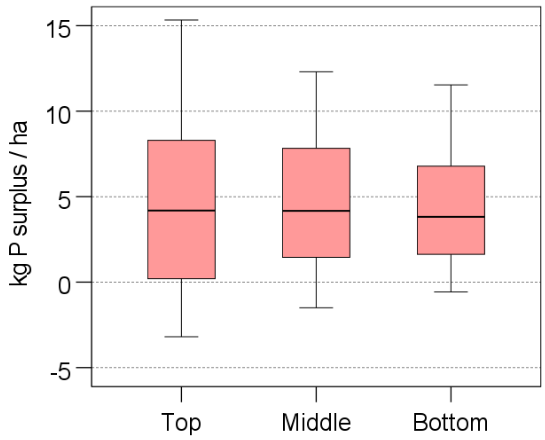
On average, cattle farms produced 9.7 kg of live-weight output per kg of N surplus. Higher NUE of beef production was prevalent on the better economic performing farms, with these top performers producing more beef live-weight per kg of surplus nitrogen, as illustrated in Figure 6-16.

Figure 6-16: NUE of beef production



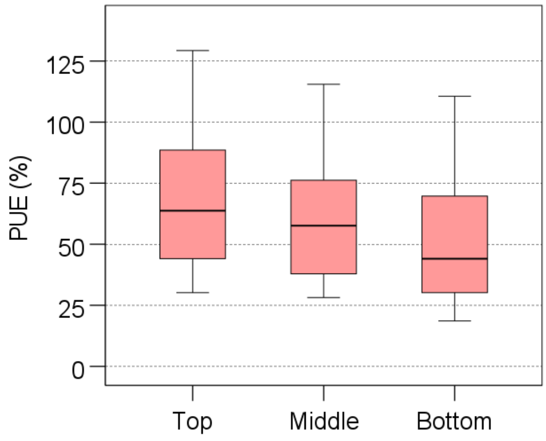
At the farm gate boundary, the P surplus across all cattle farms averaged 4.9 kg per hectare. There was a large range in P surpluses, especially across the better performing farms economically as shown in Figure 6-17.

Figure 6-17: P Balance per ha: Cattle Farms



At the farm gate boundary, the average farm PUE across all cattle farms was 69.3%. Figure 6-18 shows that higher PUE was again more prevalent on farms that performed best in economic terms. Average PUE ranged from 79.4% for the top third to 58.1% for the bottom third of cattle farmers.

Figure 6-18: P Use Efficiency: Cattle Farms



Social Sustainability Indicators

Overall, 40% of all cattle farms were considered vulnerable (a non-viable farm business with no off-farm employment). Figure 6-19 confirms that this vulnerability was associated with weaker economic performance, with 43% and 44% of the middle and bottom third of farms deemed vulnerable, compared to 33% of the top third.

Figure 6-19: Household Vulnerability: Cattle

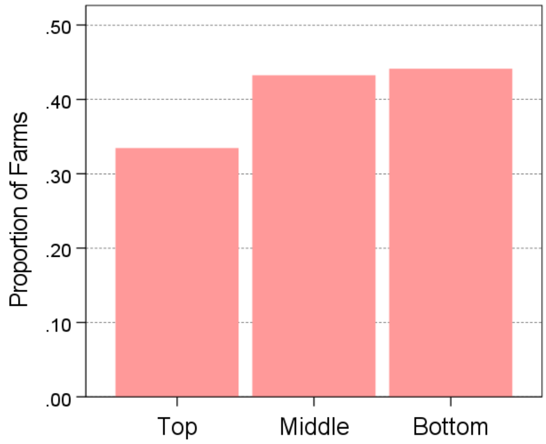
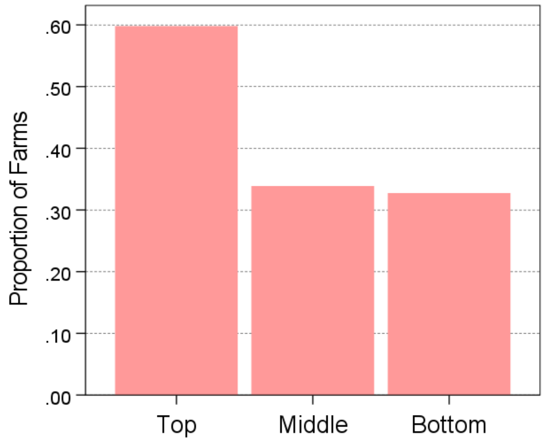


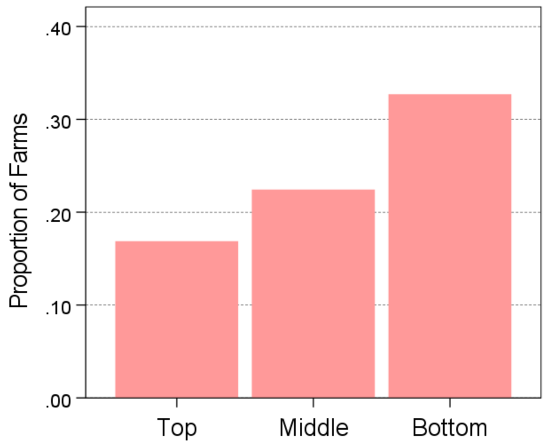
Figure 6-20 indicates that educational attainment was positively associated with the better economic performing farms. A total of 42% of cattle farmers had some level of agricultural education.

Figure 6-20: Agricultural Education: Cattle Farms



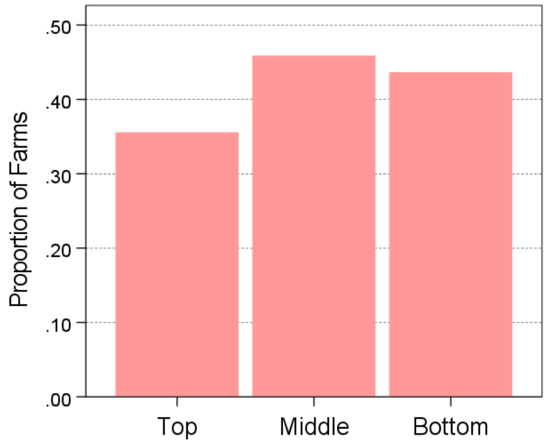
Overall, 24% of cattle farm operators were classified as being at risk of isolation; i.e. where the farmer lives alone. This was especially prevalent among farms with lower profitability, where 33% of farmers in the bottom third live alone, as shown in Figure 6-21.

Figure 6-21: Isolation Risk: Cattle Farms



Additionally, 42% of cattle farms were classified as having a high age profile. As with other indicators of social sustainability, this was more prevalent among the middle and bottom cohorts as shown in Figure 6-22.

Figure 6-22: High Age Profile: Cattle Farms



The average cattle farm operator worked on farm for 1,496 hours over the year (an average of 28.7 hours per week). The top economically performing cohort worked on average of 1,600 hours on farm compared to 1,417 and 1,468 for middle and bottom groups as outlined Figure 6-23.

Figure 6-23: Hours Worked on Farm: Cattle Farm Operator

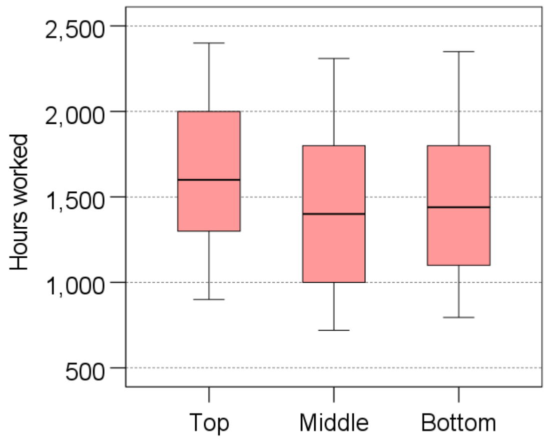
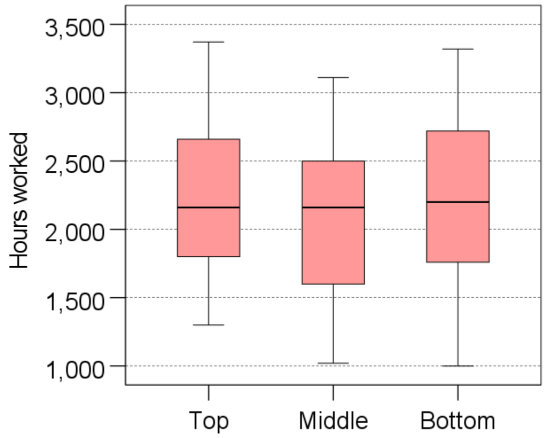


Figure 6-24 shows that total hours worked (on and off-farm) was relatively similar across the three cohorts. On average, cattle farmers worked 2,162 hours in 2020 between on and off-farm work (approximately 41.5 hours per week).

Figure 6-24: Total Hours Worked: Cattle Farm Operator

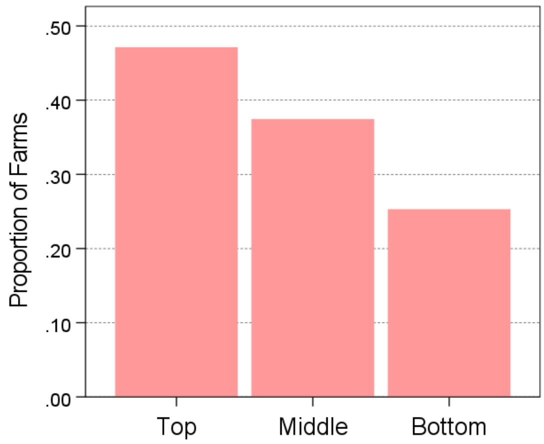


Cattle Farm Innovation Indicators

Six innovation indicators were examined for cattle farms: whether at least 50% of slurry was spread in the period January-April, the proportion of slurry applied using low emission slurry spreading equipment, proportion of chemical applied in the form of protected urea fertiliser, application of lime, grassland reseeding and whether the farmer was a member of a discussion group.

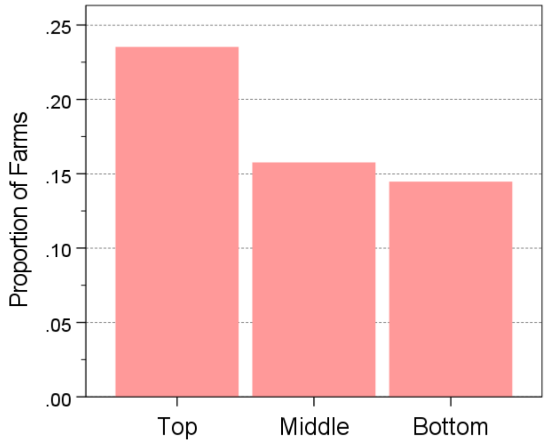
Figure 6-25 shows that those in the top economic performing group applied a lot more of the total slurry in springtime (47%) compared to the middle (37%) and bottom (25%) cohorts.

Figure 6-25: Spring Slurry Application: Cattle Farms



On average, nearly 18% of all slurry applied by cattle farmers was via low emission slurry spreading methods. This ranged from 24% for the top performing cohort to 14-15% for the middle and bottom performing cohort as outlined in Figure 6-26.

Figure 6-26: Low emission slurry spreading: Cattle Farms



The percentage of total chemical nitrogen applied in the form of protected urea averaged 1.5% across all cattle farms in 2020. This ranged from 4% for the top performing cohorts to 0% for the bottom group as seen by Figure 6-27.

Figure 6-27: Protected Urea use: Cattle Farms

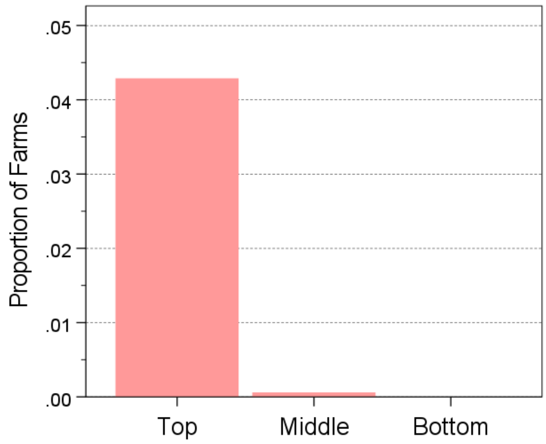
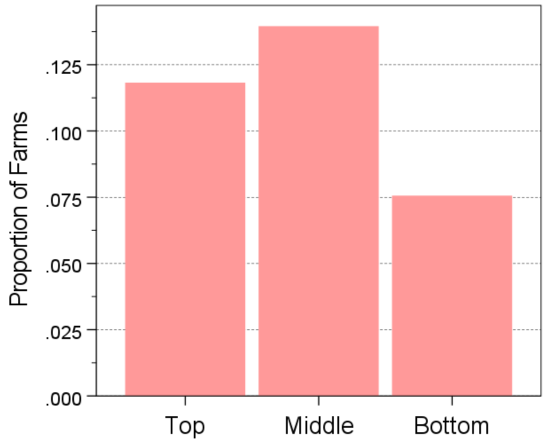


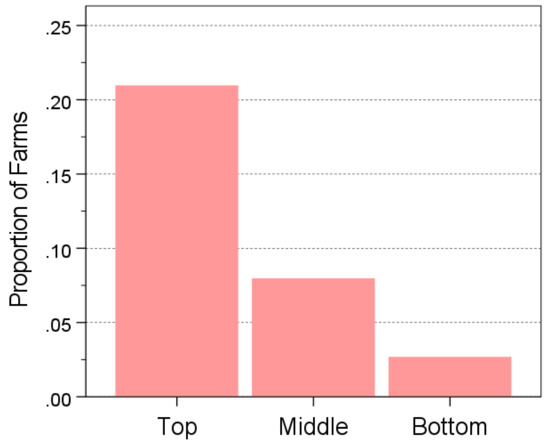
Figure 6-28 shows that liming rates were slightly higher for the top and middle performing cattle farm, at 12-14%, compared to 8% for the bottom cohort.

Figure 6-28: Liming: Cattle Farms



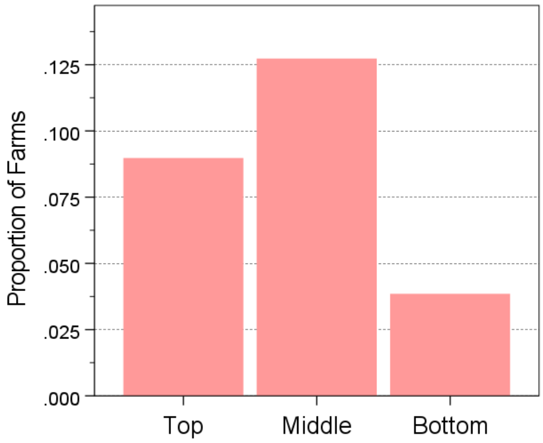
Error! Reference source not found. shows that 21% of the top economic performing cohort were members of a discussion group, compared to 8% and 3% in the middle and bottom cohort respectively.

Figure 6-29: Discussion Group: Cattle Farms



Reseeding levels were generally low across all groups, ranging from 9-13% for the top and middle cohorts to 4% for the bottom performing cohort as shown in Figure 6-30.

Figure 6-30: Re-seeding: Cattle Farms

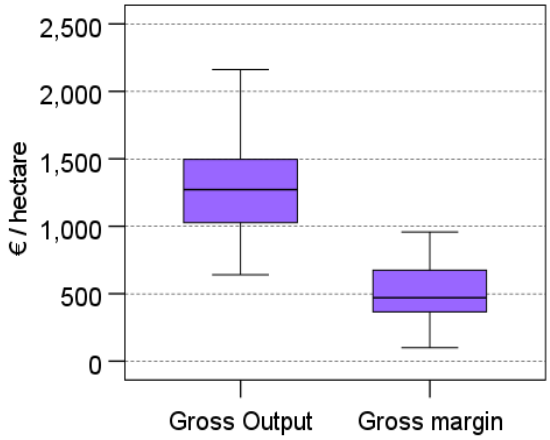


7 Sheep Farm Sustainability 2020

Economic Sustainability Indicators

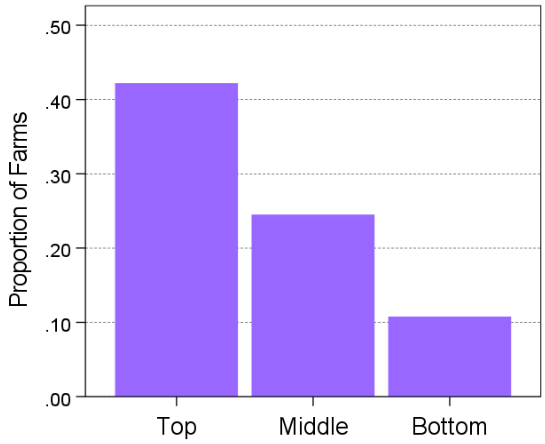
The average gross output per hectare for sheep farms was €1,314 in 2020, and the average gross margin was €507 per hectare.

Figure 7-1: Economic Return and Profitability of Land: Sheep Farms



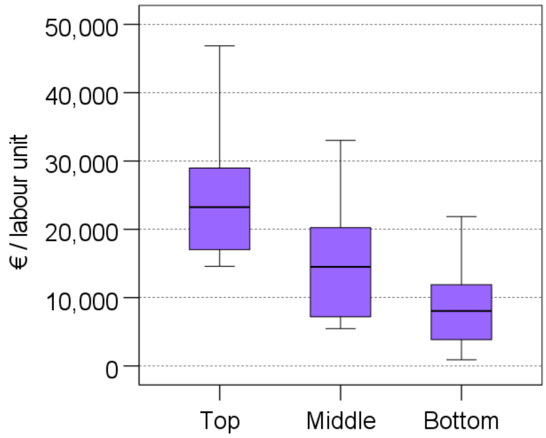
Across all sheep farms, only 26% were defined as economically viable. Figure 7-2 shows that, ranked by economic performance, the proportion of viable sheep farms ranged from 42% for the top third to 11% for the bottom third of farms.

Figure 7-2: Economic Viability: Sheep Farms



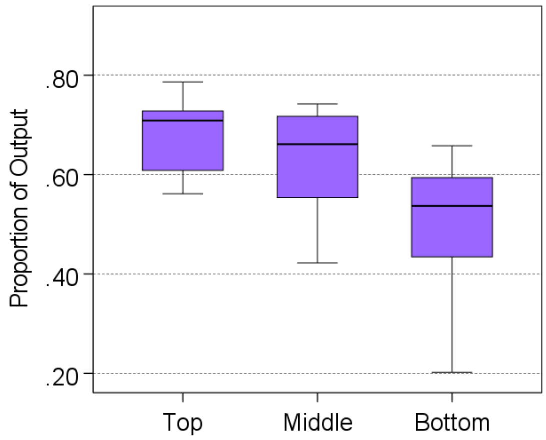
The average income per labour unit on sheep farms was €18,568. In common with cattle farms, there was a large range in economic performance, with the top third of sheep farms earning a mean income per labour unit of €27,424, compared with €9,224 for the bottom third (see Figure 7-3). Median income for the three cohorts was €23,250, €14,818 and €7,365 respectively.

Figure 7-3: Productivity of Labour: Sheep Farms



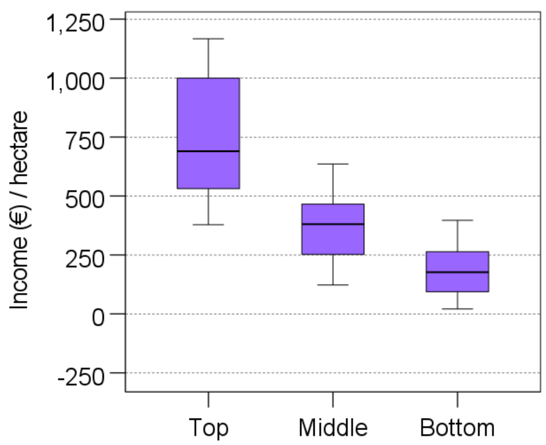
For the average sheep farm, approximately 60% of output was generated from the market, with the remaining 40% derived from direct payments. Figure 7-4 indicates that market orientation was positively associated with economic performance, with the top third of farms, based on economic performance, producing 69% of output from the market, compared with just over 51% on average for bottom third. Figure 7-4 also indicates a significant range across the bottom performing cohort in particular.

Figure 7-4: Market Orientation: Sheep Farms



The average family farm income per hectare on sheep farms was €435 in 2020. Across the subgroups, this average ranged from €744 for the top performing cohort to €147 for the bottom performers economically. Figure 7-5 shows significant ranges in income per hectare across the three groups.

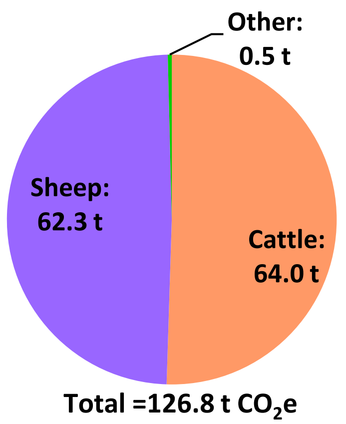
Figure 7-5: Family Farm Income per hectare: Sheep Farms



Environmental Sustainability Indicators

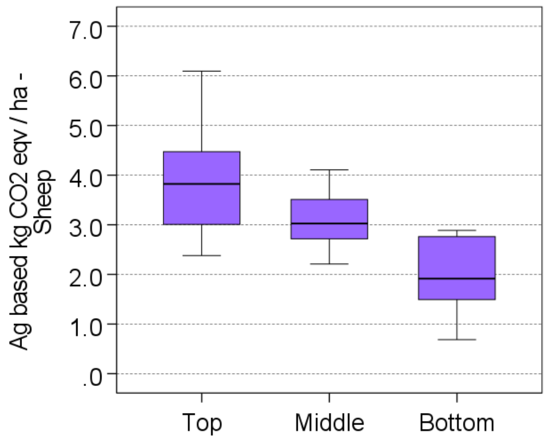
In 2020, the average sheep farm produced approximately 126.8 tonnes CO_2 equivalent of agricultural GHG emissions. Figure 7-6 indicates that just under half (49.1%) of these emissions were generated by the sheep enterprise, with over half (50.5%) generated by a cattle enterprise present on specialist sheep farms, with the remainder coming from other sources (minor arable enterprise).

Figure 7-6: Agricultural GHG Emissions for the average Sheep Farms



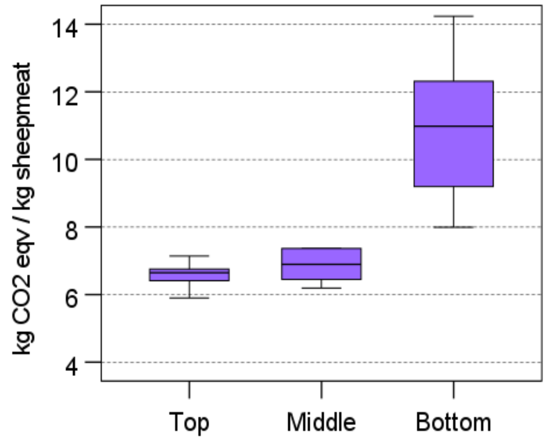
On average sheep farms emitted 3.1 tonnes of CO_2 equivalent per hectare. Higher emissions per hectare were associated with the more profitable sheep farms, as shown in Figure 7-7. However, there was a large range of results.

Figure 7-7: Agricultural GHG Emissions per hectare: Sheep Farms



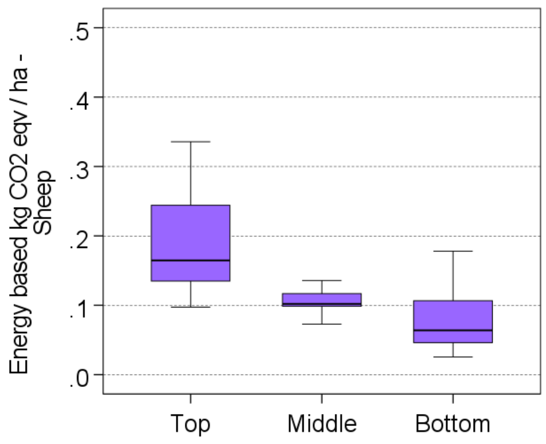
The GHG emissions generated by sheep are shown per kg of live-weight output produced (estimated using CSO price data, Hinchion, 2021). Figure 7-8 shows that the emissions intensity per kg of live-weight produced were negatively associated with economic performance. The top and middle third of farms generated 7.0 to 7.2 kg CO_2 equivalent per kg live weight produced respectively, compared to 13.2 kg CO_2 equivalent for the bottom cohorts on average. There was a noticeable large range of results across the bottom cohort.

Figure 7-8: Agricultural GHG Emissions per kg live-weight produced: Sheep Farms



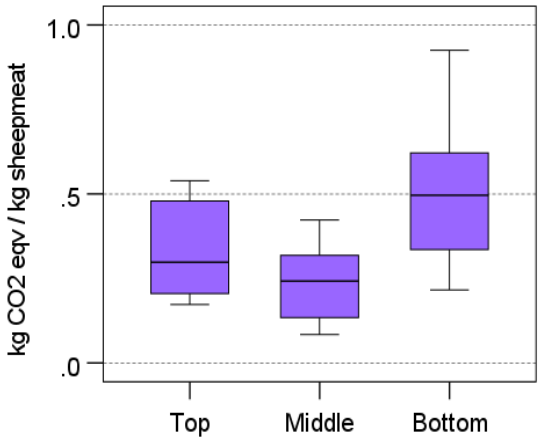
The average sheep farms emitted 0.15 tonnes of energy based CO_2 equivalent per hectare. Higher emissions per hectare were associated with the more profitable sheep farms, as shown in Figure 7-9.

Figure 7-9: Energy GHG Emissions per hectare: Sheep Farms



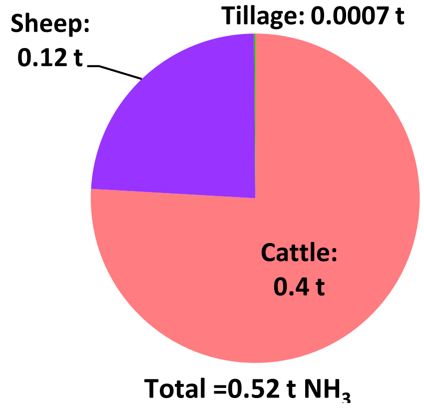
Better economic performance was also linked with lower energy based GHG emissions per unit of output, as shown in Figure 7-10. The bottom third of farms in economic terms emitted 0.67 kg CO_2 equivalent per kg live-weight sheep meat produced from energy based emissions, compared to 0.34 kg CO_2 for the top third of sheep farms.

Figure 7-10: Energy use related GHG Emissions per kg live-weight produced: Sheep Farms



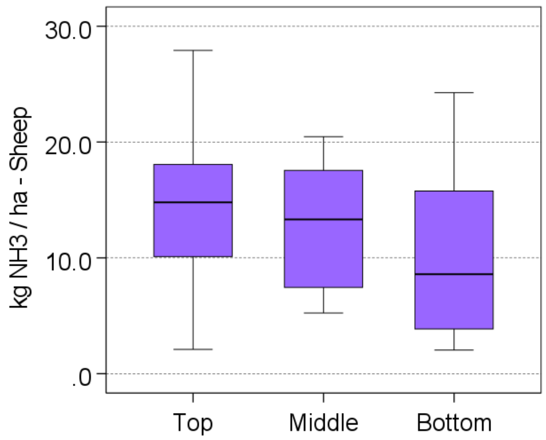
On average, specialist sheep farms emitted 0.52 tonnes of NH_3 in 2020. Even though the main output on these farms is sheep based, the majority of the NH_3 emissions related to cattle production (77%), with only 23% relating to sheep production. The remaining residual portion related to tillage crops.

Figure 7-11: Total Ammonia Emissions for the average Sheep Farm



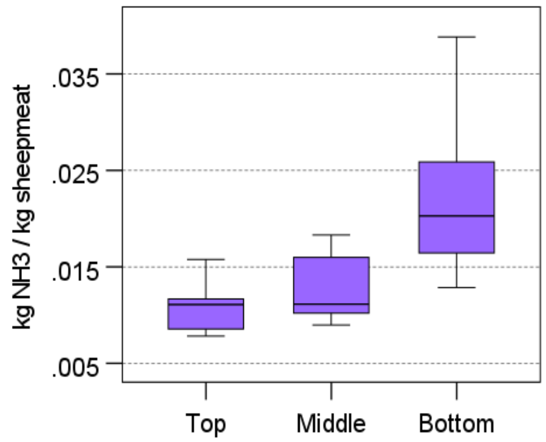
On average, a specialist sheep farm emitted 13.1 kg of ammonia per hectare in 2020. Higher per hectare emissions were associated with economically better performing farms as shown in Figure 7-12, these farms tend to operate at a higher stocking intensity.

Figure 7-12: Ammonia Emissions per hectare: Sheep Farms



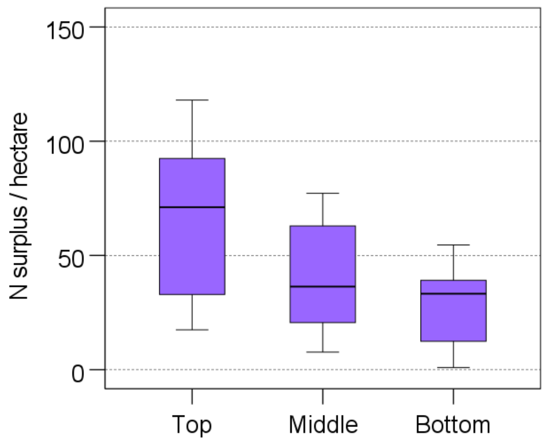
Lower ammonia emissions intensity of production was again more common among the better economically performing sheep farms. Farms in the top and middle performing cohort in economic terms were found to produce a kg of live-weight sheep meat with a lower NH_3 emission intensity footprint, as shown in Figure 7-13. On average sheep farmers produced 0.02 kg of NH_3 emissions per kg of live-weight sheep meat.

Figure 7-13: Ammonia Emissions per kg live-weight produced: Sheep Farms



As with cattle farms, the sheep farm based nitrogen surplus per hectare was positively associated with economic performance, due to greater production intensity on the more profitable sheep farms (as shown in Figure 7-14). The top third of farms, ranked by gross margin per hectare, had an average nitrogen surplus of 69.3 kg per hectare, compared with 42.1 and 30.6 kg per hectare for the middle and bottom cohorts respectively.

Figure 7-14: N Balance per ha: Sheep Farms



The average NUE across all sheep farms was 30.2%. Higher NUE was again associated with better economic performance, as shown in Figure 7-15.

Figure 7-15: N Use Efficiency: Sheep Farms

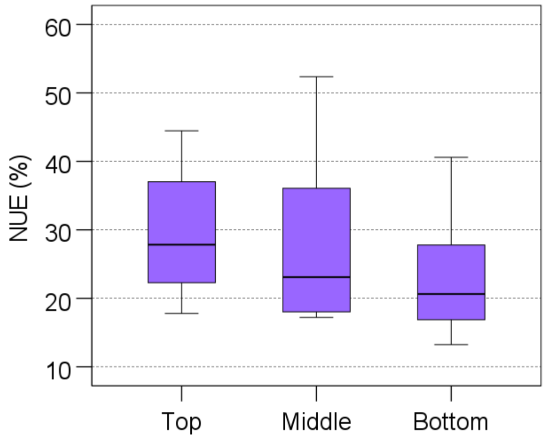
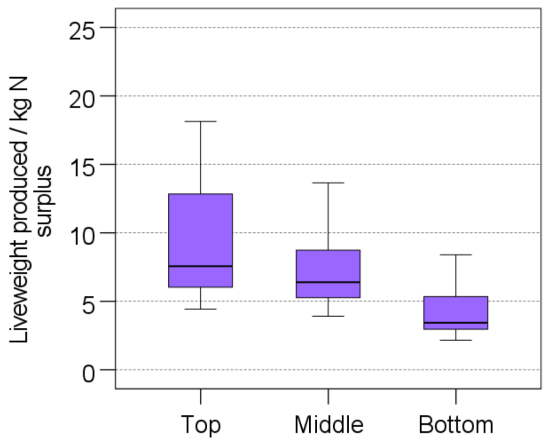


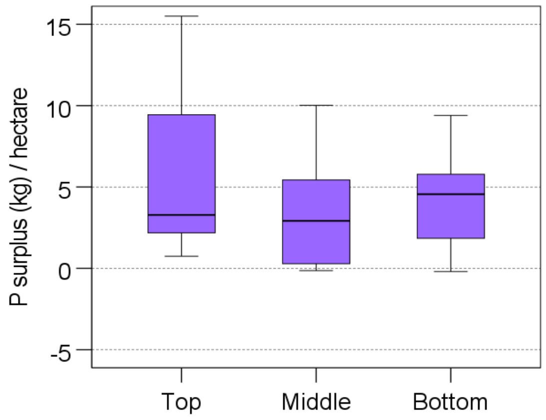
Figure 7-16 shows that the N surplus per kg of live-weight sheep meat produced tends to be positively associated with better economic performance, with the top third producing more live-weight output per kg of N surplus generated. The average across all sheep farms was 12.5 kg.

Figure 7-16: NUE by product of Sheep Farms



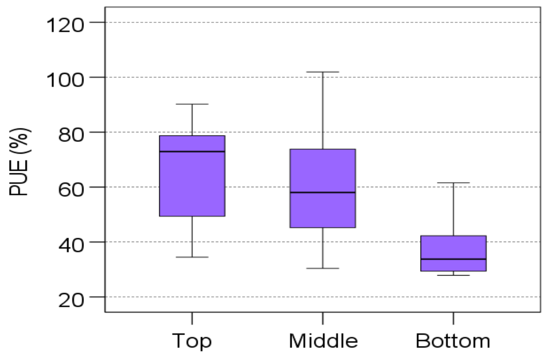
P balances across all specialist sheep farms were 4-6 kg per ha on average. There was a large range of results across the three cohorts, especially the top performing group, as shown by Figure 7-17.

Figure 7-17: P Balance per ha: Sheep Farms



Farm gate level PUE averaged 60.9% across all sheep farms in 2020. Figure 7-18 shows that higher PUE was associated with farms with better economic performance.

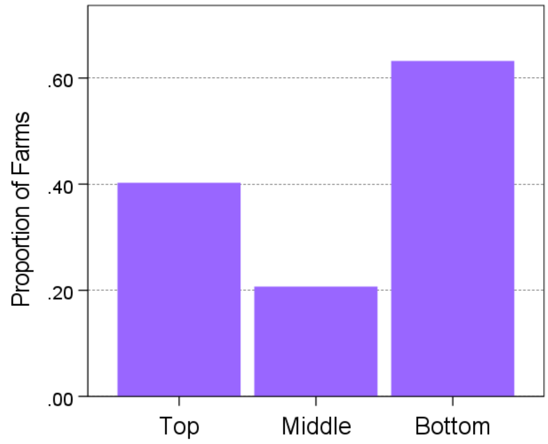
Figure 7-18: P use efficiency: Sheep Farms



Social Sustainability Indicators

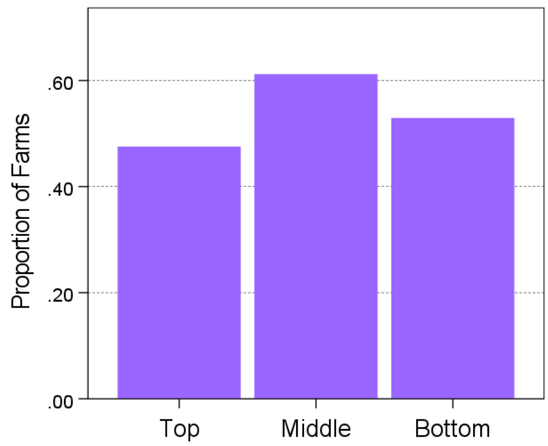
Over 42% of all sheep farms were considered vulnerable in 2020. Figure 7-19 shows that this ranged from 21% for the middle performing sheep farms to 63% for the bottom group.

Figure 7-19: Household Vulnerability: Sheep Farms



Overall, 54% of sheep farmers had received formal agricultural education. Figure 7-20 shows that agricultural education was highest among the middle third of farms by economic performance.

Figure 7-20: Agricultural Education: Sheep Farms



On average, 29% of all specialist sheep farms were classified as being at risk of isolation. Figure 7-21 shows that this was significantly higher among the bottom performing cohort of sheep farms at 45%.

Figure 7-21: Isolation Risk: Sheep Farms

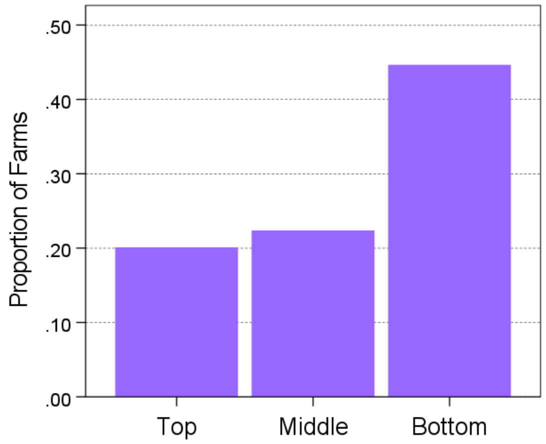
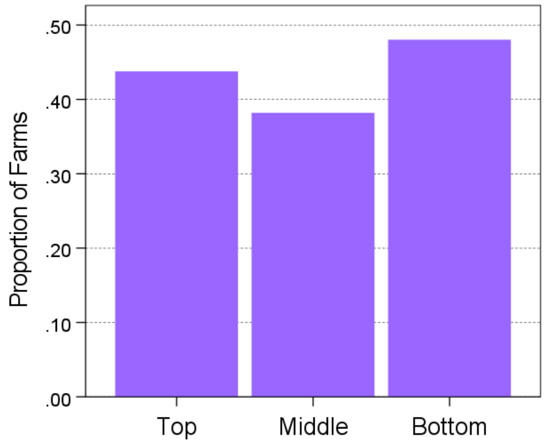


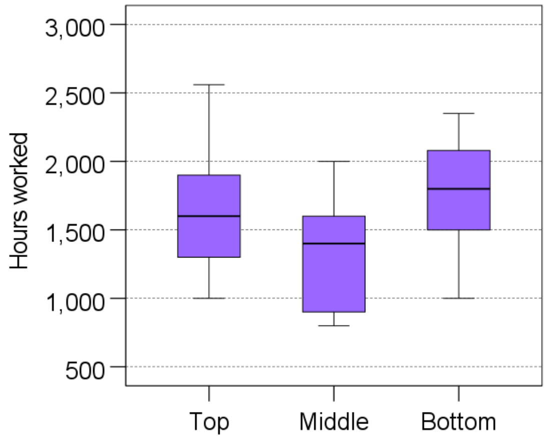
Figure 7-22 shows that the proportion of all specialist sheep farms with a high age profile averaged 43%. The bottom performing group had the highest age profile on average.

Figure 7-22: High Age Profile: Sheep Farms



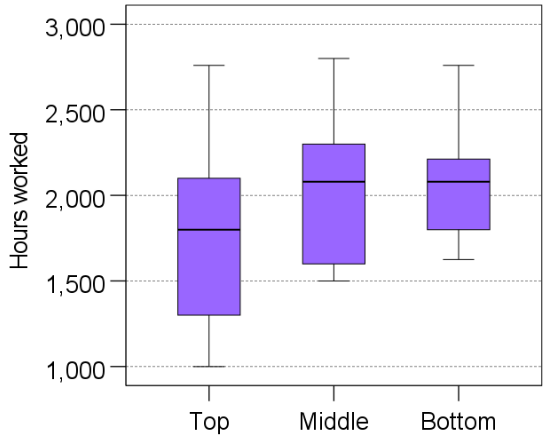
Sheep farmers worked an average of 1,512 hours per year on farm in 2020 (or 29.1 hours a week). The bottom performing cohort tend to work the most hours on farm (1,669) compared to the middle group at 1,323 (Figure 7-23).

Figure 7-23: Hours Worked: Sheep Farm Operators



On average, sheep farmers worked 1,941 hours in 2020 between on and off-farm work (approximately 37.3 hours per week). Figure 7-24 shows that total hours worked was lower across the better performing farms economically.

Figure 7-24: Total Hours Worked: Sheep Farm Operator

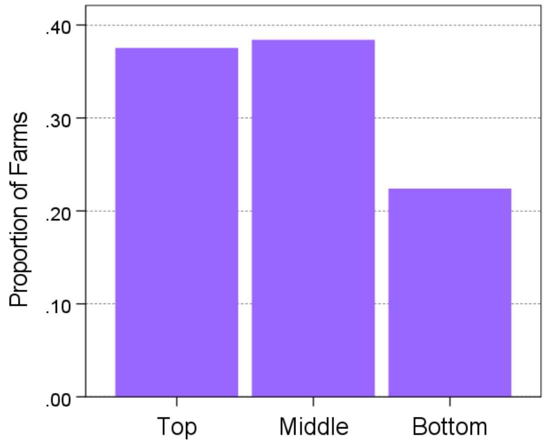


Sheep Farm Innovation Indicators

The five innovation indicators selected for sheep farms were whether at least 50% of slurry was spread in the period January-April, the portion of chemical N fertiliser applied in the form of protected urea, application of lime, grassland reseeding and whether or not the farm operator was a member of a discussion group.

Figure 7-25 shows that those in the top and middle economic performing group (37-38%) applied more of the total slurry in springtime, compared to the bottom cohort (22%). However, it should be noted that sheep farms tend to be more associated with farmyard manure (i.e solid) type storage systems, which might not lend themselves to early season application.

Figure 7-25: Spring Slurry: Sheep Farms



As seen from Figure 7-26 the use of protected urea fertiliser across sheep farmers was very limited. On average only 1.5% of chemical N fertiliser applied was in the form of protected urea in 2020.

Figure 7-26: Protected Urea use: Sheep Farms

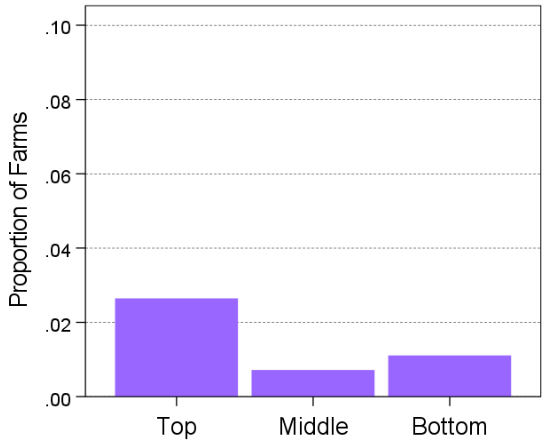


Figure 7-27 shows that liming activity was again more prevalent across the better economic performing farms, with 18-19% of the top and middle performing cohort by economic performance engaged in liming, compared to 11% of the bottom group.

Figure 7-27: Liming: Sheep Farms

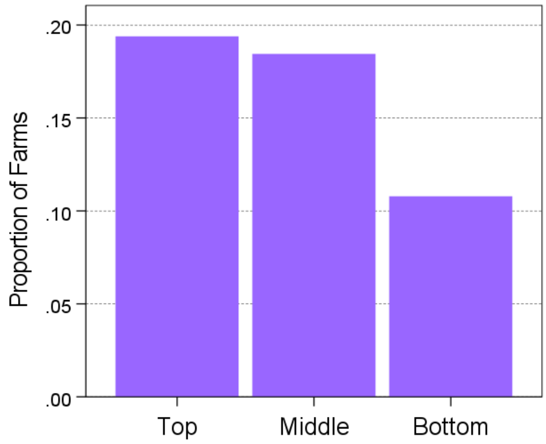


Figure 7-28 shows that higher levels of reseeding were associated with the sheep farms that performed better in economic terms.

Figure 7-28: Reseeding: Sheep Farms

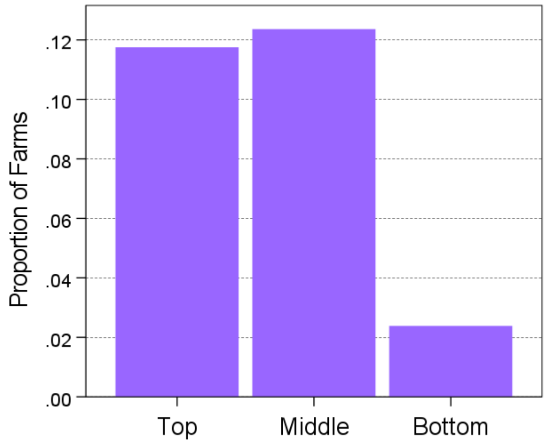
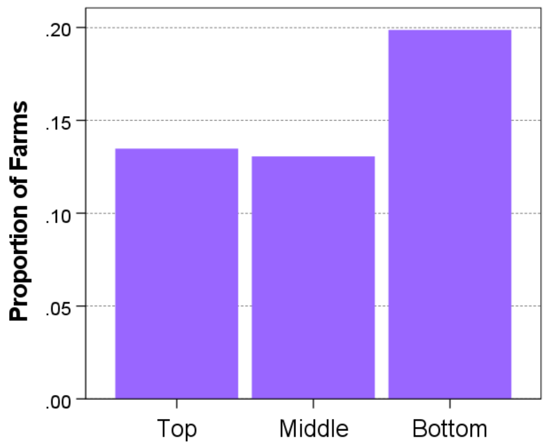


Figure 7-29 shows that membership of a discussion group ranged between 13-19% across the cohorts.

Figure 7-29: Discussion Group: Sheep Farms

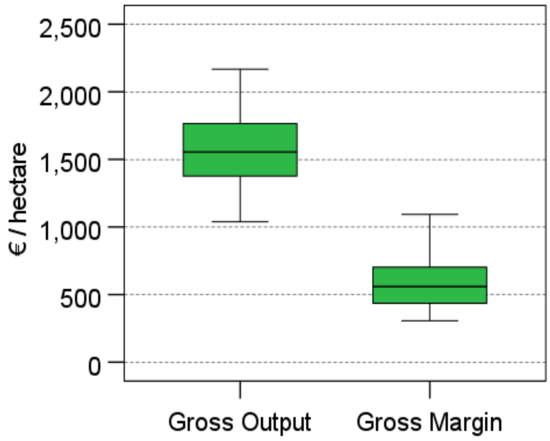


8 Tillage Farm Sustainability 2020

Economic Sustainability Indicators

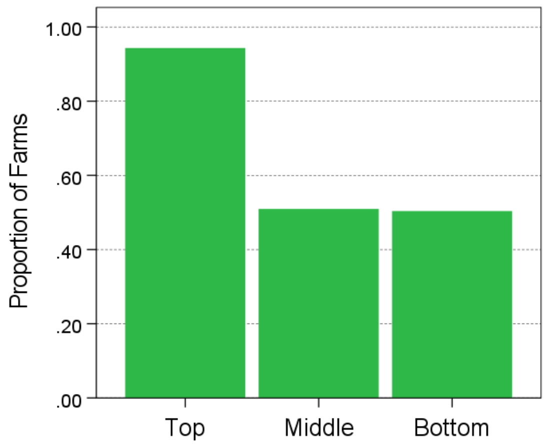
The average gross output and gross margin per hectare for tillage farms was €1,696 and €756 respectively in 2020. But there was a large distribution around the average, as seen by Figure 8-1.

Figure 8-1: Economic Return and Profitability of Land: Tillage Farms



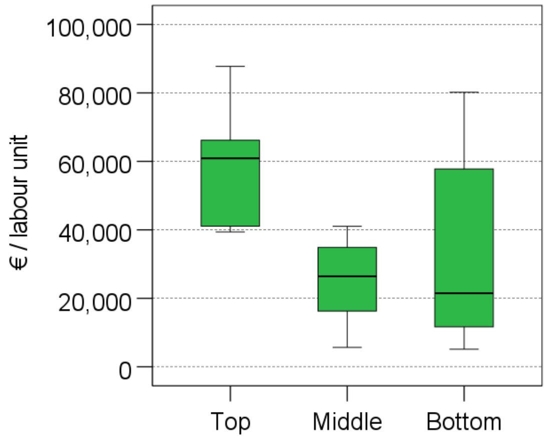
Overall, 65% of tillage farms were classified as economically viable. Figure 8-2 shows that the middle and bottom groups had significantly lower levels of viability, at 51% and 50% compared to 94% for the top performing group.

Figure 8-2: Economic Viability: Tillage Farms



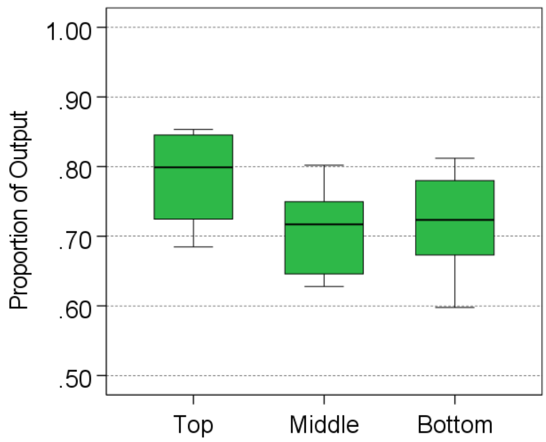
The average tillage farm income per labour unit (for unpaid family labour) was €38,225. Figure 8-3 shows that there is a large range in incomes on tillage farms, with the top one-third (ranked by gross margin per hectare) earning significantly more than the middle an bottom cohorts per labour unit provided. 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 supplied by hired labour (via the use of external contractors).

Figure 8-3: Productivity of Labour: Tillage Farms



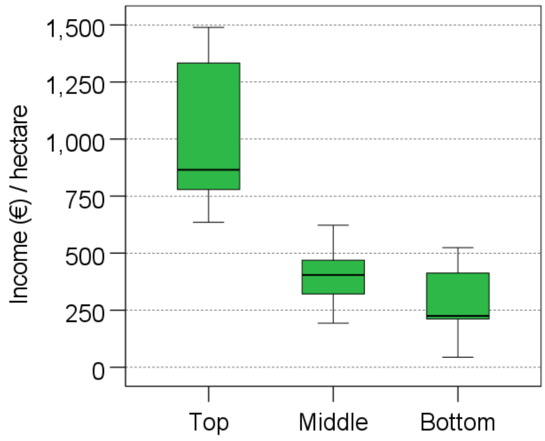
In 2020, tillage farms generated 73% of their output value from the market on average. Figure 8-4 shows that the top third of tillage farms derived 77% of farm output from the market compared to 71% for the middle and bottom groups on average.

Figure 8-4: Market Orientation: Tillage Farms



The average family farm income per hectare on tillage farms was €558 in 2020. Median income ranged from €866 from the top performing cohort to €225 for the bottom performers economically. Figure 8-5 shows significant ranges in income per hectare across the three groups.

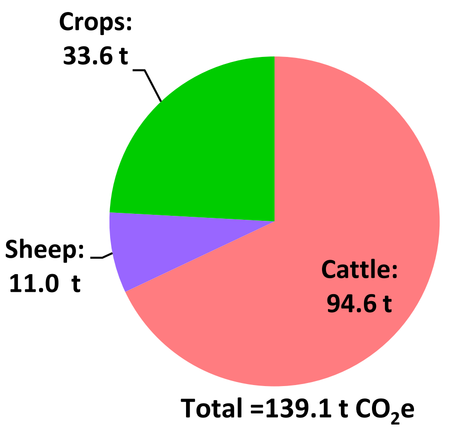
Figure 8-5: Family Farm Income per hectare: Tillage Farms



Environmental Sustainability Indicators

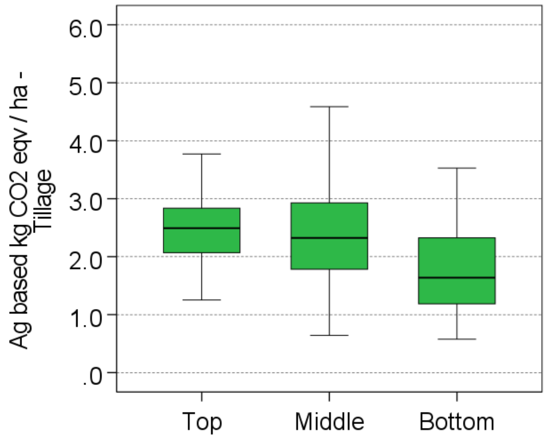
The average tillage farm produced 139.1 tonnes CO_2 equivalent of agricultural GHG emissions in 2020 as illustrated in Figure 8-6. However, only 24.1% of GHG emissions were generated from crop production. Despite being specialised in crop production, 68% of tillage farm emissions were from cattle present on these farms, with a further 7.9% from sheep.

Figure 8-6: Agricultural GHG Emissions for the average Tillage Farm



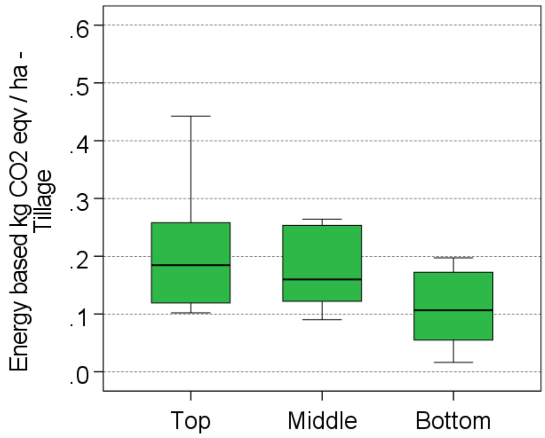
The average specialist tillage farm produced 2.2 tonnes of agriculture based CO_2 equivalent per hectare of agricultural GHG emissions in 2020. Higher emissions per hectare were again associated with higher economic performance.

Figure 8-7: Agricultural GHG Emissions per hectare: Tillage Farms



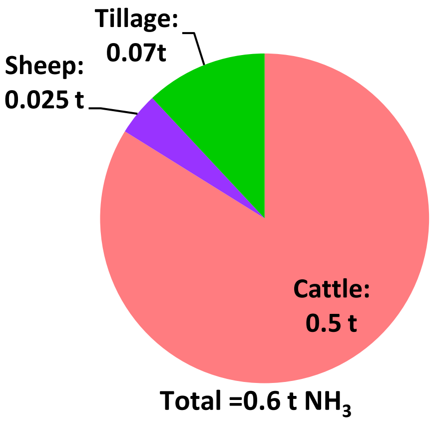
Specialist tillage farms on average produced 0.19 tonnes of energy based CO_2 equivalent per hectare of energy based GHG emissions in 2020. Higher emissions per hectare were again associated with higher economic performance as seen by Figure 8-8.

Figure 8-8: Energy GHG Emissions per hectare: Tillage Farms



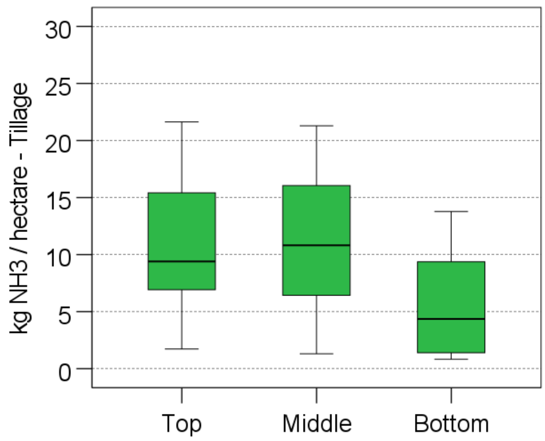
Tillage farms on average emitted 0.6 tonnes of NH_3 in 2020. Again, even though the main farm output is crop related, the bulk of emissions are associated with cattle rearing, at 83%. Of the remaining emissions, 12% were associated with tillage production and 5% with a sheep enterprise.

Figure 8-9: Total Ammonia Emissions for the average Tillage Farm



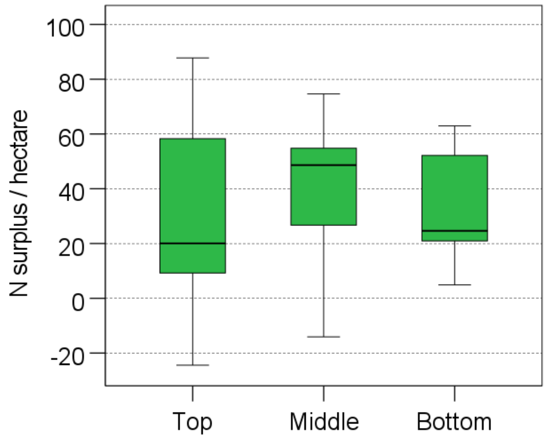
The average specialist tillage farm emitted 9.2 kg of NH_3 per hectare in 2020. Again, higher emissions per hectare were associated with higher economic performance. Economic performance tends to be positively associated with farm production intensity levels.

Figure 8-10: Total Ammonia Emissions per hectare: Tillage Farms



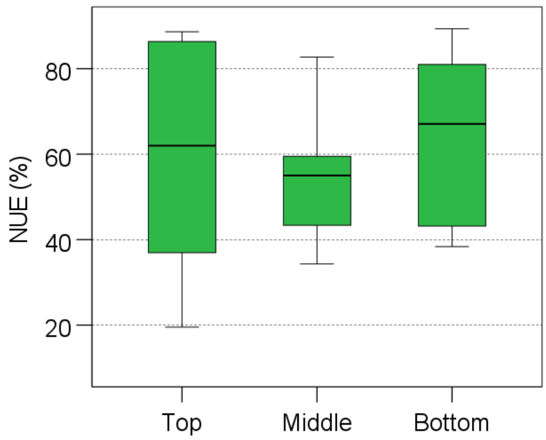
The average N surplus was 43.9 kg per hectare, but there was a large range in the farm results. Figure 8-11 shows higher N surpluses were aligned with higher economic performance.

Figure 8-11: N Balance per hectare: Tillage Farms



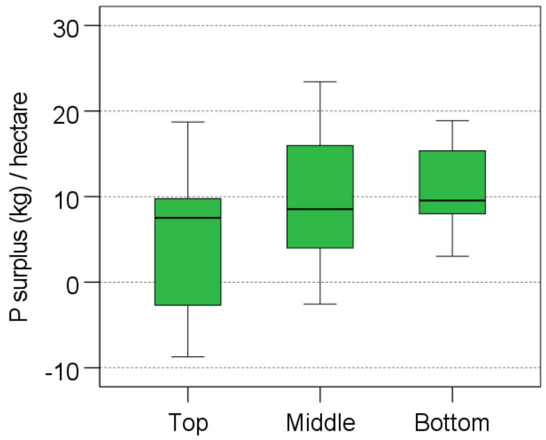
Across all tillage farms, the average NUE was circa 62.6%. There was a large distribution in NUE across the three groups as illustrated in Figure 8-12.

Figure 8-12: N Use Efficiency: Tillage Farms



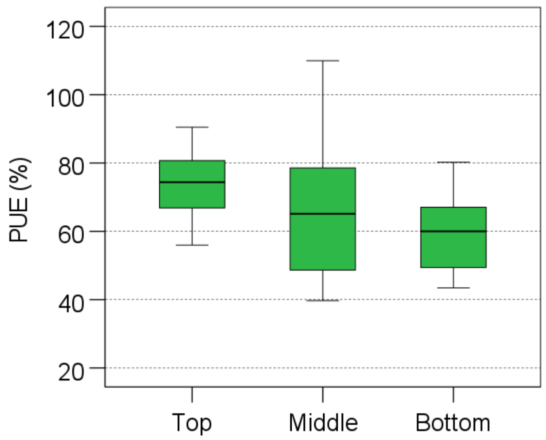
The average P balance across all tillage farms was 7.2 kg per hectare. However, as illustrated in Figure 8-13, there was again a large range of results around these group averages, but better farms, in economic terms, tended to have slightly lower P balances.

Figure 8-13: P Balance per hectare: Tillage Farms



PUE averaged circa 72.6% across all tillage farms. PUE tended to be higher across the top performing group, compared to the middle and bottom cohort as illustrated by Figure 8-14.

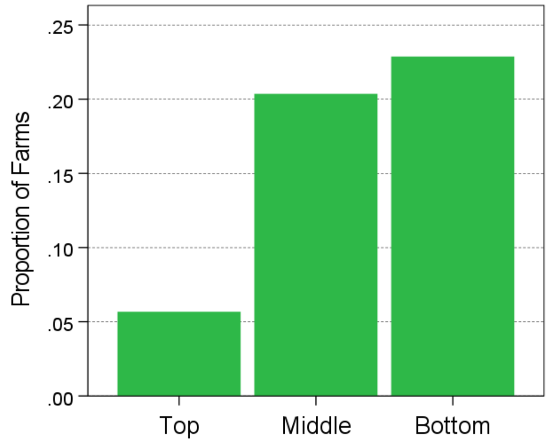
Figure 8-14: P Use Efficiency: Tillage Farms



Social Sustainability Indicators

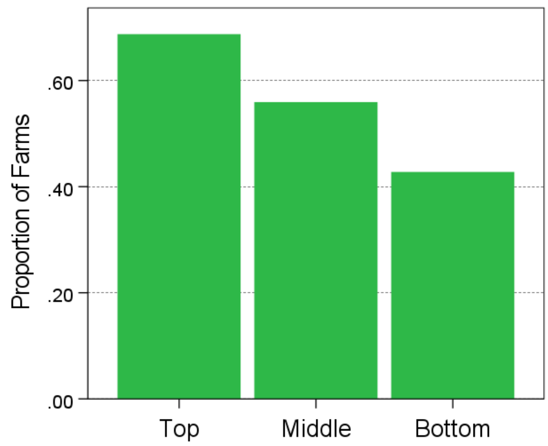
On average, a total of 16% of tillage farms are considered economically vulnerable. Figure 8-15 indicates that household vulnerability was highest across the bottom cohort at 23%.

Figure 8-15: Household Vulnerability: Tillage



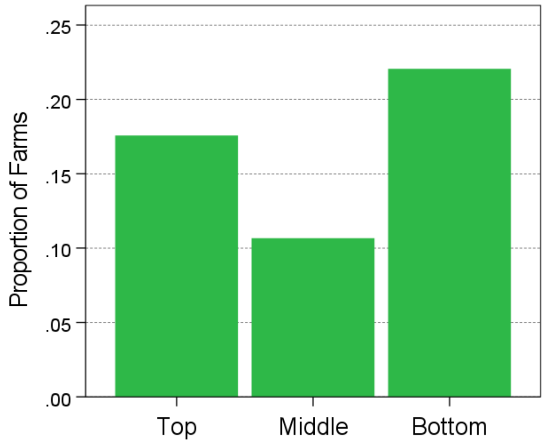
A total of 56% of tillage farmers had attained some level of agricultural education or training. Figure 8-16 shows that this rate was higher for the better performing tillage farms economically.

Figure 8-16: Agricultural Education: Tillage Farms



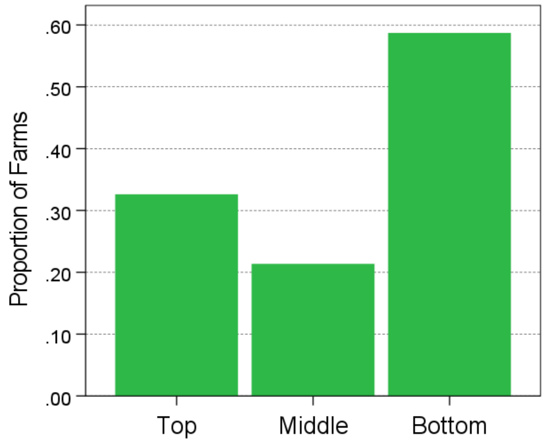
Overall, 17% of tillage farms were identified as being at risk of isolation (i.e. where the farm operator lived alone). At 22%, this rate was highest for the bottom performing cohort as illustrated by Figure 8-17.

Figure 8-17: Isolation Risk: Tillage Farms



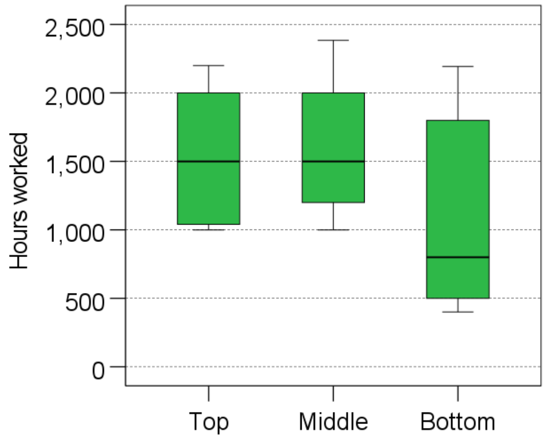
An average of 38% of tillage farms were identified as having a high age profile. Figure 8-18 shows that over 59% of farm households in the bottom group had a high age profile.

Figure 8-18: High Age Profile: Tillage Farms



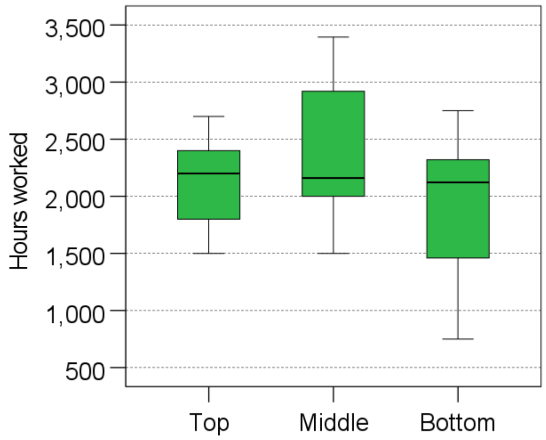
The average tillage farmer worked 1,421 hours on farm in 2020 (27.3 hours per week). However, Figure 8-19 shows that the average was lower for the bottom third of farms, ranked by gross margin per hectare. Teagasc NFS data show that the bottom cohort tend to hire more contractors to do field work, hence reducing the farm operators own time contribution.

Figure 8-19: Hours Worked on Farm: Tillage Farms



On average, sheep farmers worked 2,081 hours per year between on and off-farm work in 2020 (approximately 40 hours per week). Figure 8-20 shows that total hours worked tended to be higher across the middle cohort by economic performance.

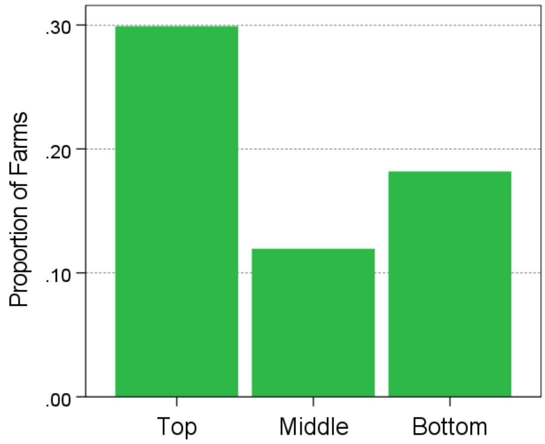
Figure 8-20: Total Hours Worked: Tillage Farm Operator



Tillage Innovation Indicators

The innovation indicators examined for tillage farms were: liming rates, membership of a discussion group and growing of a break crop. Figure 8-21 shows that liming rates were higher for the top performing cohorts (30%) compared to the middle (12%) and bottom (18%) performing cohort.

Figure 8-21: Liming: Tillage Farms



On average between 20% of tillage farms were in discussion groups. This ranged from 12% for the middle group to 26% for bottom cohort. However, this includes this covers all types of discussion groups (e.g. beef and sheep).

Figure 8-22: Discussion Group: Tillage Farms

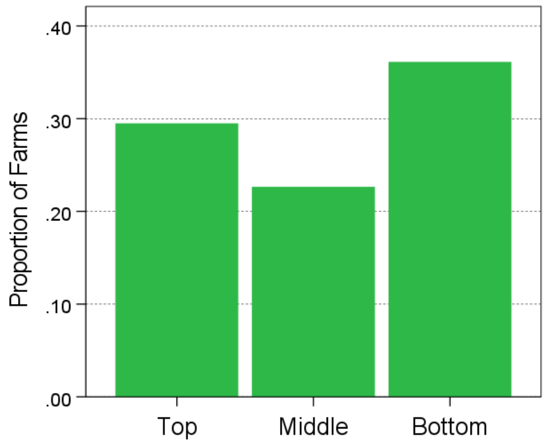
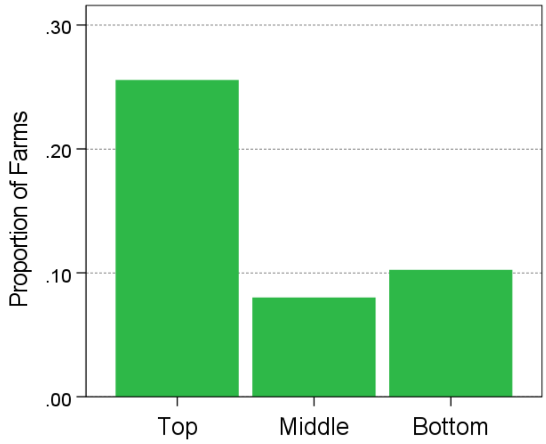


Figure 8-23 shows that 26% of the top performing cohorts grew a break crop compared to 8-10% for the middle and bottom groups.

Figure 8-23: Break Crops: Tillage



9 Farm System Comparisons 2020

Economic Indicators

A comparison of economic sustainability indicators across different farm types is shown in Figure 9-1. In general, dairy farms show the strongest economic performance, significantly ahead of all other systems in terms of gross output, gross margin and family farm income on a per hectare basis.

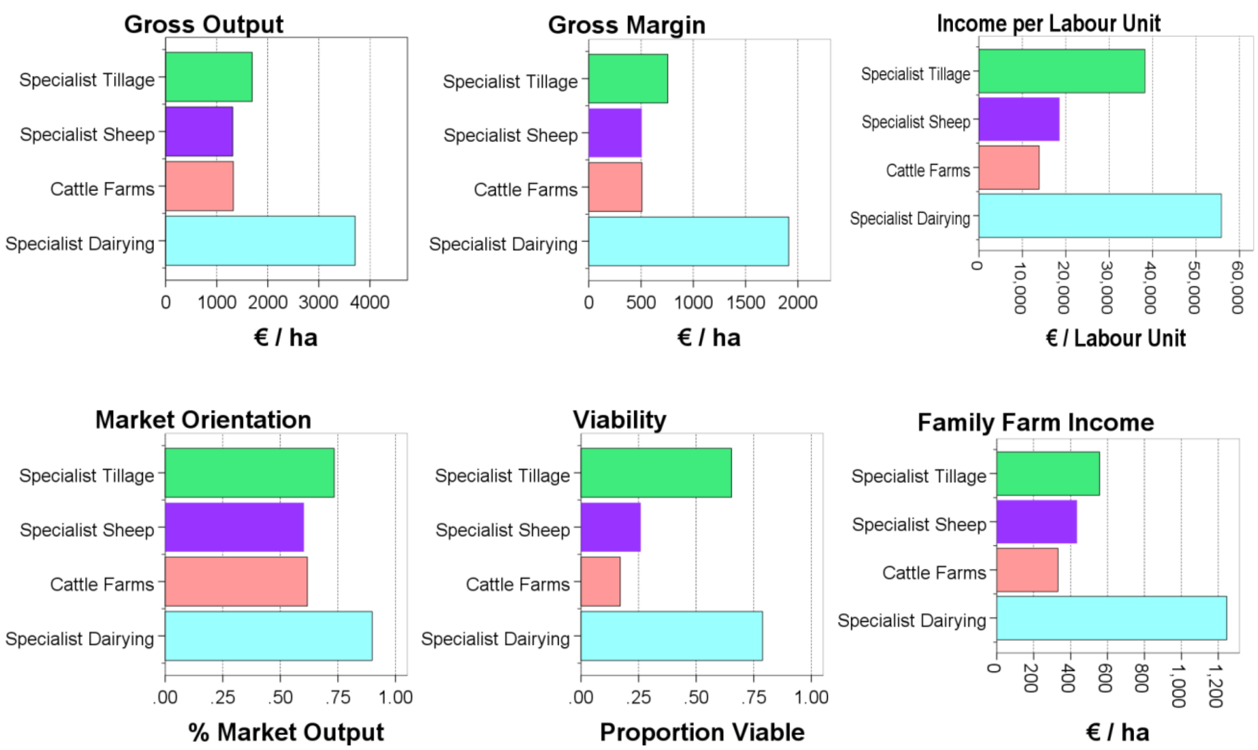
Output, Margins and Income: Tillage farms were ahead of both cattle and sheep farms (which were relatively similar) in terms of gross output, gross margin and family farm income per hectare, but tillage farms were behind dairy farms in terms of income per labour unit. Sheep farms, and especially cattle farms, returned significantly lower income per labour unit in comparison to dairy farms and tillage farms in 2020.

Market Orientation: The various farm systems are most similar in terms of market orientation, with dairy and tillage having the greatest share of gross output from the market.

Viability: Cattle and sheep farms are most at risk financially, with only about 25% of sheep farms and 20% of cattle farms classed as economically viable. Dairy farms were the most economically viable, followed by tillage systems.

Caveat: It is important to note that these are average values for each farm type and that earlier analysis in this report has highlighted the range around these average values in the case of each farm system type. Averages, while useful do not tell the full story. In some cases, the extent of the distribution around the average is such that there may be an overlap in the distribution of performance between different farm systems.

Figure 9-1: Economic Sustainability: Farm System Comparison 2020 (average per system)



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 the different outputs produced. More detail can be obtained by comparing within farm type variations (see previous section), but some shared environmental indicators across different farm types are presented in Figure 9-2.

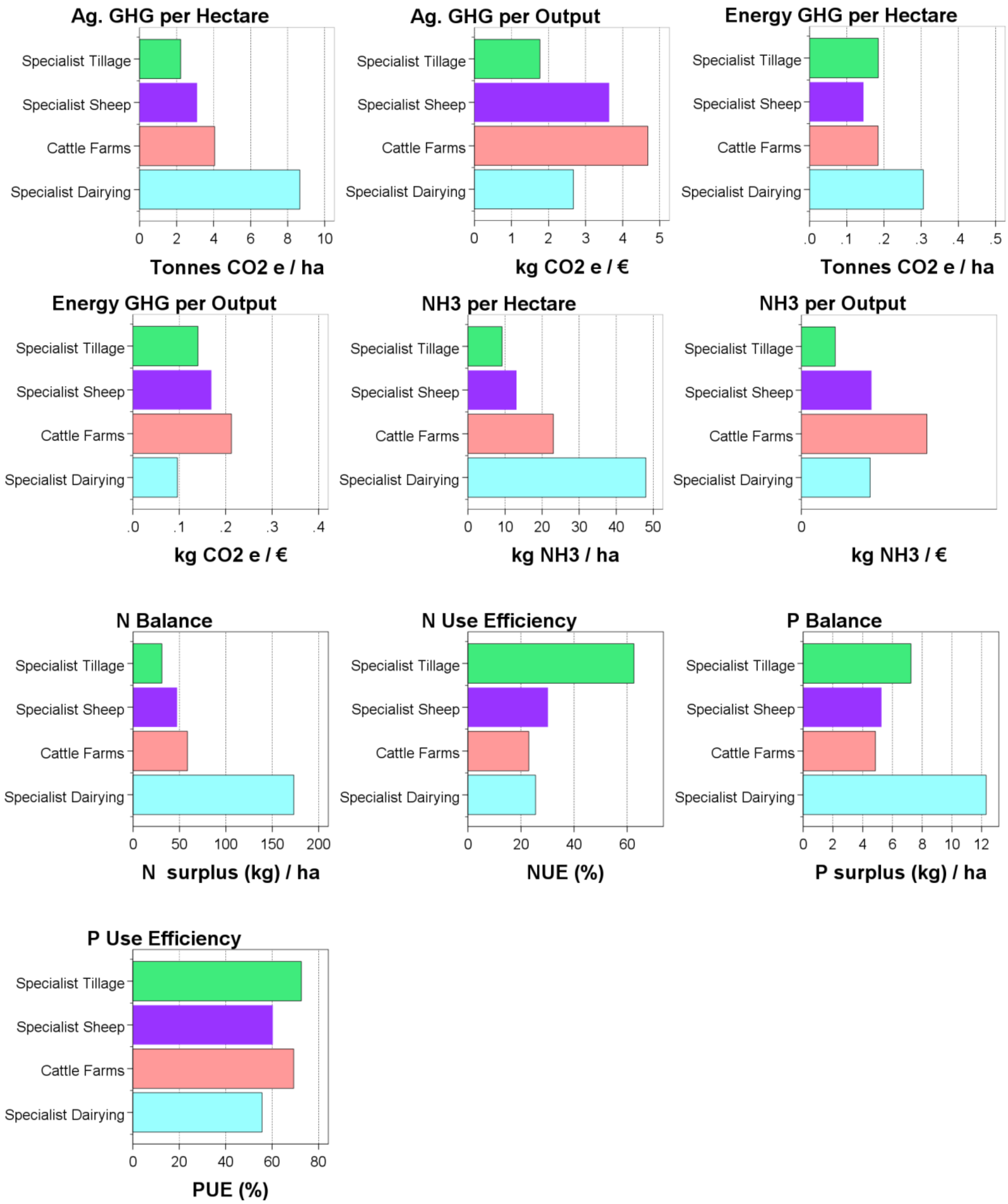
Greenhouse Gas Emissions: Bovine based farming systems typically have higher greenhouse gas emissions per hectare than tillage systems, but this is to be expected due to the greater emissions associated with animal production as opposed to crops, especially in ruminant systems. Dairy farms show the highest emissions on a per hectare basis, significantly greater than any other system. This is attributable to the greater production intensity on these farms. Dairy based emissions per hectare are a function of greater stocking rates, more energy intensive diets for dairy cows and higher use of chemical fertilisers than the other livestock systems. In terms of kg of GHG emissions per euro of output generated, livestock farms (especially cattle) had much higher emission due to the lower value of output generated in beef and sheep compared to dairy systems.

Ammonia Emissions: In common with GHG emissions, ammonia emissions per hectare were significantly higher on dairy farms compared to all other systems. Cattle farms had the next highest level of emissions per hectare (though on average these were only half those of the average dairy farms) followed by sheep and tillage farms. In terms of ammonia (NH_3) emission per euro of market output generated, cattle farms exhibited the highest ammonia emissions intensity (due to the generally lower levels of output) followed 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.

N Surplus: 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 NUE metric, dairying is similar to the other livestock systems, while tillage farms have greater NUE on average. It should be noted that tillage systems by their nature will have higher NUE, as the nitrogen is not cycling through an animal (and subject to the various loss pathways).

P Surplus: Dairy farms had the highest farm gate level P balances, significantly higher than those for 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 unavailable for farms in the NFS. PUE was highest on tillage farms, which was higher than that observed across all of the livestock systems.

Figure 9-2: Environmental Sustainability: Farm System Comparison 2020 (average per system)



Social Indicators

Comparison of the social sustainability indicators of different farm types (in Figure 9-3) shows a similar overall trend to the economic performance indicators shown in Figure 9-1, with dairy and tillage farms being distinct from cattle and sheep systems, with respect to their social sustainability performance, but with some notable exceptions.

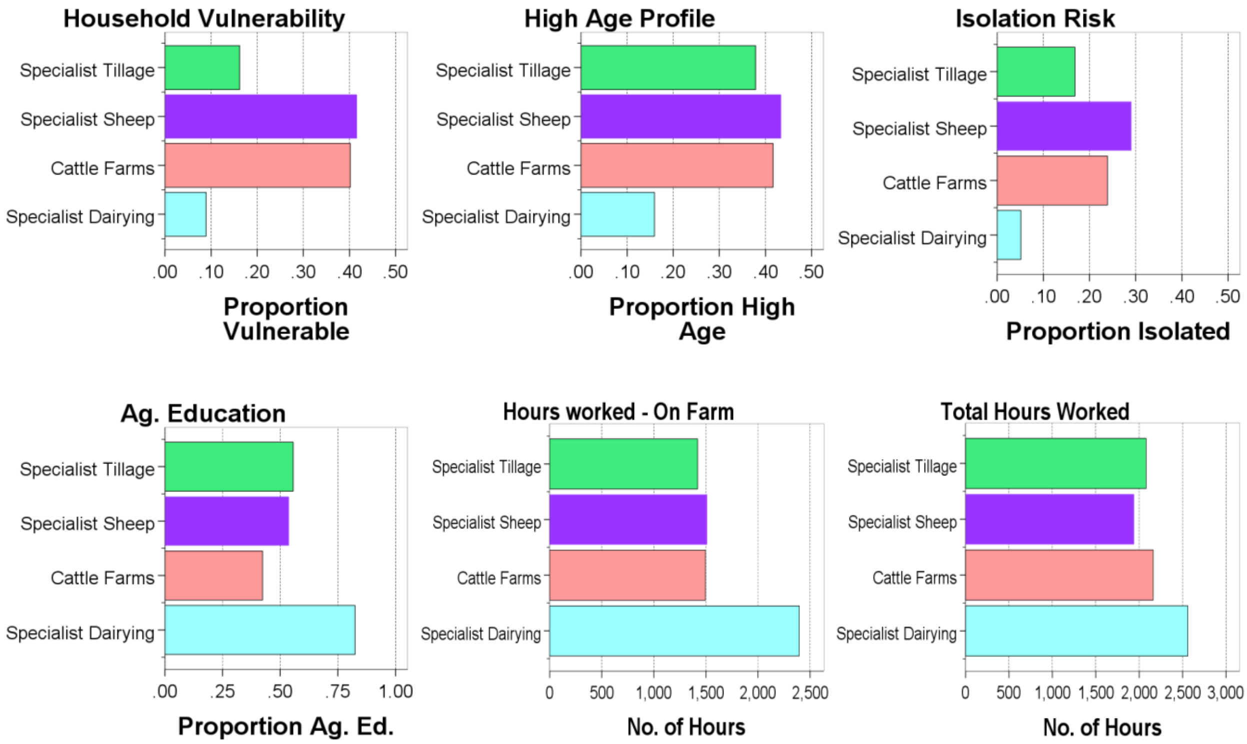
Hours Worked: The greater labour intensity of dairying is illustrated by the longer hours worked on farm. When accounting for total hours worked (on and off-farm employment), dairy farmer still have the highest number of hours worked on average but the gap between other farm systems is reduced.

Household Vulnerability: Given that there were lower levels of economic viability across cattle and sheep farms (see Figure 9-1) these systems were also more likely to have a more vulnerable household structure (non-viable with no off-farm employment within the household).

High Age Profile: Cattle, sheep and then tillage farms were also more likely to have a high age profile, while cattle and sheep farms were more likely to be operated by farmers living alone. However, there was less variation for these measures than for other social sustainability indicators.

Agricultural Education: On average, dairy farmers were more likely to have attained agricultural education or training compared to other farm systems.

Figure 9-3: Social Sustainability: Farm System Comparison 2020 (average per system)



10 Time Series Comparisons with a three year rolling average: 2015-2020

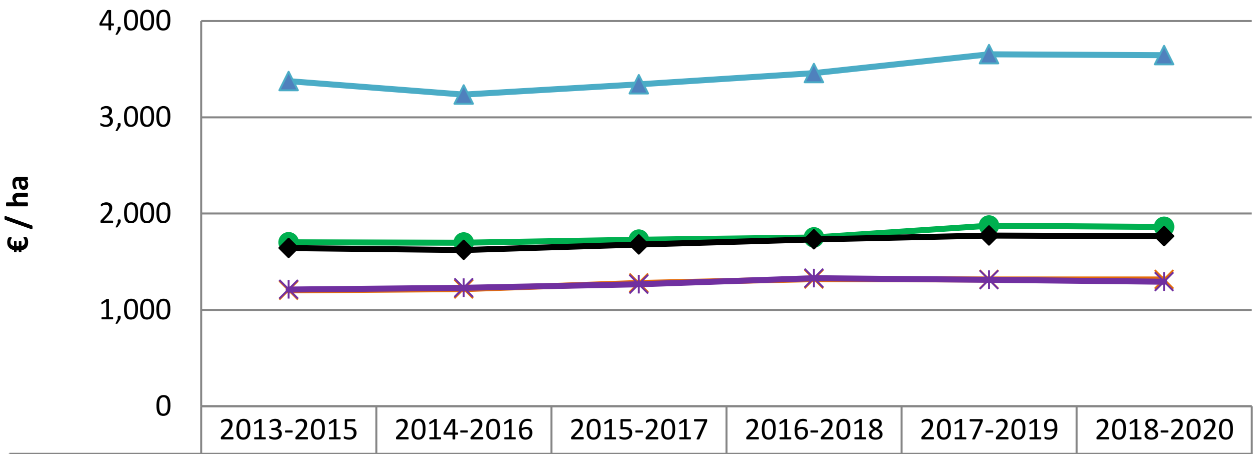
Building on research presented in previously published Teagasc Sustainability reports (Hennessy et al., 2013; Lynch et al., 2016, Buckley et al., 2019, Buckley et al., 2020a, Buckley et al., 2020b), we can track the evolution of farm-level sustainability indicators over time. The figures presented below highlight changes in indicator scores, with averages presented across all farm types. As short term input and output price volatility and weather events in a given year can occur and distort intertemporal trends, results below are presented on the basis of a **three year rolling average** (i.e. the result for 2015 is based on the average of the years 2013 to 2015 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 the control of an individual farmer** (e.g. 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 one year movements in such time series. The reported data contains both the signal and noise components and the use of the three year moving average based indicators allows for the signal component of the indicator to be more apparent.

10.1 Economic sustainability indicators

Figure 10-1 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.

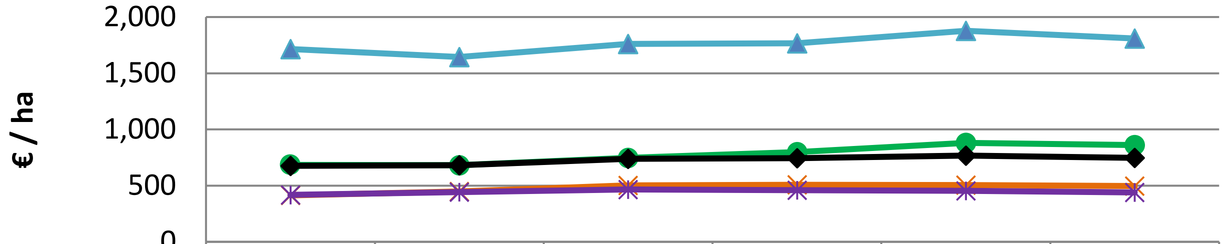
Figure 10-1: Economic Returns to Land: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	3,374	3,236	3,341	3,459	3,654	3,646
Cattle	1,203	1,217	1,279	1,320	1,318	1,315
Sheep	1,212	1,230	1,267	1,329	1,314	1,294
Tillage	1,702	1,698	1,730	1,753	1,875	1,862
All Farms	1,644	1,622	1,679	1,732	1,772	1,765

The profitability of land (gross margin per hectare) in dairying is again significantly higher than for all other systems and tends to increase over the years, significantly so at the end of the study period. Tillage farms again have the second highest gross margin per hectare. The lowest gross margins per hectare are on cattle and sheep farms, as illustrated in Figure 10-2.

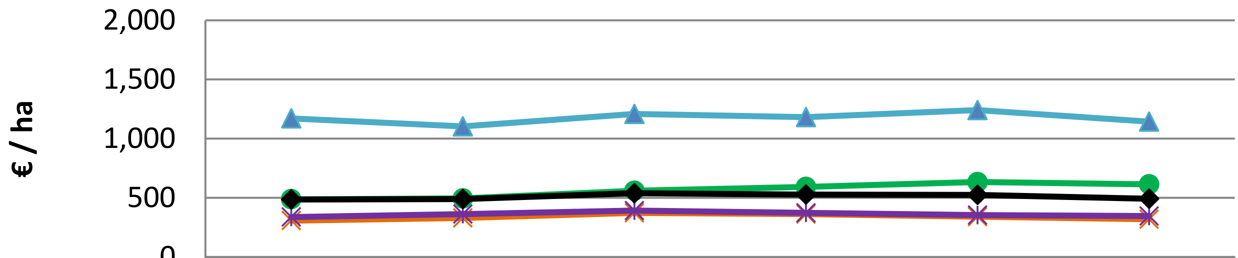
Figure 10-2: Profitability of Land: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	1,715	1,645	1,759	1,766	1,878	1,809
Cattle	413	448	501	508	504	496
Sheep	418	442	466	460	453	441
Tillage	685	682	748	797	880	860
All Farms	676	682	738	744	767	747

The ranking of systems based on Family Farm Income per hectare mirrors the ranking for profitability of land, with dairy incomes significantly higher than for all other systems. Similarly, Tillage farms are ranked second. The lowest family farm income per hectare are on by cattle and sheep farms, as illustrated by Figure 10-3.

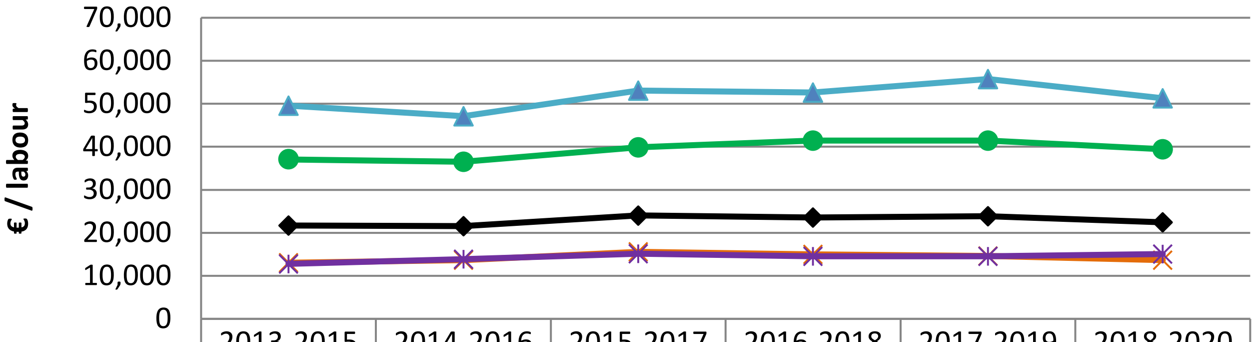
Figure 10-3: Family Farm income: 3 year rolling average 2015-2019



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	1,171	1,104	1,210	1,181	1,241	1,145
Cattle	307	330	373	363	339	320
Sheep	337	362	392	374	355	346
Tillage	487	493	559	592	634	614
All Farms	486	488	539	527	523	492

Figure 10-4 compare farm income per labour unit, which broadly follow similar trends to the gross output, gross margin and family farm income per hectare indicators. However, the differences between farm types when income per labour unit are not as pronounced as in the case of gross output, gross margin and family farm income, due to adjustment to reflect different labour intensities of each production system. Returns to labour are significantly higher on dairy and tillage farms, compared to cattle and sheep systems.

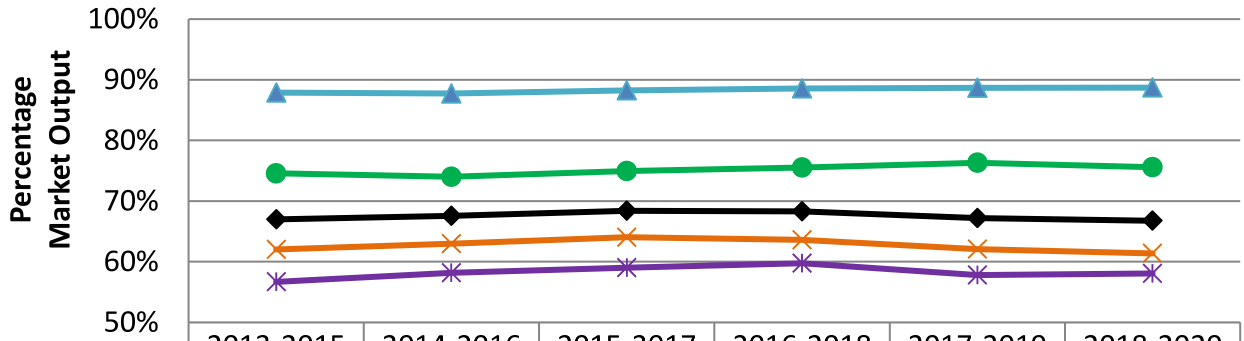
Figure 10-4: Productivity of Labour: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	49,544	47,118	53,066	52,594	55,759	51,300
Cattle	13,049	13,688	15,582	15,021	14,647	13,640
Sheep	12,787	13,892	15,144	14,542	14,539	15,048
Tillage	37,057	36,528	39,888	41,435	41,453	39,418
All Farms	21,695	21,565	24,049	23,572	23,890	22,414

Figure 10-5 illustrates that dairying is the most market orientated of all the systems (86 to 89%) followed by tillage systems (73 to 76%). The market orientation of cattle and sheep systems was the lowest at between 56% and 64%.

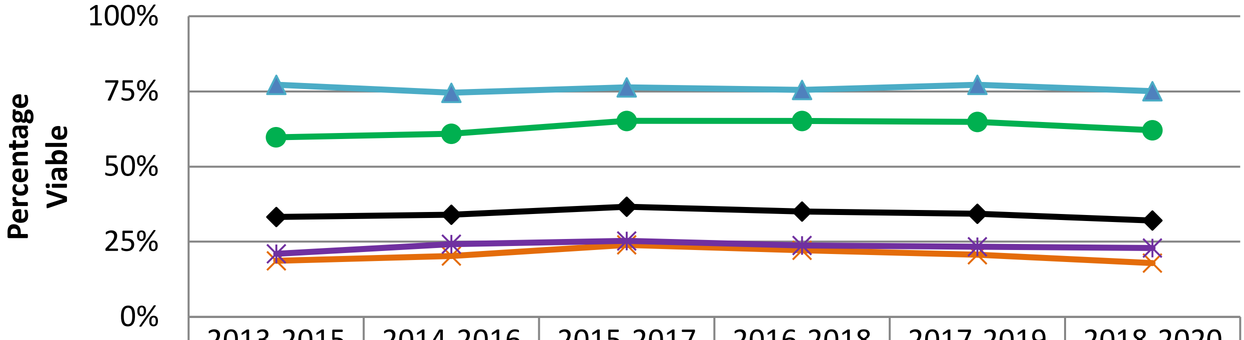
Figure 10-5: Percentage of Output Derived from Market: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	88%	88%	88%	89%	89%	89%
Cattle	62%	63%	64%	64%	62%	61%
Sheep	57%	58%	59%	60%	58%	58%
Tillage	75%	74%	75%	76%	76%	76%
All Farm	67%	68%	68%	68%	67%	67%

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 77%), compared to cattle or sheep farms (18% to 25%) over the period examined. Viability, as with the other economic indicators, is effected by variations in sectoral output prices over the period examined.

Figure 10-6: Economic Viability: 3 year rolling average 2015-2020

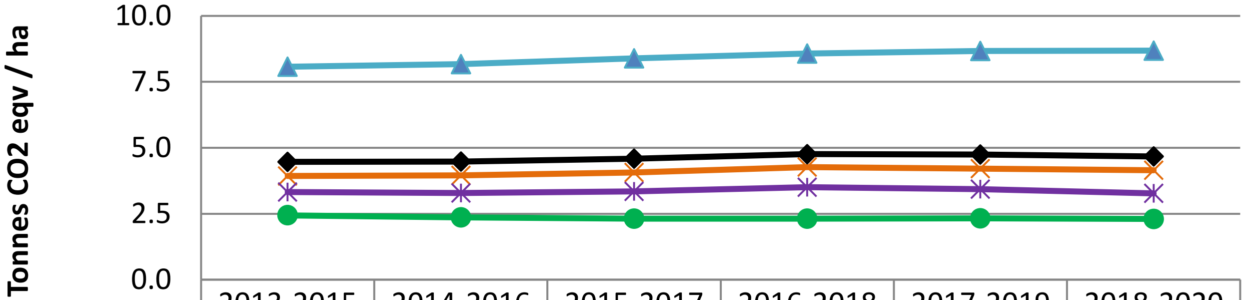


	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	77%	75%	76%	76%	77%	75%
Cattle	19%	20%	24%	22%	21%	18%
Sheep	21%	24%	25%	24%	23%	23%
Tillage	60%	61%	65%	65%	65%	62%
All Farm	33%	34%	37%	35%	34%	32%

10.2 Environmental sustainability indicators

Figure 10-7 shows that average agricultural GHG emissions per hectare have been increasing over the study period (4.5 to 4.7-4.8 tonnes CO_2 equivalent per hectare). Due to the more intensive nature of production in dairy systems compared to all other grassland systems, agricultural GHG emissions per hectare on dairy farms are over 2 to 4 times higher compared to other farm systems. The main trends observed are an increase in dairy emissions per hectare (and to a lesser extent cattle farms) and relative stability in emission intensity per hectare across the other systems. The increase in dairy GHG emissions is the driver for the increase in overall GHG emissions per hectare.

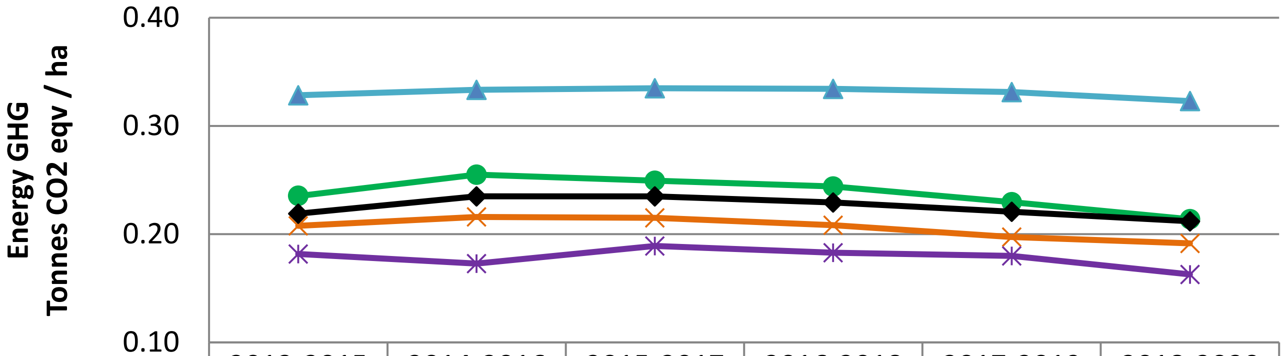
Figure 10-7: Ag. Greenhouse Gas Emissions per hectare: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	8.1	8.2	8.4	8.6	8.7	8.7
Cattle	3.9	3.9	4.1	4.3	4.2	4.2
Sheep	3.3	3.3	3.3	3.5	3.4	3.3
Tillage	2.4	2.4	2.3	2.3	2.3	2.3
All Farms	4.5	4.5	4.6	4.8	4.7	4.7

Figure 10-8 shows that energy based GHG emission generally remained stable over the study period. Energy based emissions were highest on dairy farms, since they are greater users of fuel and electricity.

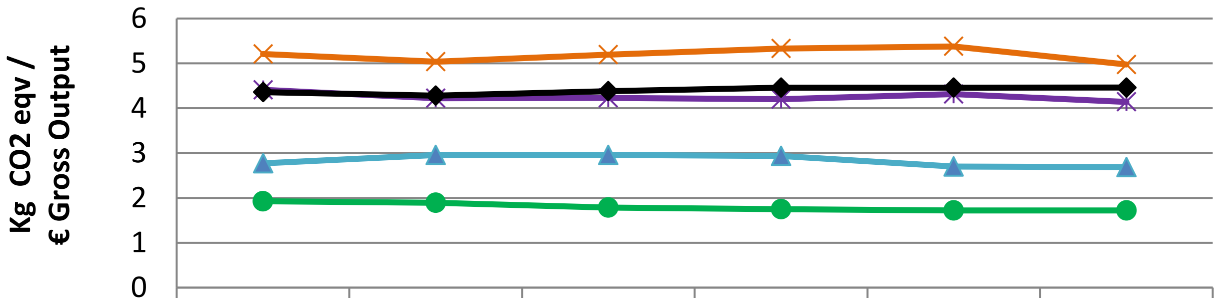
Figure 10-8: Energy Greenhouse Gas Emissions per hectare: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	0.33	0.33	0.33	0.33	0.33	0.32
Cattle	0.21	0.22	0.22	0.21	0.20	0.19
Sheep	0.18	0.17	0.19	0.18	0.18	0.16
Tillage	0.24	0.26	0.25	0.24	0.23	0.21
All Farms	0.22	0.23	0.23	0.23	0.22	0.21

Figure 10-9 illustrates that, over the study period, agricultural GHG emissions per euro of gross output generated has remained relatively stable across all systems on a three year rolling average basis. Emissions per euro of output generated are significantly higher across cattle and sheep farms in all the years considered. These results are reflective of the greater value of output produced in dairying and the lower emissions associated with non-livestock orientated tillage systems. The increase in dairy emissions per hectare, shown in Figure 10-7, are not reflected in a similar evolution in the emissions per euro output indicator in Figure 10-9.

Figure 10-9: Ag. GHG Emissions per Euro output: 3 year rolling average 2015-2020

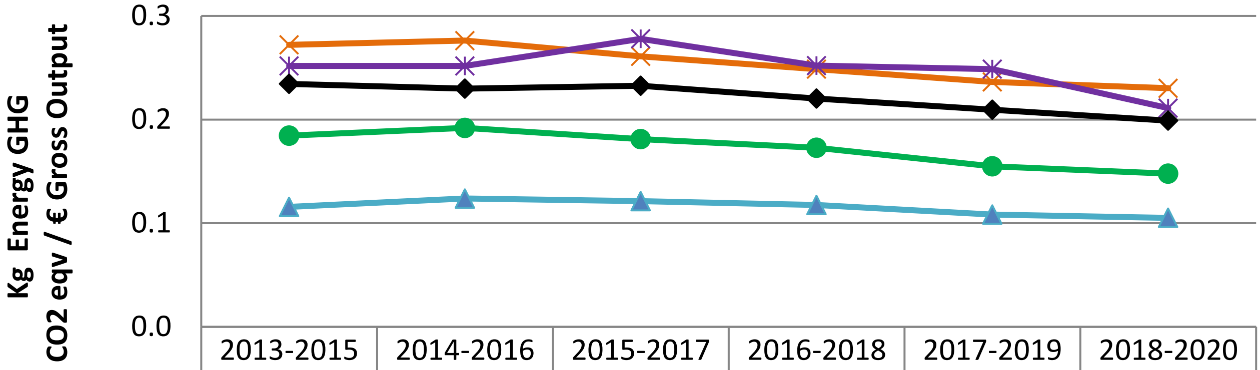


	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	2.8	3.0	3.0	2.9	2.7	2.7
Cattle	5.2	5.0	5.2	5.3	5.4	5.0
Sheep	4.4	4.2	4.2	4.2	4.3	4.1
Tillage	1.9	1.9	1.8	1.7	1.7	1.7
All Farms	4.4	4.3	4.4	4.5	4.5	4.5

Figure 10-10 illustrates energy related GHG emissions per euro 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 compared to dairying, over the period presented.

Across all farm systems, energy emissions per euro of output showed a declining trend over the study period.

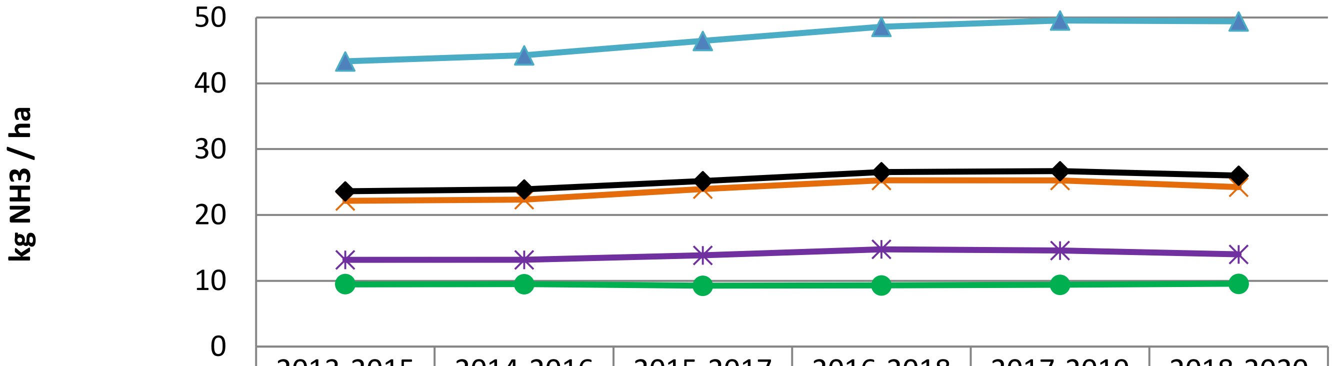
Figure 10-10: Energy related GHG Emissions per Euro output: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	0.12	0.12	0.12	0.12	0.11	0.11
Cattle	0.27	0.28	0.26	0.25	0.24	0.23
Sheep	0.25	0.25	0.28	0.25	0.25	0.21
Tillage	0.18	0.19	0.18	0.17	0.16	0.15
All Farms	0.23	0.23	0.23	0.22	0.21	0.20

Figure 10-11 illustrates that on a three year rolling average basis across all farms, ammonia (NH_3) emissions per hectare are relatively static over the early and middle of the period presented, but have increased more recently before levelling off. 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 towards the end of the study period.

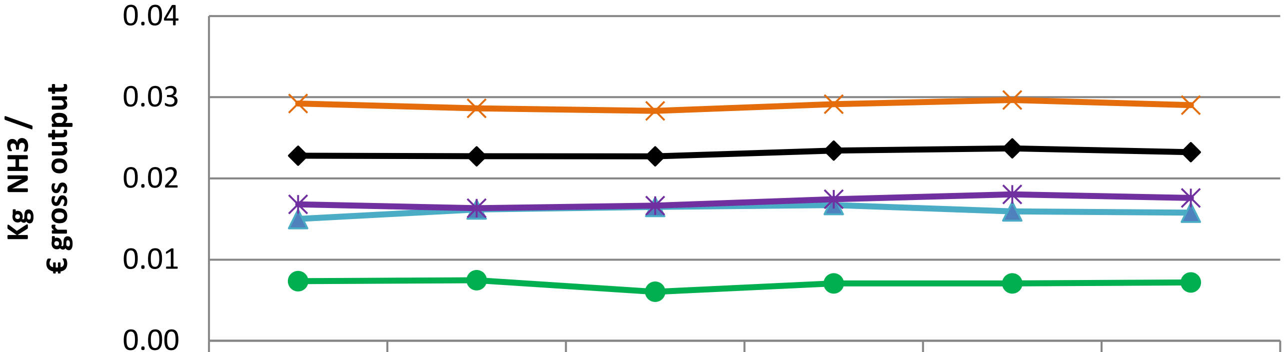
Figure 10-11: Kg of Ammonia Emissions per hectare: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	43.3	44.3	46.4	48.6	49.5	49.4
Cattle	22.1	22.3	23.9	25.3	25.2	24.2
Sheep	13.2	13.2	13.8	14.8	14.6	14.0
Tillage	9.5	9.5	9.3	9.3	9.4	9.6
All Farms	23.6	23.9	25.1	26.5	26.7	26.0

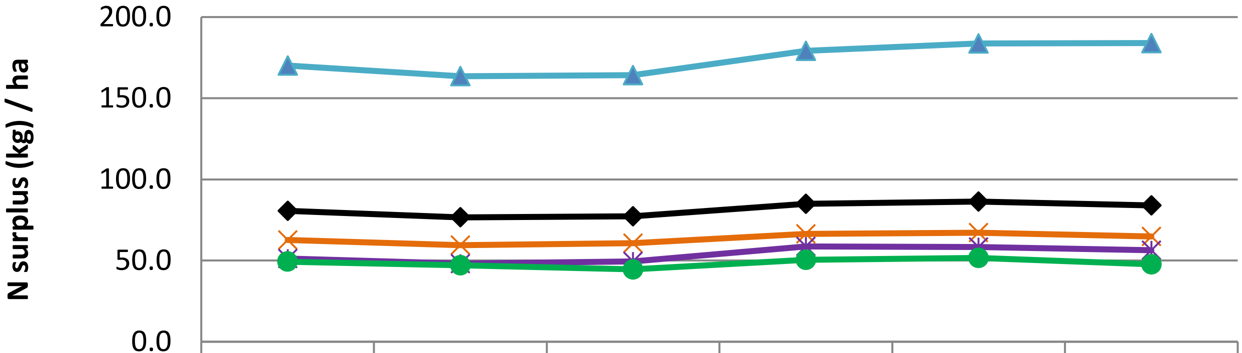
Figure 10-12 illustrates NH_3 emissions per euro of market based gross output. Results indicate that emissions per euro of output are higher on cattle farms compared to all other systems over the study period. This is a function of the low levels of output on these farms. Dairy and sheep farms had very similar levels of NH_3 emissions 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.

Figure 10-12: Ammonia (NH_3) Emissions per Euro Output: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	0.015	0.016	0.016	0.017	0.016	0.016
Cattle	0.029	0.029	0.028	0.029	0.030	0.029
Sheep	0.017	0.016	0.017	0.017	0.018	0.018
Tillage	0.007	0.007	0.006	0.007	0.007	0.007
All Farms	0.023	0.023	0.023	0.023	0.024	0.023

Figure 10-13: Nitrogen Balance per ha: 3 year rolling average 2015-2020

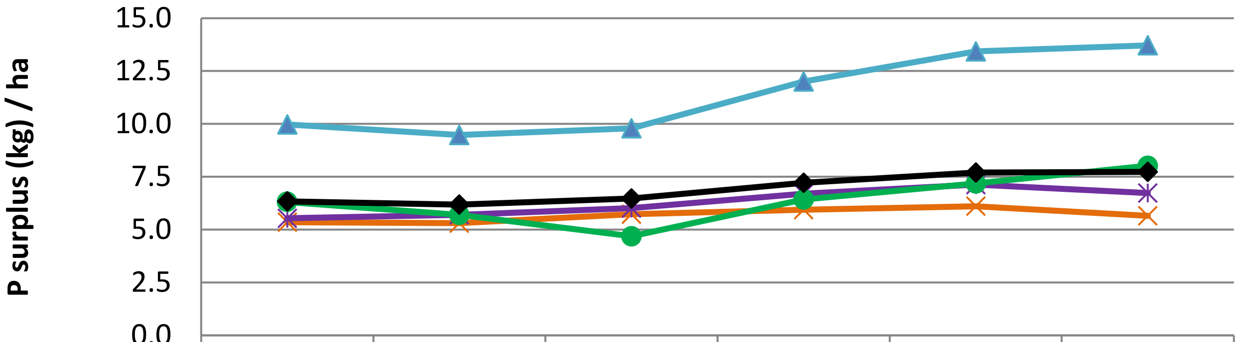


	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	170.1	163.5	164.2	179.1	183.8	184.0
Cattle	62.7	59.5	60.7	66.4	67.2	64.9
Sheep	51.3	48.1	49.4	58.7	58.4	56.4
Tillage	49.3	47.0	44.6	50.4	51.6	47.7
All Farms	80.6	76.6	77.3	84.9	86.3	84.0

Across all farm systems, the N balance per hectare was slightly higher at the end versus the start of the period examined. Again, due to the more intensive nature of production, N surpluses are significantly higher for dairy farms compared to all other systems. Due to the non-livestock orientated nature of production on tillage farms, N surpluses are, on average, lowest across these farms over the period examined. N surpluses are affected by a range of factors, some within and some (such as variability in the weather) outside the farmer's control. Higher N surplus years tended to be associated with adverse annual weather conditions.

Figure 10-14 illustrates that P balances have tended to increase over the study period. P surpluses are significantly higher on dairy farms compared to all other systems. It should also be noted that farm gate P balances must be interpreted with care, since establishing the optimal balance requires a soil test. Farmers are allowed to run significant farm gate surpluses, if soil P status is sub optimal (deficient). In 2020 Teagasc analysed a total 30,035 soil samples comprising of dairy, drystock and tillage farm enterprises (Teagasc, 2021). Results indicate that 53% of samples taken are P deficient (at either index 1 or 2 for phosphorus).

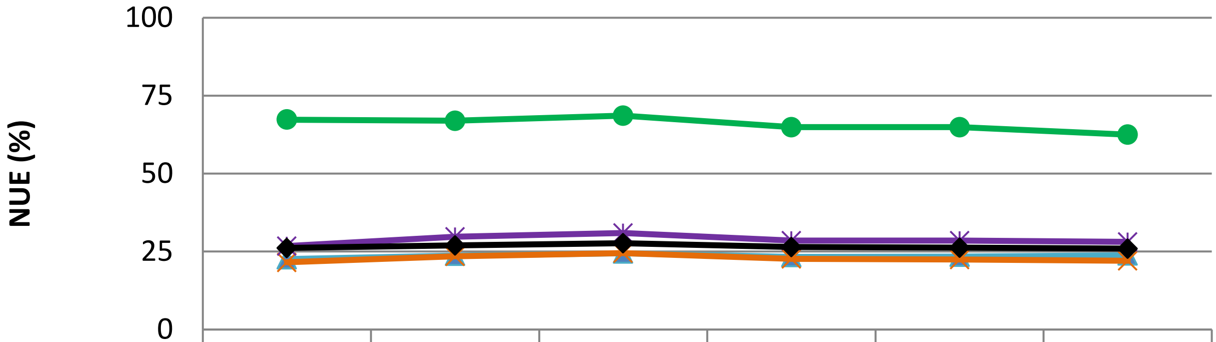
Figure 10-14: Phosphorus (P) Balance per ha: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	10.0	9.5	9.8	12.0	13.4	13.7
Cattle	5.3	5.3	5.7	5.9	6.1	5.7
Sheep	5.5	5.7	6.0	6.7	7.1	6.7
Tillage	6.3	5.7	4.7	6.4	7.2	8.0
All Farms	6.3	6.2	6.5	7.2	7.7	7.7

Figure 10-15 illustrates that dairy and cattle farms tended to have the lowest NUE over the study period. Tillage NUE was generally significantly higher than all other systems due to the mainly non-livestock nature of this system.

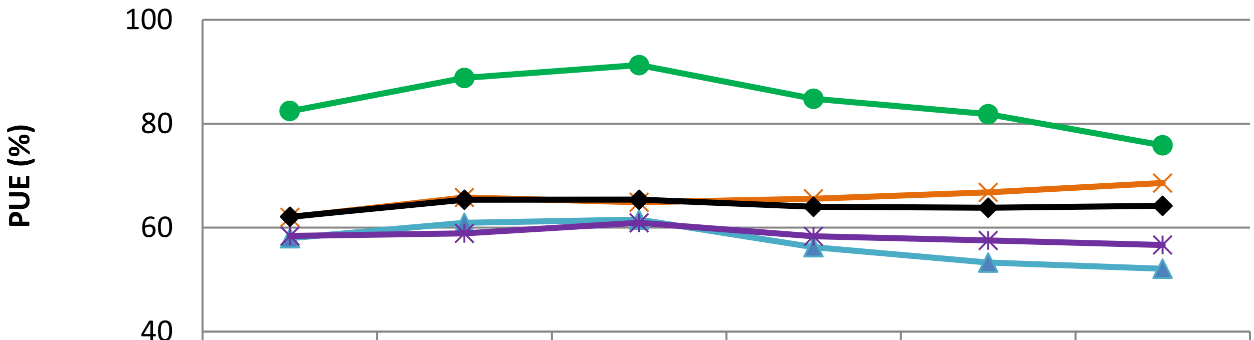
Figure 10-15: Nitrogen Use Efficiency: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	22.6	23.7	24.5	23.3	23.4	23.8
Cattle	21.6	23.5	24.5	22.7	22.4	22.0
Sheep	26.8	29.8	31.0	28.5	28.5	28.1
Tillage	67.3	67.0	68.6	64.9	64.9	62.5
All Farms	26.1	27.0	27.7	26.5	26.3	26.0

Figure 10-16 illustrates that, on a three year rolling average basis across all farm systems, PUE (P outputs / P inputs) has generally declined between the start and end of the period presented, for dairy and tillage, while it has increased for cattle systems. It should also be noted that P fertiliser allowances were increased in 2014 following regulatory changes, which allowed more P to be applied to fields with sub-optimal soil P levels. Farm gate PUE measures must be interpreted with care, since establishing true PUE requires a soil test.

Figure 10-16: Phosphorus Use Efficiency: 3 year rolling average 2015-2020

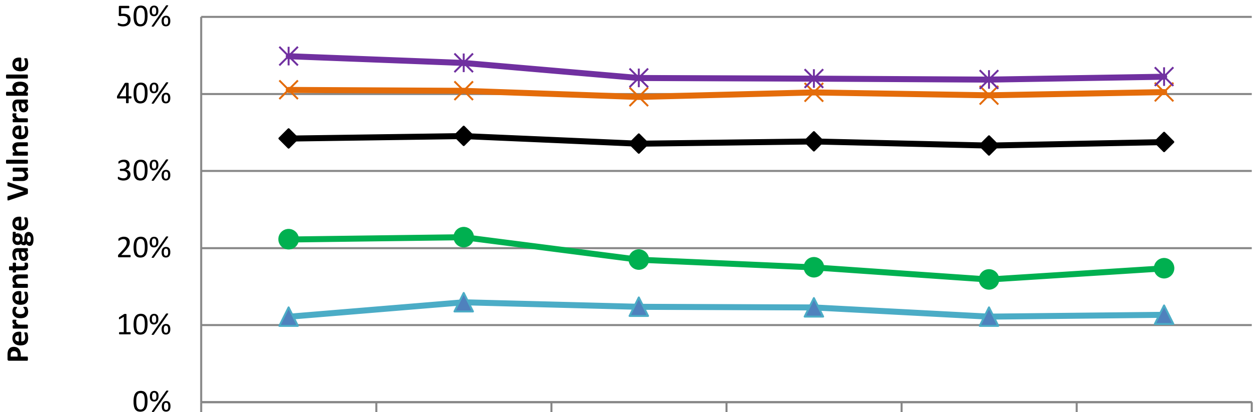


	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	58.0	61.0	61.6	56.3	53.3	52.1
Cattle	62.0	65.8	64.9	65.5	66.8	68.6
Sheep	58.4	58.9	60.9	58.4	57.6	56.7
Tillage	82.4	88.8	91.3	84.8	81.9	75.8
All Farms	62.1	65.4	65.4	64.0	63.8	64.2

10.3 Social Sustainability Indicators

Figure 10-17 shows that on a three-year rolling average the rate of vulnerability (non-viable farm business and no off-farm employment) of all farming households has remained stable over the 2015-2020 period across all systems , at between 33 and 35%. Dairying and tillage systems tend to have significantly lower levels of household vulnerability than cattle and sheep systems.

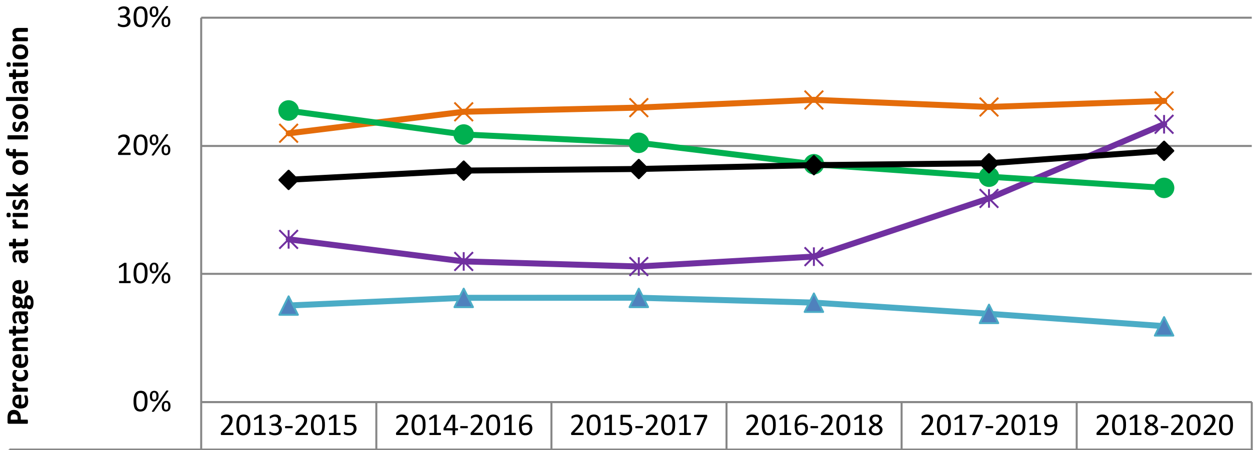
Figure 10-17: Farm Household Vulnerability: 3 year rolling average 2015-2020



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	11%	13%	12%	12%	11%	11%
Cattle	41%	40%	40%	40%	40%	40%
Sheep	45%	44%	42%	42%	42%	42%
Tillage	21%	21%	18%	17%	16%	17%
All Farms	34%	35%	34%	34%	33%	34%

Figure 10-18 shows that on a three-year rolling average basis the percentage of farmers at risk of isolation has increased from the start (17%) to the end (20%) of the study period across all systems. The percentage of tillage farmers at risk of isolation has decreased over the study period (23% to 17%) while the percentage of cattle farmers at risk has increased (21 to 23%). However, overall isolation risk tends to be higher on non-dairy farms.

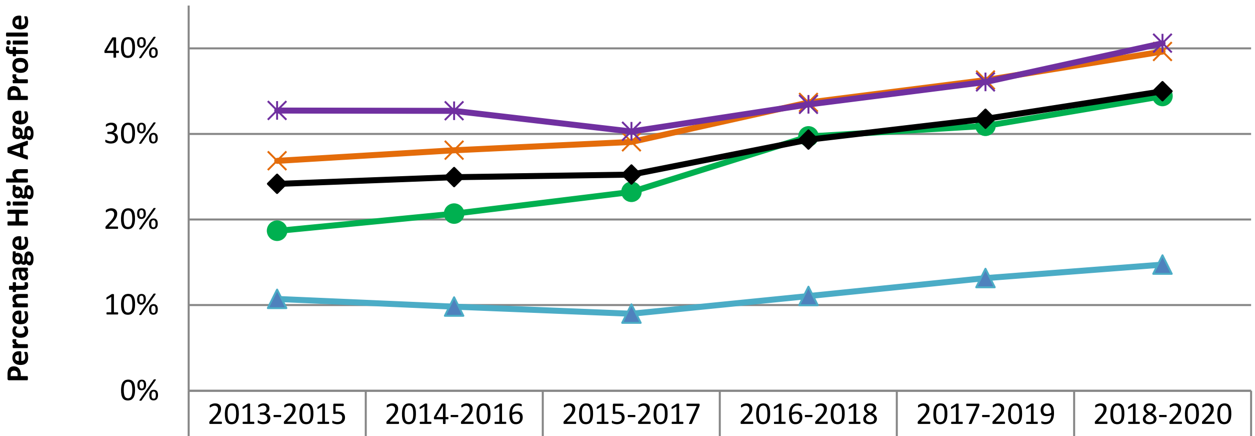
Figure 10-18: Isolation Risk: 3 year rolling average 2015-2020 (average per system)



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	8%	8%	8%	8%	7%	6%
Cattle	21%	23%	23%	24%	23%	23%
Sheep	13%	11%	11%	11%	16%	22%
Tillage	23%	21%	20%	19%	18%	17%
All Farms	17%	18%	18%	18%	19%	20%

Figure 10-19 shows that on a three year rolling average basis the percentage of all farms with a high age profile has increased between the start and end of the study period (24% to 35%). Dairy farms tend to have the lowest age profile across all the farm systems (9% to 13%), compared to other systems which tend to be double or treble this rate.

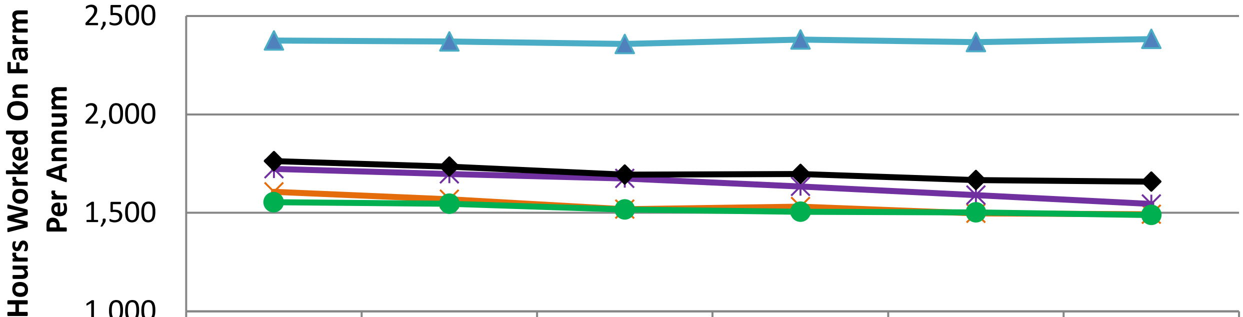
Figure 10-19: High Age Profile: 3 year rolling average 2015-2020 (average per system)



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	11%	10%	9%	11%	13%	15%
Cattle	27%	28%	29%	34%	36%	40%
Sheep	33%	33%	30%	33%	36%	41%
Tillage	19%	21%	23%	30%	31%	34%
All Farm	24%	25%	25%	29%	32%	35%

Figure 10-20 shows that the hours worked on-farm per annum has declined slightly across all farms between 2012 and 2020. Hours worked on farm per annum is significantly higher on dairy farms, compared to all other farm systems.

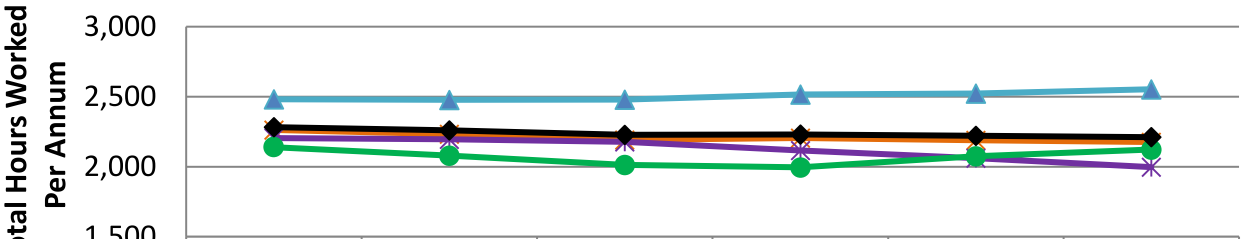
Figure 10-20: Hours Worked On Farm Per Annum: 3 year rolling average 2015-2020 (average per system)



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	2,375	2,371	2,358	2,381	2,368	2,383
Cattle	1,607	1,569	1,518	1,531	1,497	1,493
Sheep	1,723	1,698	1,674	1,635	1,590	1,545
Tillage	1,554	1,546	1,517	1,505	1,502	1,489
All Farms	1,763	1,735	1,695	1,698	1,666	1,659

Figure 10-21 illustrates the total hours worked by the farm operator (including on and off farm employment) by farm systems. Results indicate that longer overall hours are worked by dairy farmers and that the number of hours worked has increased over time. The opposite trend is observed for sheep farmers (fewer hours worked over time) with the number of hours worked by farmers in the cattle and tillage systems remaining relatively stable.

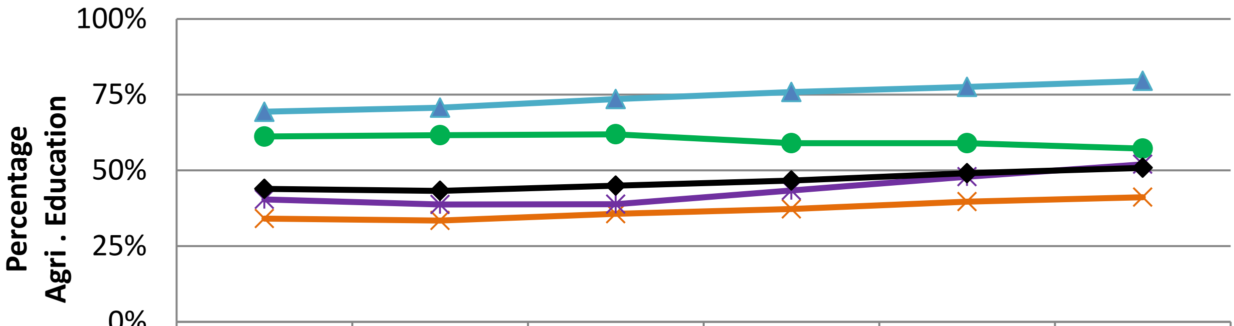
Figure 10-21: Total Hours Worked Per Annum: 3 year rolling average 2015-2020 (average per system)



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	2,481	2,477	2,480	2,516	2,523	2,553
Cattle	2,262	2,233	2,192	2,204	2,189	2,176
Sheep	2,204	2,194	2,177	2,116	2,060	1,997
Tillage	2,139	2,078	2,012	1,995	2,074	2,123
All Farms	2,282	2,259	2,228	2,231	2,220	2,211

Figure 10-22 indicates that the percentage of famers who have received some form of agricultural education has increased over the period 2015-2020 at between 44% and 51%. Significantly, higher levels of formal agricultural education are observed for dairy farmers.

Figure 10-22: Formal Agricultural Education: 3 year rolling average 2015-2020 (average per system)



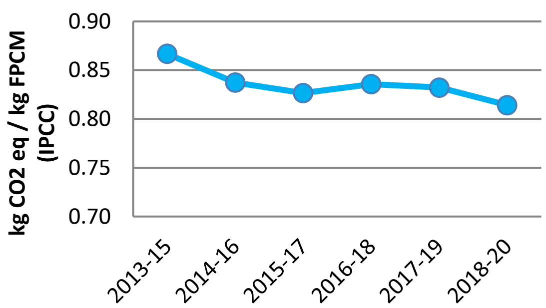
	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Dairy	69%	71%	74%	76%	78%	80%
Cattle	34%	33%	36%	37%	40%	41%
Sheep	40%	39%	39%	43%	48%	52%
Tillage	61%	62%	62%	59%	59%	57%
All Farms	44%	43%	45%	47%	49%	51%

10.4 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 and sheep meat). Results are again reported on the basis of a three year rolling average (e.g. the 2013-2015 results are the average of 2013, 2014 and 2015 results). Results for individual years are reported in the appendices for each farm system.

Results presented in Figure 10-23 show that, on a three year rolling average basis, the kg of CO_2 equivalent per kg of FPCM has generally followed a declining trend since 2013.

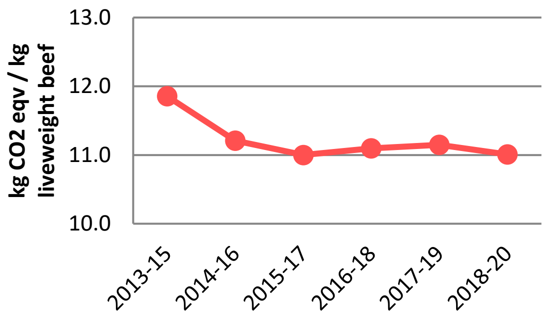
Figure 10-23: Ag. GHG Emissions per kg FPCM: 2015-2020 Dairy Farms*



Note: (IPCC approach) 3 year rolling average

Figure 10-24 indicates that kg of CO2 equivalent per kg of live-weight beef produced on cattle farms also tended to follow a declining trend, before again levelling out towards the end of the study period.

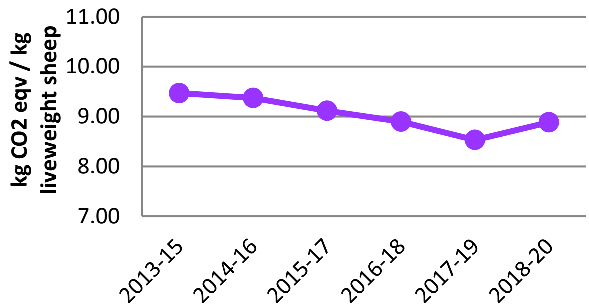
Figure 10-24: Ag. GHG Emissions per kg live-weight beef produced: 2015-2020 (Cattle Farms*)



Note: (IPCC approach) 3 year rolling average

Figure 10-25 indicates, on three year rolling average basis, a steady declining trend in terms of kg of CO_2 emitted per kg of live-weight sheep produced between 2014 and 2019, with a slight upturn at the end of the study period.

Figure 10-25: Ag. GHG Emissions per kg live-weight sheep produced: 2015-2020 Sheep Farms*

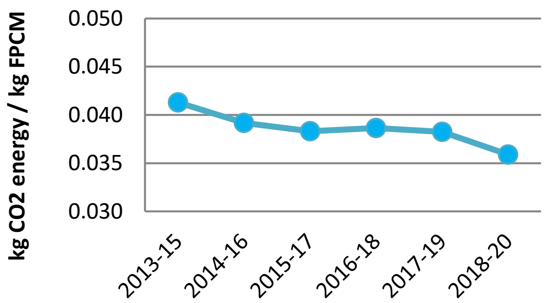


Note: (IPCC approach) 3 year rolling average

Energy based GHG emissions may be affected by the weather in any given year (e.g. wet conditions may require extra movement of farm livestock herds).

Results presented in Figure 10-26 indicate a gradual decline in energy based GHG emissions associated with milk production between the start and end of the study period.

Figure 10-26: Energy use related GHG emissions per kg FPCM: 2015-2020 Dairy Farms



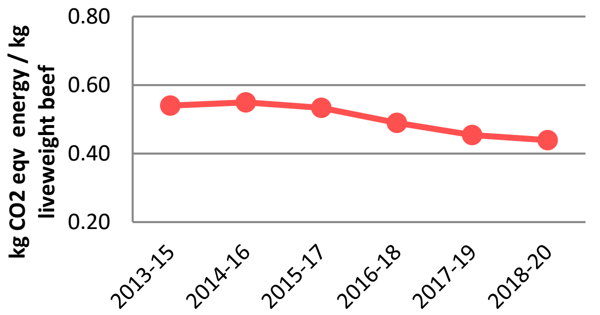
Note: (IPCC approach) 3 year rolling average

Energy based CO_2 emissions related to the production of live-weight beef on cattle farms were relatively static over the study, with a

Methodological update from previous report, numbers have been amended.

declining trend evident toward the end of the study period as illustrated in Figure 10-27.

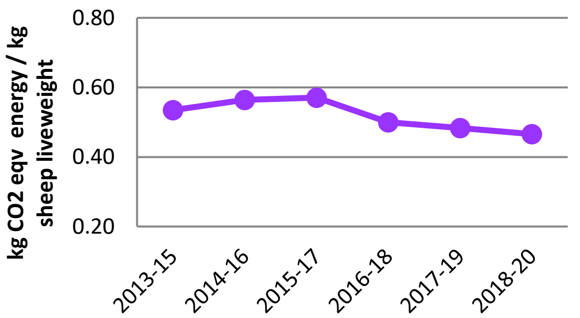
Figure 10-27: Energy use related GHG emissions per kg live-weight beef produced: 2015-2020 Cattle Farms*



Note: (IPCC approach) 3 year rolling average

Energy related GHG emissions from the production of live-weight sheep were also relatively static over the first part of the study period with a declining trend evident towards the end of the period as illustrated in Figure 10-28.

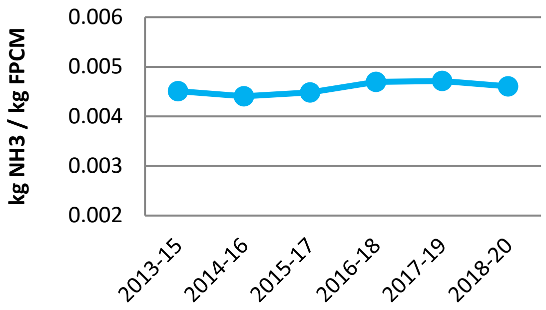
Figure 10-28: Energy use related GHG emissions per kg live-weight sheep produced: 2015-2020 Sheep Farms*



Note: (IPCC approach) 3 year rolling average

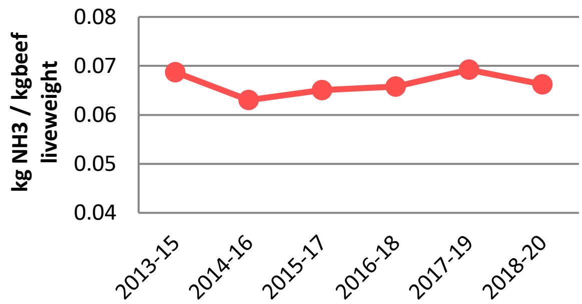
On a three year rolling average basis, the NH_3 emissions intensity of milk production tended to be relatively stable over the study period, outlined in Figure 10-29.

Figure 10-29: Ammonia emissions per kg FPCM: 2015-2020 3 year rolling average Dairy Farms



On a three year rolling average basis, NH_3 emissions per kg of live-weight beef produced on cattle farms were relatively stable over most of the period presented, as shown in Figure 10-30.

Figure 10-30: Ammonia emissions per kg live-weight beef produced: 2015-2020 Cattle Farms



This pattern was repeated for NH_3 emissions per kg of live-weight sheep meat produced on sheep farms, as illustrated in Figure 10-31.

Figure 10-31: Ammonia emissions per kg live-weight sheep produced: 2015-2020 Sheep Farms*

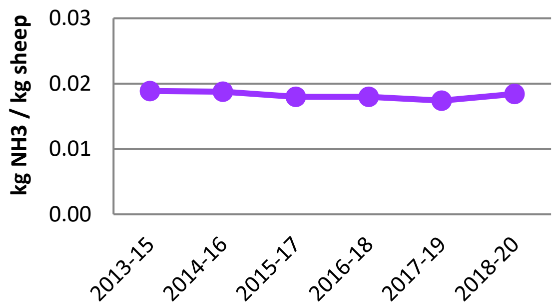


Figure 10-32 illustrates the trend on dairy farms in terms of kg of FPCM produced per kg of N surplus (excess of N input over outputs), on a

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**Methodological update from previous report, numbers have been amended.*

three year rolling average basis. The graph shows an increase in FPCM produced per kg of N surplus followed by a levelling off at the end of the period.

Figure 10-32: kg of FPCM produced per kg of N surplus: 2015-2020 Dairy Farms

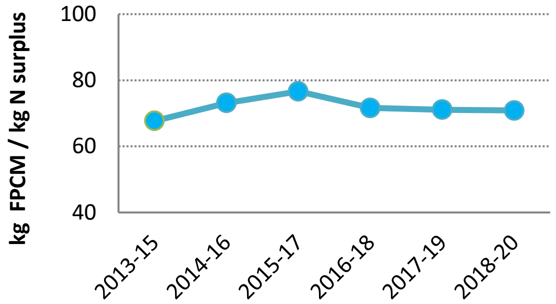
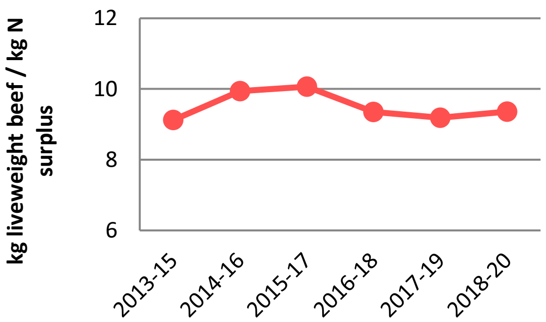


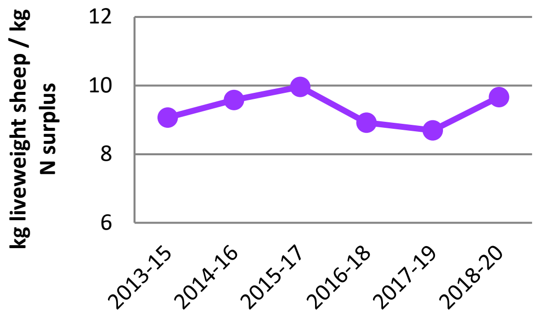
Figure 10-33 shows the trend per kg of live-weight beef produced per kg of N surplus. Based on a three year rolling average, results indicate an increasing trend at the start of the study period, followed by a decrease mid study period, before a levelling off at the end of the study period.

Figure 10-33: kg of live-weight beef produced per kg of N surplus: 2015-2020 Cattle Farms*



Results for kg of live-weight sheep meat produced per kg of N surplus on sheep farms are presented in Figure 10-34. The data indicate an increasing trend at the start of the study period, followed by a decline mid study period before a return to original levels.

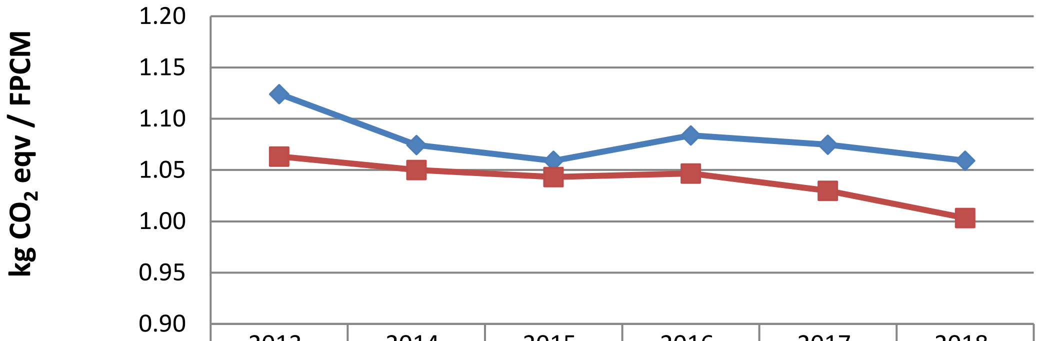
Figure 10-34: kg of live-weight sheep produced per kg of N surplus: 2015-2020 Sheep Farms



11 National Cross Validation of Carbon Footprint of Milk Production

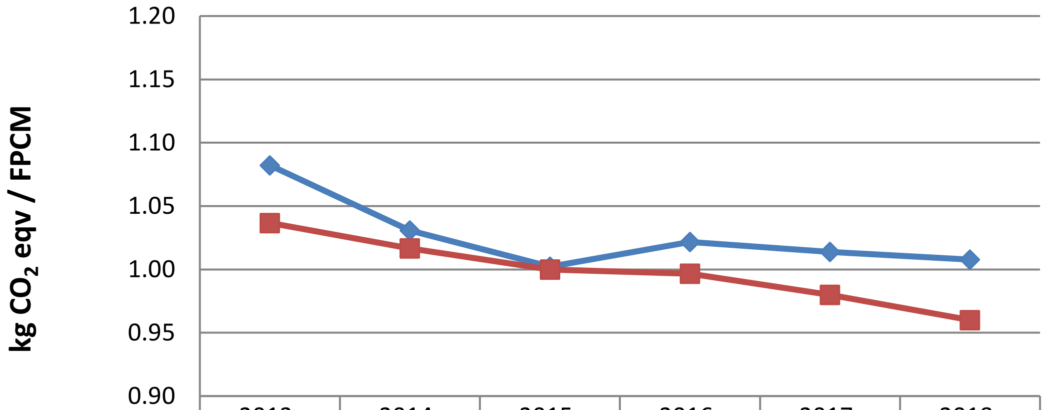
Using the broader LCA approach (including agricultural and energy based emissions) the Teagasc NFS data have been used in conjunction with the Teagasc LCA model (O'Brien et al., 2014; Herron et al., 2021) to produce LCA carbon footprint indicators using NFS data. Results from this LCA approach indicate that the carbon footprint of Irish milk production (CO_2 equivalent per kg of FPCM produced) 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). However, an increase was evident for the 2016-2018 period. This can be largely attributed to adverse weather experienced in 2018. However, this upward trend has been reversed and a more long terms downward trend for the 2017-2020 period is evident, both on a weighted farm and national aggregate basis. 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 approach and farm level data collected and published as part of the Bord Bia Sustainable Dairy Assurance Scheme (SDAS) (Murphy, 2021) as outlined below.

Figure 11-1: GHG per kg FPCM (LCA Approach) – 3 year rolling nationally weighted farm average



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Teagasc NFS	1.12	1.07	1.06	1.08	1.07	1.06
Bord Bia SDAS	1.06	1.05	1.04	1.05	1.03	1.00

Figure 11-2: GHG per kg FPCM (LCA Approach) – 3 year rolling average weighted by milk supply.



	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	2018-2020
Teagasc NFS	1.08	1.03	1.00	1.02	1.01	1.01
Bord Bia SDAS	1.04	1.02	1.00	1.00	0.98	0.96

12 Ongoing 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 Teagasc Sustainability Reports (Hennessy et al., 2013; Lynch et al., 2016; Buckley et al., 2019, Buckley et al., 2020) and shows the changes in relevant indicators through time.

The indicator set reported will continue to evolve (in terms of new indicators and the methodology used to calculate existing indicators) and will continue where possible to 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 sustainability metrics is continually under review. To that end, work is ongoing to strengthen the social and environmental indicators in particular. As such, two important environmental aspects not yet included are currently in progress.

Life-Cycle Analysis Model for Beef and Sheep 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 and sheep farms and the volume of the principal output (milk) can be more easily recorded. In addition, there are much more limited movements of animals onto and off of dairy farms as compared to beef farms. By contrast there are a range of different systems on beef and sheep farms and movements of animals onto and off of farms can be quite diverse depending on the specifics of the cattle system in operation. In addition, the output of the farm (live-weight gain) can be hard to capture as it is not directly observed and measured by the farmer. However, LCA models for beef and sheep production have been developed by Teagasc colleagues in the Animal and Grassland Research and Innovation Programme and the Teagasc NFS data collection schedule is being expanded to enable the application of a Beef and Sheep LCA carbon footprint in Teagasc Sustainability Report indicator set using Teagasc NFS data.

Biodiversity

Farms produce food, but also produce/maintain a range of eco system services, including 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 global concerns associated with the intensification of agricultural production is that wildlife and native flora may be negatively impacted, resulting in irrevocable or difficult to reverse biodiversity loss. Biodiversity is therefore an important component of farm performance, but can usually only reliably be assessed by detailed on-farm surveys. Typically, such measurement is resource intensive and represents a long term commitment, which would ordinarily be beyond the current scope and resources of the Teagasc NFS.

However, competitive research funding has now allowed ecologists to use remote mapping to identify farmland habitat biodiversity on close to 300 NFS farms. A ground truthing exercise for this data has been completed and a biodiversity index measure is being generated for each farm. If further funding for this initiative could be secured this would allow the habitat biodiversity assessment and biodiversity index to be undertaken on all NFS farms. It could also allow this assessment to be repeated on a periodic basis to track changes in habitat biodiversity over time.

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Appendix 1 – Individual year results by farm system 2015-2020

Table A 1: Sustainability Indicator results for Dairying Farms 2015-2020

Indicator	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Economic Sustainability Metrics			€			
Economic return per hectare (gross output)	3,283	3,021	3,720	3,637	3,605	3,695
Profitability per hectare (gross margin)	1,710	1,457	2,111	1,728	1,793	1,906
Family farm income per hectare	1,149	942	1,538	1,063	1,123	1,248
Productivity of labour	49,363	41,188	68,646	47,947	50,683	55,271
			Percentage:			
Market orientation	88	87	90	89	88	90
Viability	75	69	85	73	74	79
Social Sustainability Metrics						
Household vulnerable	13%	16%	8%	13%	12%	9%
Isolation	8%	8%	8%	7%	6%	5%
High age profile	6%	9%	12%	12%	15%	17%
Hours worked on farm	2,329	2,370	2,341	2,397	2,365	2,386
Total hours worked	2,442	2,513	2,485	2,883	2,534	2,575
Agricultural education	71%	74%	76%	77%	79%	82%
Environmental Sustainability Metrics						
			tonnes CO2 eqv per farm			
Total farm average Ag. GHG emissions*	460.7	482.1	499.5	513.5	505.8	510.7
of which dairy*	316.3	334.1	349.6	361.3	367.3	373.0
cattle*	141.9	143.8	145.0	150.5	136.6	136.1
sheep*	1.2	1.1	1.1	1.0	1.0	0.9
other*	1.3	3.1	3.7	0.8	0.9	0.7
energy use*	17.4	17.6	17.5	17.8	17.5	16.6
			tonnes CO_2 eqv per ha			
Ag GHG Emissions*	8.2	8.3	8.6	8.8	8.6	8.6
Energy GHG Emissions*	0.34	0.34	0.33	0.33	0.33	0.31
			kg CO_2 eqv			
GHG Emissions per kg milk*	0.81	0.83	0.84	0.84	0.82	0.81
GHG Emissions per kg FPCM*	0.81	0.82	0.84	0.84	0.81	0.79
GHG Emissions per € output*	2.9	3.3	2.7	2.8	2.6	2.7
Energy Emissions per kg milk*	0.037	0.038	0.040	0.039	0.037	0.033
Energy Emissions eqv per kg FPCM*	0.037	0.037	0.040	0.039	0.036	0.033
GHG Emissions per kg FPCM (LCA)*	1.03	1.06	1.08	1.11	1.03	1.04
			tonnes NH_3 per farm			
Total farm average NH3 emissions*	2.48	2.68	2.78	2.99	2.87	2.84
of which dairy*	1.60	1.78	1.86	2.01	2.00	1.99
cattle*	0.88	0.90	0.91	0.97	0.86	0.84
sheep*	0.00	0.00	0.00	0.00	0.00	0.00
tillage*	0.00	0.00	0.00	0.00	0.00	0.00

Indicator	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
		Kg NH_3				
NH_3 emissions per hectare*	44.4	46.3	48.4	51.1	49.2	48.0
NH_3 emissions per Euro output*	0.016	0.018	0.015	0.016	0.016	0.015
NH_3 emissions per kg milk*	0.004	0.004	0.005	0.005	0.005	0.004
NH_3 emissions per kg FPCM*	0.004	0.005	0.005	0.005	0.005	0.004
N Balance per hectare	155.9	164.8	171.9	200.7	178.7	172.6
P Balance per hectare	9.0	9.0	11.4	15.6	13.3	12.3
		percentage				
N use efficiency	25.0	24.0	24.4	21.5	24.4	25.6
P use efficiency	63.8	62.4	58.4	48.7	53.5	54.9
		Per kg of N Surplus				
Kg FPCM	78.6	75.3	76.0	63.6	73.7	75.3

*** Methodological update from previous report, with historical numbers revised accordingly.**

Table A 2: Sustainability Indicator results for Cattle Farms 2015-2020

Indicator	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,189	1,312	1,336	1,312	1,306	1,327
Profitability per hectare (gross margin)	463	507	533	483	497	510
Family Farm Income per hectare	346	381	391	317	311	331
Productivity of labour	15,029	14,809	16,909	13,344	13,688	13,888
			percentage			
Market orientation	64%	64%	64%	62%	60%	62%
Viability	24%	23%	25%	18%	18%	17%
Social Sustainability Metrics						
Household vulnerable	38%	42%	39%	40%	41%	40%
Isolation	22%	24%	23%	24%	22%	24%
High age profile	25%	31%	32%	38%	39%	42%
Hours worked	1,474	1,566	1,508	1,513	1,470	1,496
Total Hours Worked	2,170	2,202	2,202	2,209	2,157	2,162
Agricultural education	36%	33%	38%	41%	40%	42%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions*	128.2	134.0	137.6	144.4	133.6	131.6
of which dairy*	0.0	0.0	0.0	0.0	0.0	0.0
cattle*	124.4	130.2	133.7	140.7	130.1	127.9
sheep*	3.4	3.5	3.1	3.4	3.3	3.5
other*	0.4	0.3	0.8	0.3	0.3	0.2
energy use*	6.7	6.6	6.1	6.1	5.9	5.5
			tonnes CO_2 eqv per ha			
Ag GHG Emissions*	3.7	4.2	4.2	4.3	4.1	4.1
Energy GHG Emissions*	0.22	0.23	0.20	0.20	0.19	0.18
			kg CO2 eqv			
Ag. GHG Emissions per kg live-weight beef*	11.2	10.8	11.0	11.5	11.0	10.5
Ag. GHG Emissions per € output*	4.91	4.78	5.89	5.33	4.92	4.68
Energy Emissions per kg live-weight beef*	0.59	0.54	0.47	0.46	0.43	0.43
			tonnes NH_3 per farm			
Total farm average NH3 emissions*	0.73	0.76	0.82	0.86	0.79	0.74
of which dairy*	0.00	0.00	0.00	0.00	0.00	0.00
cattle*	0.73	0.76	0.82	0.86	0.79	0.73
sheep*	0.01	0.01	0.01	0.01	0.01	0.01
tillage*	0.00	0.00	0.00	0.00	0.00	0.00
			kg NH_3			
NH_3 emissions per hectare*	21.6	24.1	25.8	25.9	24.0	22.8
NH_3 emissions per Euro output*	0.03	0.03	0.03	0.03	0.03	0.03
NH_3 emissions per kg live-weight beef*	0.07	0.06	0.07	0.07	0.07	0.06
			kg per ha			
N Balance per hectare	53.6	63.2	65.2	70.9	65.4	58.4
P Balance per hectare	5.4	5.6	6.2	6.0	6.1	4.9

Indicator	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
			percentage			
N use efficiency	22.6	23.2	24.2	20.8	22.3	23.0
P use efficiency	61.2	69.4	64.0	63.2	73.3	69.3
			Per kg of N Surplus			
kg Live weight beef	10.8	10.1	9.2	8.7	9.7	9.7

*** Methodological update from previous report, with historical numbers revised accordingly.**

Table A 3: Sustainability Indicator results for Sheep Farms 2015-2020

Indicator	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,134	1,291	1,375	1,322	1,246	1,314
Profitability per hectare (gross margin)	417	435	545	400	414	507
Family Farm Income per hectare	332	383	461	277	326	435
Productivity of labour	14,122	14,266	17,043	12,316	14,259	18,568
	percentage					
Market orientation	57%	61%	60%	59%	55%	60%
Viability	24%	24%	27%	20%	23%	26%
Social Sustainability Metrics						
Household vulnerable	45%	42%	41%	44%	41%	42%
Isolation	11%	9%	12%	13%	23%	29%
High age profile	28%	33%	30%	38%	41%	43%
Hours worked on farm	1,700	1,675	1,644	1,581	1,543	1,512
Total hours worked	2,189	2,212	2,132	2,004	2,044	1,941
Agricultural education	36%	39%	42%	50%	52%	54%
Environmental Sustainability Metrics						
	tonnes CO_2 eqv per farm**					
Total farm average Ag. GHG emissions*	121.4	130.8	136.3	133.6	126.4	126.8
of which dairy*	1.1	0.0	1.7	0.0	0.0	0.0
cattle*	63.3	70.3	70.7	70.2	65.5	64.0
sheep*	56.5	60.0	63.3	62.9	60.6	62.3
other*	0.5	0.5	0.6	0.5	0.3	0.5
energy use*	6.8	6.2	6.5	6.2	6.1	5.3
	tonnes CO_2 eqv per ha					
Ag GHG Emissions*	3.0	3.4	3.6	3.5	3.2	3.1
Energy GHG Emissions*	0.19	0.18	0.20	0.18	0.17	0.14
	kg CO_2 eqv					
Ag. GHG Emissions per kg live-weight sheep produced*	9.7	8.9	8.7	9.1	7.8	9.7
Ag. GHG Emissions per € output*	4.3	4.2	4.2	4.2	4.6	3.6
Energy Emissions per kg live-weight sheep produced*	0.71	0.52	0.49	0.49	0.47	0.44
	tonnes NH_3 per farm					
Total farm average NH3 emissions*	0.50	0.55	0.58	0.59	0.55	0.52
of which dairy*	0.01	0.00	0.01	0.00	0.00	0.00
cattle*	0.38	0.42	0.44	0.45	0.42	0.40
sheep*	0.11	0.12	0.13	0.14	0.14	0.12
tillage*	0.00	0.00	0.00	0.00	0.00	0.00
	kg NH_3					
NH_3 emissions per hectare*	11.9	14.5	14.8	15.0	13.9	13.1
NH_3 emissions per Euro output*	0.016	0.018	0.016	0.018	0.019	0.015
NH_3 emissions per kg live-weight sheep*	0.019	0.018	0.017	0.019	0.016	0.020
	kg per ha					
N Balance per hectare	42.4	52.5	53.4	70.2	51.7	47.4
P Balance per hectare	5.9	5.6	6.5	8.0	6.9	5.3

Indicator	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
			percentage			
N use efficiency	32.1	29.3	31.5	24.7	29.4	30.2
P use efficiency	58.6	60.6	63.6	50.9	58.2	60.9
			Per kg of N Surplus			
kg Live weight sheep	10.9	9.5	9.6	7.7	8.8	12.5

*** Methodological update from previous report, with historical numbers revised accordingly.**

Table A 4: Sustainability Indicator results for Tillage Farms 2015-2020

Indicator	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,784	1,671	1,734	1,852	2,038	1,696
Profitability per hectare (gross margin)	757	671	817	904	921	756
Family farm income per hectare	559	502	616	658	627	558
Productivity of labour	38,978	36,355	44,330	43,620	36,410	38,225
			percentage			
Market orientation	77%	73%	76%	78%	75%	73%
Viability	62%	60%	74%	62%	59%	65%
Social Sustainability Metrics						
Household vulnerable	20%	23%	11%	18%	18%	16%
Isolation	21%	21%	19%	16%	18%	17%
High age profile	15%	28%	27%	34%	31%	38%
Hours worked on farm	1,540	1,525	1,462	1,504	1,542	1,421
Total hours worked	2,115	1,988	1,933	2,064	2,225	2,081
Agricultural education	62%	62%	61%	62%	62%	56%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions*	155.3	149.0	144.1	148.2	138.9	139.1
of which dairy*	0.0	0.1	0.0	0.0	0.0	0.0
cattle*	100.9	89.1	88.8	99.1	90.8	94.6
sheep*	8.8	7.3	6.8	7.6	9.5	11.0
other*	45.7	52.5	48.5	41.4	38.4	33.6
energy use*	15.6	16.7	13.5	14.1	13.6	12.4
			tonnes CO_2 eqv per ha			
Ag GHG Emissions*	2.4	2.2	2.3	2.4	2.2	2.2
Energy GHG Emissions*	0.23	0.28	0.23	0.22	0.24	0.18
			kg CO_2 eqv			
Ag. GHG Emissions per € output*	1.82	1.78	1.76	1.70	1.70	1.77
			tonnes NH_3 per farm			
Total farm average NH3 emissions*	0.63	0.60	0.57	0.69	0.62	0.60
of which dairy*	0.00	0.00	0.00	0.00	0.00	0.00
cattle*	0.55	0.50	0.51	0.55	0.50	0.50
sheep*	0.01	0.01	0.01	0.01	0.02	0.03
tillage*	0.07	0.08	0.05	0.12	0.11	0.07
			kg NH_3			
NH_3 emissions per hectare*	9.7	9.0	8.8	10.1	9.3	9.2
NH_3 emissions per Euro output*	0.007	0.007	0.007	0.007	0.007	0.007
			kg per ha			
N Balance per hectare	44.7	46.3	43.0	62.0	49.9	43.9
P Balance per hectare	4.4	5.0	4.7	9.6	7.2	7.2
			percentage			
N use efficiency	68.1	67.9	69.8	57.1	67.8	62.6
P use efficiency	92.7	90.5	90.6	73.3	81.6	72.6

Table A 5: Sustainability Indicator results for All Farms 2015-2020

Indicator	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,605	1,638	1,793	1,766	1,758	1,771
Profitability per hectare (gross margin)	703	676	835	722	745	775
Family Farm income per hectare	505	490	622	468	481	527
Productivity of labour	22,958	21,024	28,164	21,529	21,976	23,737
			percentage			
Market orientation	68%	68%	69%	68%	65%	67%
Viability	36%	34%	40%	31%	32%	33%
Social Sustainability Metrics						
Household vulnerable	33%	36%	32%	34%	34%	33%
Isolation	18%	19%	18%	19%	19%	21%
High age profile	21%	27%	28%	33%	34%	37%
Hours worked on farm	1,670	1,724	1,674	1,681	1,645	1,650
Total hours worked	2,218	2,244	2,221	2,285	2,211	2,194
Agricultural education	44%	43%	47%	49%	51%	52%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions*	189.1	196.2	201.8	208.3	198.7	198.4
energy use*	9.3	9.3	8.8	8.8	8.6	8.0
			tonnes CO_2 eqv			
Ag GHG Emissions per hectare*	4.3	4.7	4.8	4.9	4.6	4.6
Ag GHG Emissions per Euro output*	4.2	4.2	4.7	4.4	4.2	3.9
Energy GHG Emissions per hectare*	0.24	0.24	0.23	0.22	0.22	0.20
			tonnes NH_3 per farm			
Total farm average NH3 emissions*	1.00	1.06	1.11	1.18	1.11	1.07
			kg NH_3			
NH_3 emissions per hectare*	23.2	25.4	26.8	27.4	25.8	24.7
NH_3 emissions per Euro output*	0.023	0.023	0.023	0.025	0.024	0.021
			kg per ha			
N Balance per hectare	70.9	79.3	81.7	93.6	83.7	74.8
P Balance per hectare	6.1	6.2	7.1	8.3	7.6	6.4
			percentage			
N use efficiency	27.7	27.2	28.1	24.1	26.6	27.2
P use efficiency	63.5	68.2	64.5	59.3	67.7	65.6