Teagasc National Farm Survey Sustainability Report 2023

OCTOBER 29TH 2024

Photo: Mary Bettini Blank

AGRICULTURAL ECONOMICS AND FARM SURVEY DEPARTMENT TEAGASC

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Agriculture and Food Development Authority

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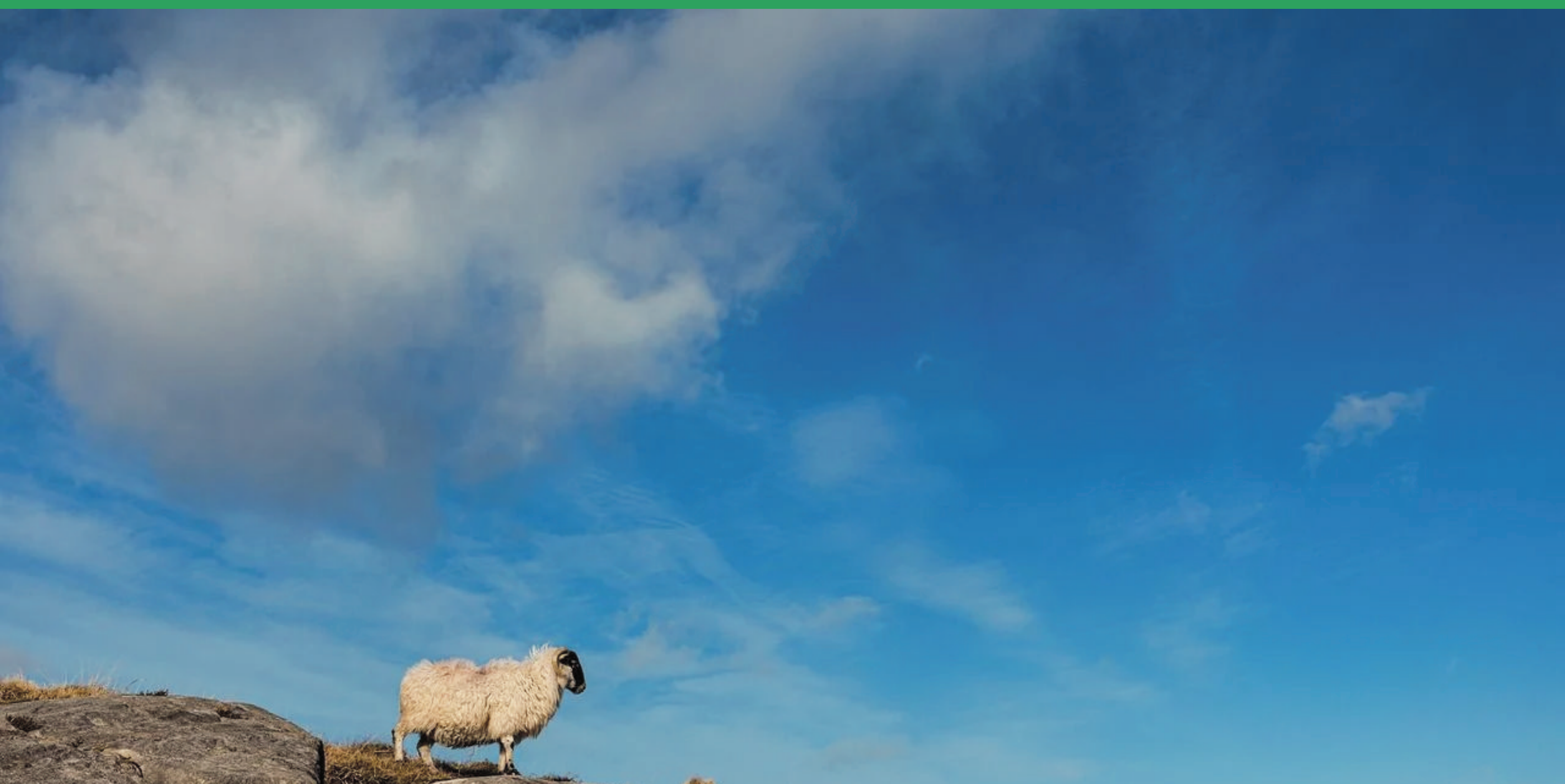

Acknowledgements

The authors wish to thank all who contributed to the Teagasc National Farm Survey 2023 - the farmers who participate voluntarily, the Central Statistics Office who select the sample and provide the population weights. Our appreciation is extended to the Teagasc research staff involved in the collection and validation of the farm data: John Brennan, Liam Deane, Tommy Doyle, Pat Harnett, Padraig Joyner, Grainne Kenny, John McConnon, Kevin McNamara, Cian Murphy, Meadhbh Murphy, Stephen Murray, Martin Nicholson, Niamh Noone, Jim Robinson, David Schilder, Niall Stringer and John Teehan, as well as Muriel Clarke for the administration of the survey.

Monetary Amounts in Nominal Terms

Monetary figures in this report are presented in nominal terms. This is relevant when considering incomes over time, as inflation, even at a low rate, accumulates over several years and erodes the purchasing power of money. For much of the last decade inflation has been very low in Ireland. However, in 2021 and in 2023, the inflation rate has increased sharply. This is important when considering the change in nominal amounts over recent years.

Interpreting the Box Plots

Some of the data contained in this report are presented in a series of boxplots. These help provide a more in-depth description of the data. In each boxplot, the green shaded boxes are representative of the farms that lie between the 25th and 75th percentile of the NFS farm population. The line within the box represents the median (middle) data point, i.e. half of all farms lie either above or below this point. The tails at either end correspond to the minimum and maximum data points with extreme outliers removed.

Abbreviations

CH_4	Methane
CO_2	Carbon dioxide
CO_2e	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

CO2 equivalent: For reporting purposes all non-carbon dioxide (CO_2) emissions of GHG are converted to CO_2 equivalents using appropriate global warming potentials (GWP100) for CH_4 and N_2O which are respectively 28 and 265 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) per farm: The average amount of territorial greenhouse gas emissions (CO_2, N_2O, CH_4) produced in a particular farm type. The approach follows the recognised IPCC methodology used in the calculation on the National GHG inventory

Greenhouse Gases (GHG) per hectare: The average amount of territorial greenhouse gas emissions (CO_2, N_2O, CH_4) produced in a particular farm system expressed on a per hectare basis. The approach follows the recognised IPCC methodology used in the calculation on the National GHG inventory

Greenhouse Gases (GHG) per unit of output: The average amount of territorial greenhouse gas emissions (CO_2, N_2O, CH_4) associated with the production of a specific type of agricultural product, expressed as kg CO_2 equivalent per kg of produce (e.g. per kg beef, milk). The approach follows the recognised IPCC methodology used in the calculation on the National GHG inventory

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.

Glossary of Terms

Global Warming Potential: When counting the emissions of various greenhouse gases they are brought to a common base, or CO2 equivalent. This common base is arrived at by applying a global warming potential (GWP) to each gas (e.g. N2O, CH4). The GWP for CH4 and N2O used in this report are those published by the IPCC AR5 report.

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 an indicator 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.

What's in the Report?

Farm Sustainability Performance

1. Dairy Farm 2023
2. Cattle Farm 2023
3. Sheep Farms 2023
4. Tillage Farms 2023
5. Time series 2018-2023

Farm Categorisation

- Farms typically produce more than one type of agricultural output. In the National Farm Survey farms are categorised into farm types according to their principal output.

- In this Report for 2023, the survey sample is representative of a population of 83,771 farms in Ireland.

Key Performance Indicators

- A broad range of economic, environmental and social indicators is provided, including farm income, labour input, GHG emissions, ammonia emissions, N & P use efficiency, household characteristics and technology adoption.

Farm Classification

Teagasc collects farm data through the National Farm Survey, principally in fulfilment of Ireland's obligation as a member of the European Union. However, the National Farm Survey has evolved over the years to produces a comprehensive list of measures relating to farm sustainability, covering economic, social and environmental performance metrics.

This report focusses mainly on the economic sustainability of Irish agriculture. A dedicated Sustainability Report covering the wider suite of sustainability metrics will be produced later in the year.

The results of the Teagasc National Farm Survey (NFS) can be decomposed in various ways. One of the most common ways in which the results are presented is on a system basis. By system, the NFS farms are categorised into one of six farm types: Dairy, Cattle Rearing, Cattle Other, Sheep, Tillage and Mixed Livestock. Given that individual farms typically have more than one farm enterprise, a rigorous basis for categorising farms into each system is required.

The method of classifying farms into farming systems, is based on the EU farm typology, as set out in Commission Decision 78/463 and its subsequent amendments. The approach is utilised by all members of the EU Farm Accountancy Data Network (FADN).

The methodology assigns a standard output (SO) to each type of animal and each hectare of crop on the farm. Farms are then classified into groups, according to the proportion of total SO which comes from each enterprise. It is important to appreciate that system titles refer to the **dominant** enterprise in each group. For example, the cattle rearing system refers to those farms where the greater proportion of the farm's activity relates to suckler beef production. There are many other farms (including those in the dairy, sheep and tillage systems) that have a cattle enterprise, but where the main enterprise of the farm is not cattle production. Similarly, there will be farms that have sheep, but where cattle is the main enterprise. Tillage farms will sometime also have a secondary enterprise, most often a cattle production system. The mixed nature of many Irish farms is reflected in the individual contribution of livestock and crop categories to farm gross output.

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Executive Summary

This report provides the latest available information on the sustainability performance of farms in Ireland, based on detailed analysis of data collected through the Teagasc National Farm Survey. Economic, Social, Environmental and Innovation sustainability metrics are produced for Dairy, Cattle, Sheep and Tillage farms in 2023. The report also includes time series results over several years, which allows an assessment of how farm sustainability has changed temporally.

Economic sustainability

- All farm systems recorded their lowest average incomes in several years in 2023. The year 2023 was characterised by a sharp decline in milk and cereal prices, lower production volumes and high input prices, exasperated by the bad weather.
- The decline in Dairy and Tillage farm incomes in 2023 follows on from a year of record incomes in 2022.
- Livestock farms also saw a decline in income on in 2023 on the back of high input prices and decreased output.
- Economic viability (family labour is remunerated at greater than or equal to the minimum wage and there is also sufficient income generated by the farm to provide an additional five per cent return on non-land based assets) was significantly challenged across all farm system in 2023 with record lows recorded across dairy, sheep and tillage farms.

Social sustainability

- On the back of economic viability results levels of household vulnerability (non-viable and no off-farm employment) notably increased across dairy, sheep and tillage farms.
- In line with long-term established trends, dairy farms tends to be associated with a lower isolation risk (living alone). Fewer dairy farm households have a high age profile in comparison with other farm systems. Tillage farms also tend to generally outperform livestock farms on these social sustainability metrics.
- Conversely, dairying is typically very labour intensive. Results again indicate that dairy farm operators works significantly more hours per year on farm than the average farm operator in the other farm systems. Given the hours required on farm, relatively few dairy farmers work off farm but even when accounting for time spent working off farm (which can be significant for drystock systems) the labour input of dairy farm operators tends to exceed that of farm operators of all other farm systems.

Environmental sustainability

- Due to intensity of production absolute gaseous emissions (GHG and NH_3) on dairy farms remain significantly higher than on livestock and arable based farm systems. However, on fott of lowr animal numbers and fertiliser applications absolute GHG emissions (per farm & hectares) on Dairy farms was lower in 2023 compared to the previous 2 years. However, due to reduce milk output on the back of challenging market conditions the GHG and NH_3 emissions per kg of milk increased in 2023. N and P balances per hectare also declined in 2023 compared to the previous years.

- Non-Dairy Systems: Farm level and per hectare level GHG & NH_3 emissions on cattle, sheep and tillage farms were slightly up in 2023 versus the year before on foot of slightly increase animal inventories and fertiliser applications (Sheep & Tillage). N balances on cattle and tillage farms remained relatively stable in 2023 with sheep farms showing slight increases.

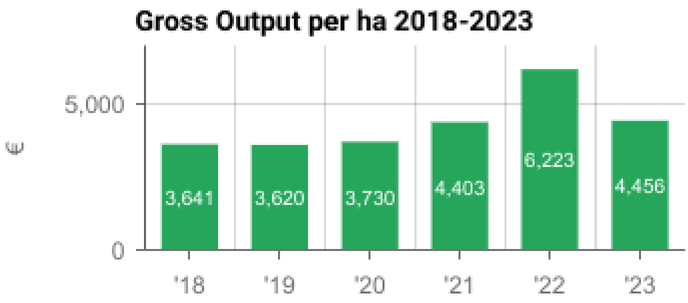
Innovation

- The transition towards the use of LESS equipment for slurry application continued in 2023. In total, 81% of slurry on the average dairy farm and 38% on the slurry on the average cattle farm was applied via LESS. Greater quantities are also being spread in the early season.
- The percentage of chemical N applied in the form of protected urea is growing on dairy farms (27%). This trend is also evident on cattle farms but remains at a relatively low level in absolute terms (6%).

Dairy: Economic Sustainability

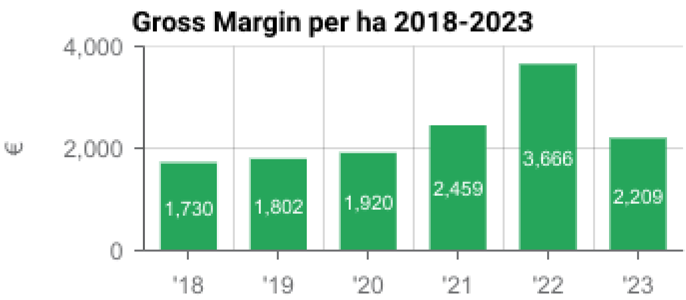
Gross Output per ha 2023

€4,456



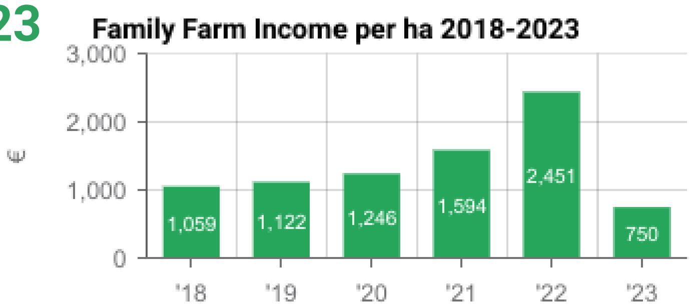
Gross Margin per ha 2023

€2,209



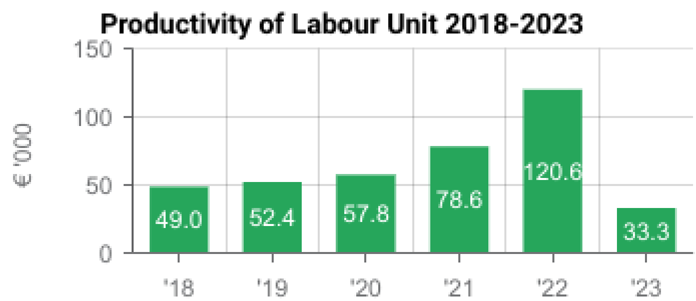
Family Farm Income per ha 2023

€750



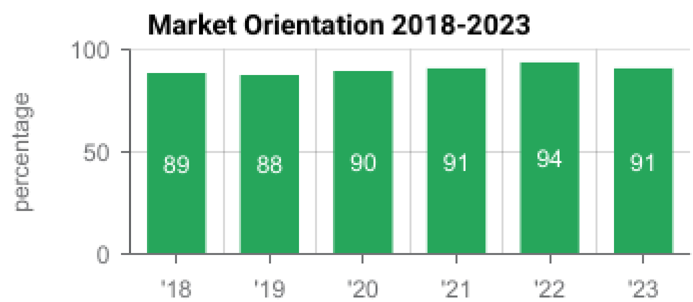
Productivity of Labour 2023

€33,329



Market Orientation 2023

91%



Viability 2023

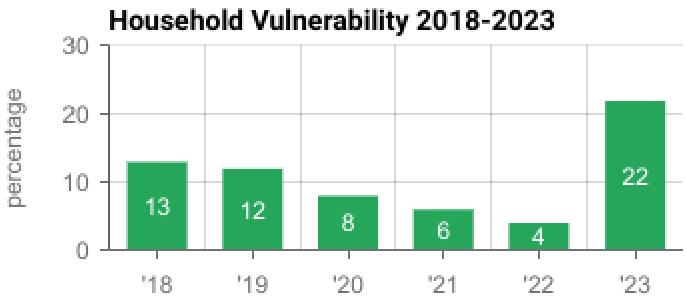
52%

Source: Teagasc National Farm Survey

Dairy: Social Sustainability

Household Vulnerability 2023

22%

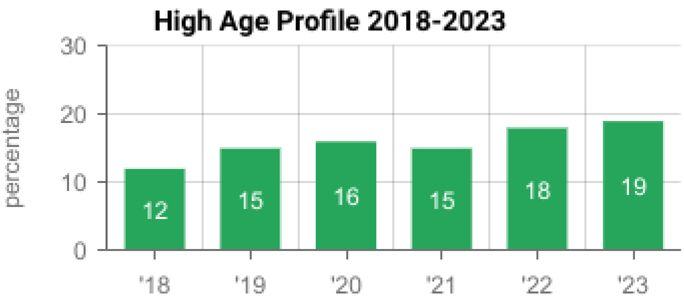


Isolation 2023

7%

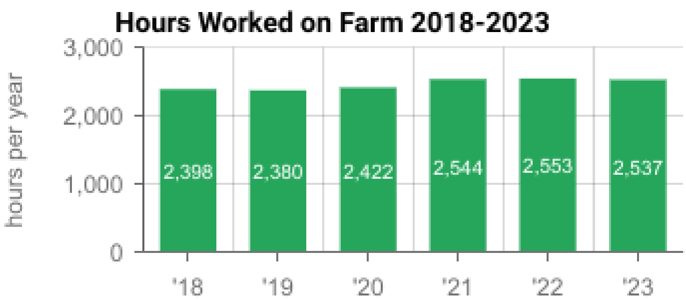
High Age Profile 2023

19%



Hours Worked on Farm 2023

2,537

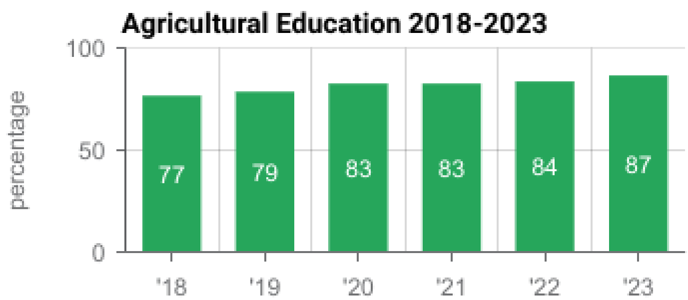


Total Hours Worked 2023

2,707

Agricultural Education 2022

87%



Source: Teagasc National Farm Survey

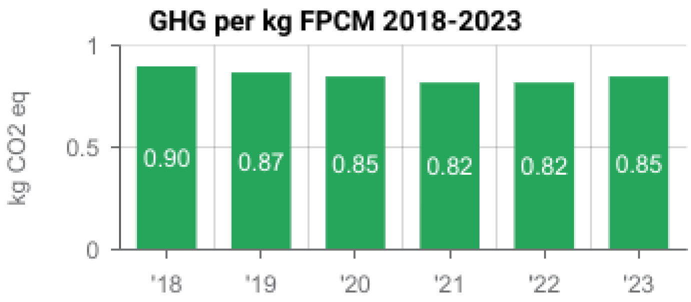
Dairy: Environmental Sustainability

CO2 eq per ha 2023

9.5

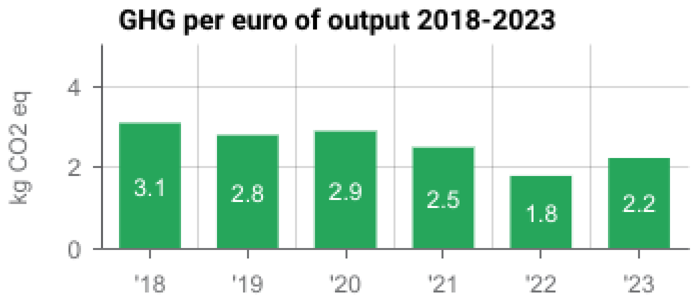
CO2 Eq per kg FPCM 2023

0.85



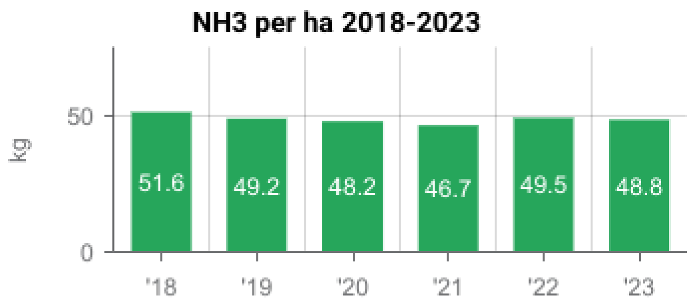
CO2 Eq per euro of output 2023

2.2



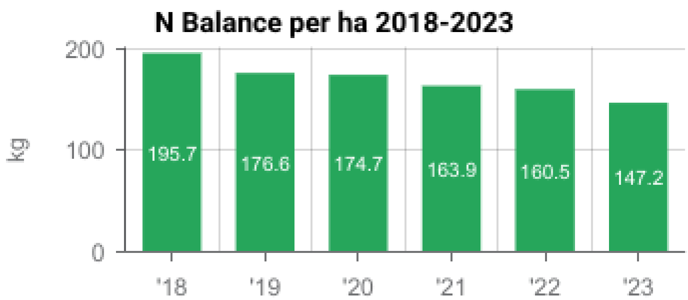
NH3 kg per ha 2023

48.8



N Balance kg per ha 2023

147.2

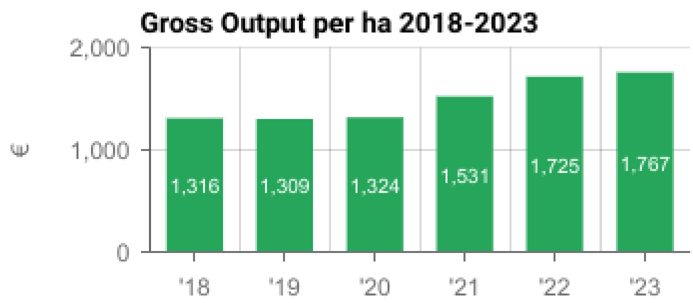


Source: Teagasc National Farm Survey

Cattle: Economic Sustainability

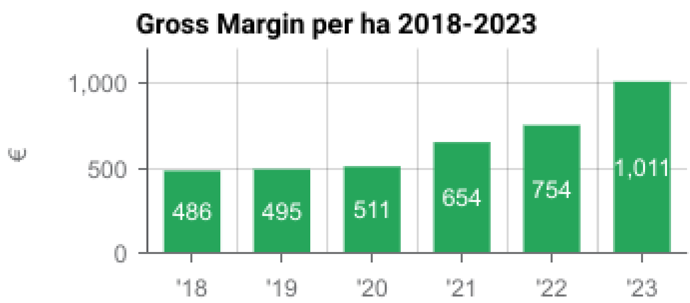
Gross Output per ha 2023

€1,767



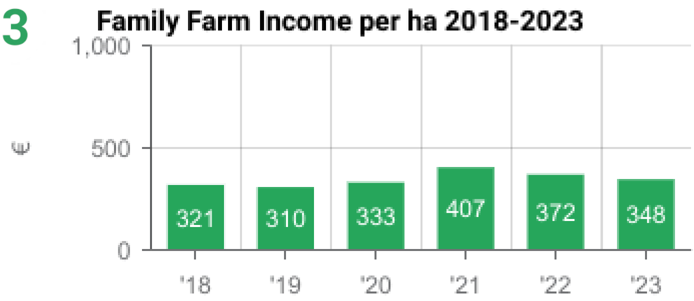
Gross Margin per ha 2023

€1,011



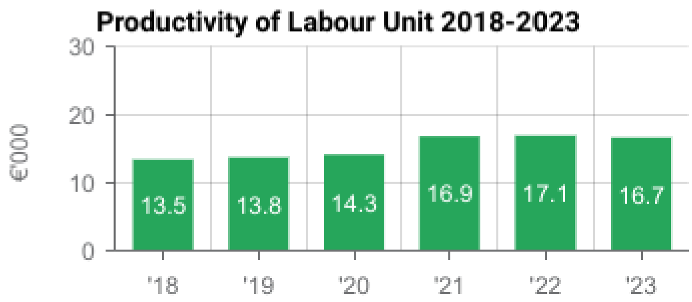
Family Farm Income per ha 2023

€348



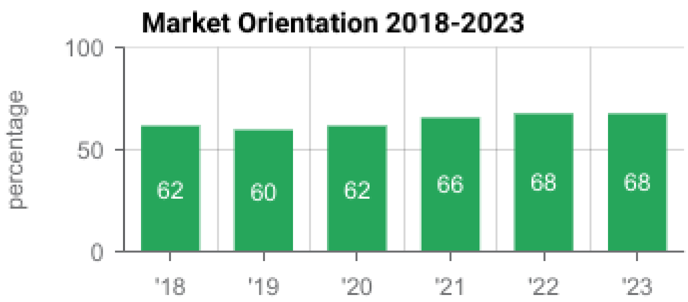
Productivity of Labour 2023

€16,747



Market Orientation 2023

68%



Viability 2023

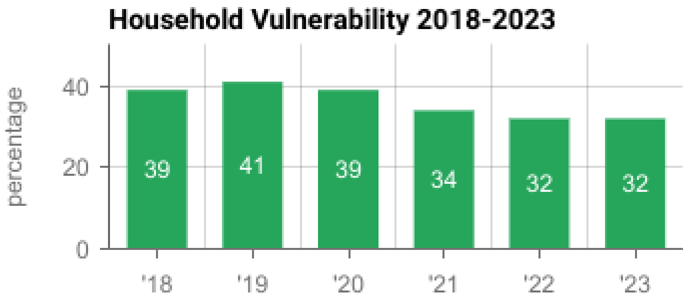
23%

Source: Teagasc National Farm Survey

Cattle: Social Sustainability

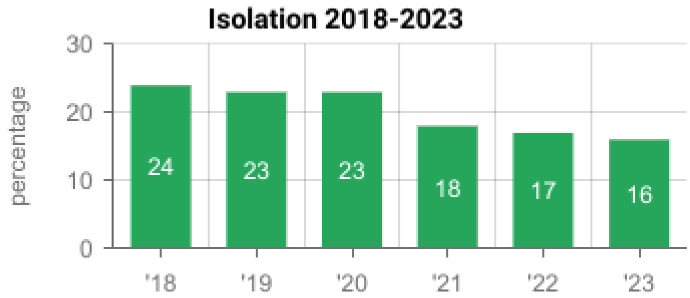
Household Vulnerability 2023

32%



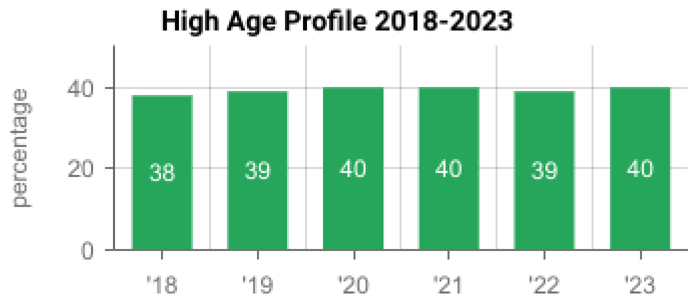
Isolation 2023

16%



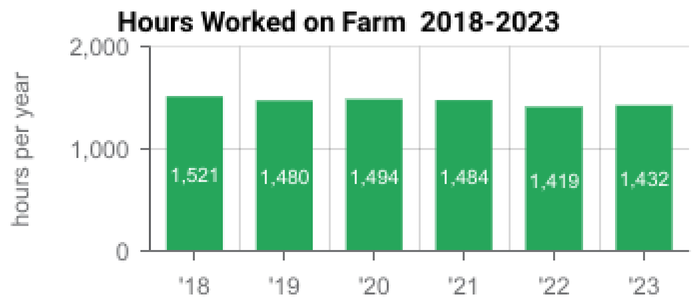
High Age Profile 2023

40%



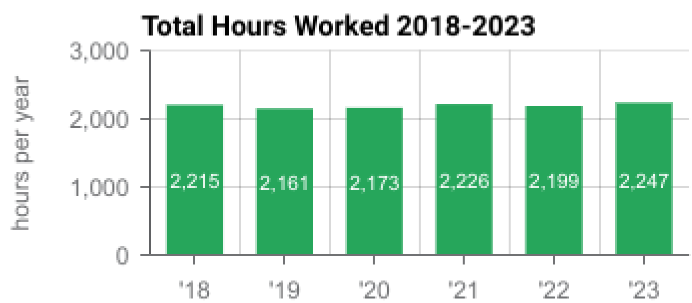
Hours Worked on Farm 2023

1,432



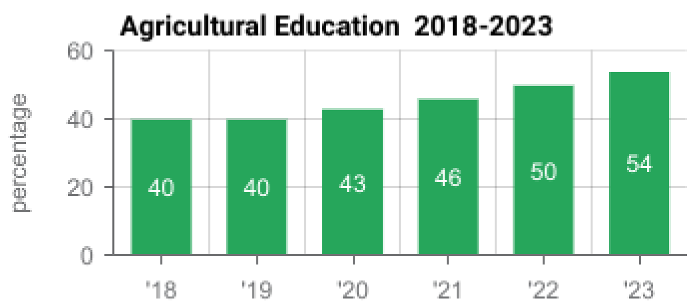
Total Hours Worked 2023

2,247



Agricultural Education 2023

54%

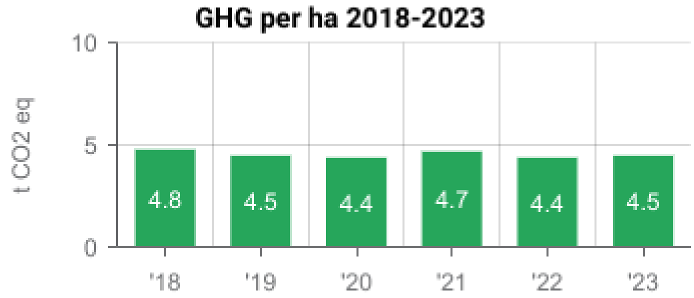


Source: Teagasc National Farm Survey

Cattle: Environmental Sustainability

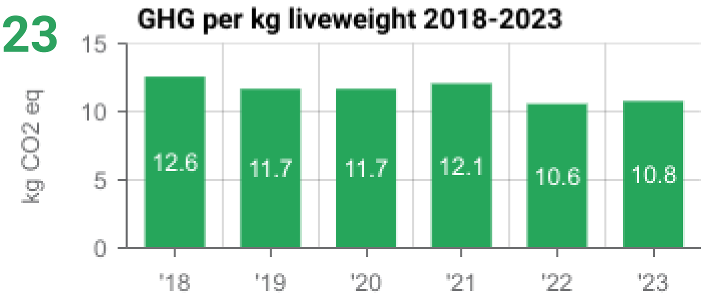
CO2 eq per ha 2023

4.5



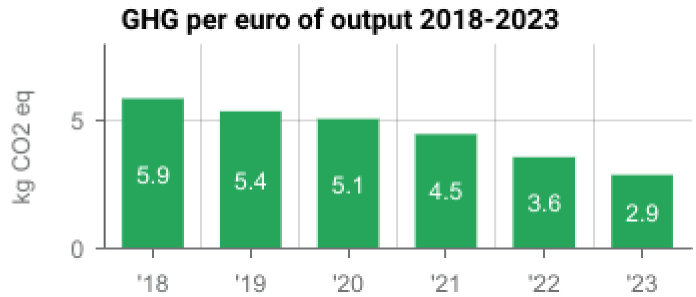
CO2 eq per kg of liveweight 2023

10.8



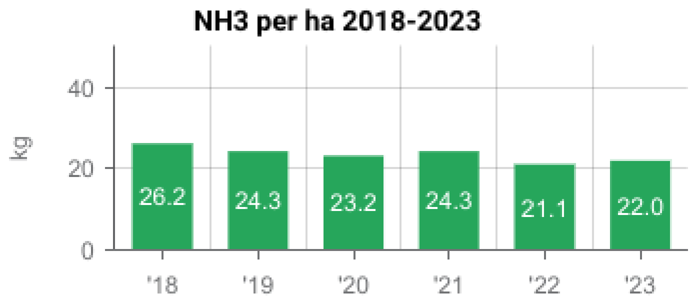
CO2 per euro of output 2023

2.9



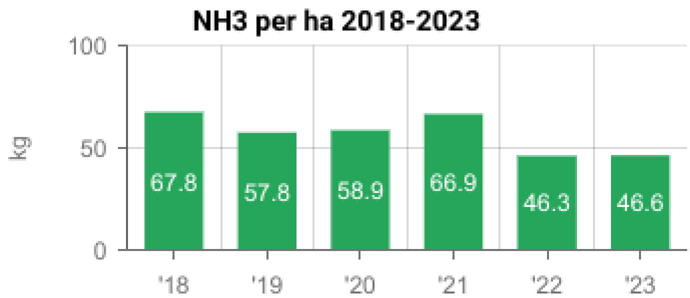
NH3 kg per ha 2023

22.0



N Balance kg per ha 2023

46.6

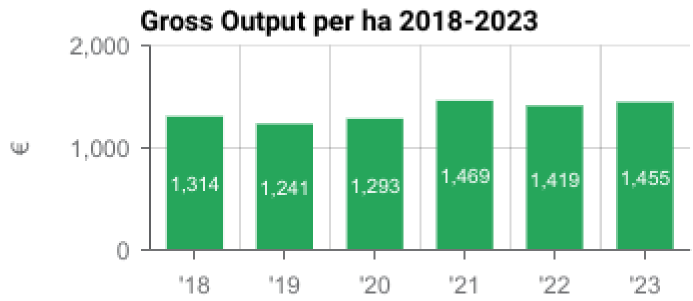


Source: Teagasc National Farm Survey

Sheep: Economic Sustainability

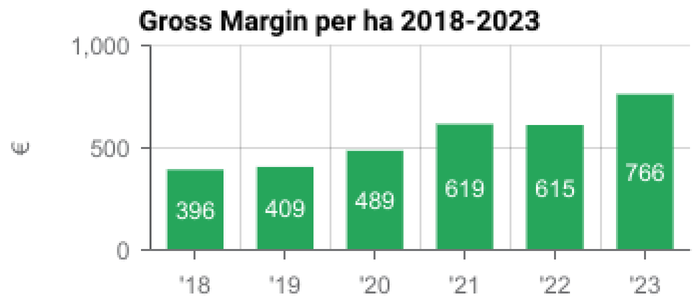
Gross Output per ha 2023

€1,455



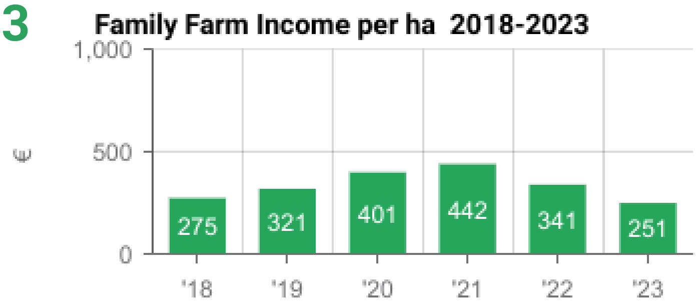
Gross Margin per ha 2023

€766



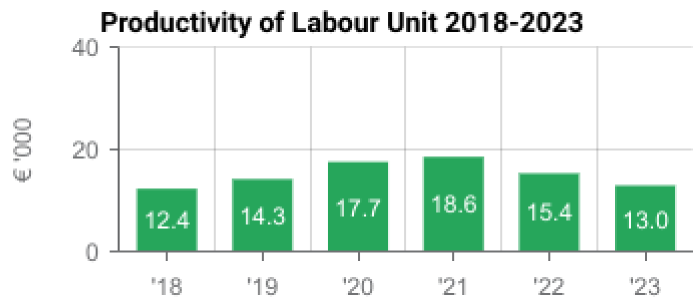
Family Farm Income per ha 2023

€251



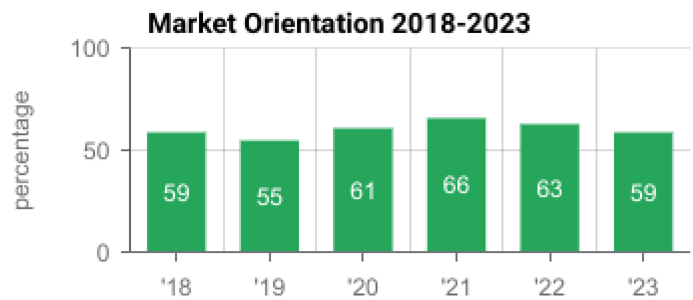
Productivity of Labour 2023

€13,011



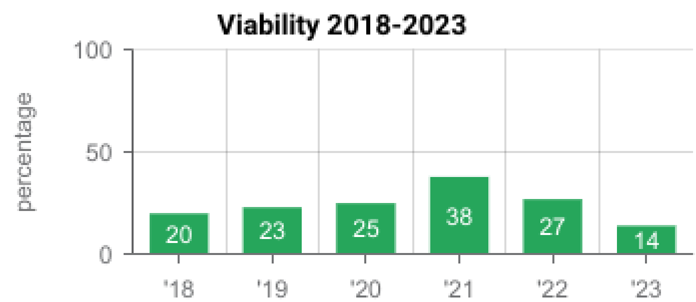
Market Orientation 2023

59%



Viability 2023

14%

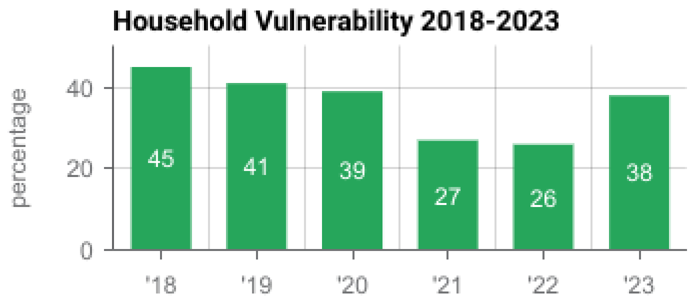


Source: Teagasc National Farm Survey

Sheep: Social Sustainability

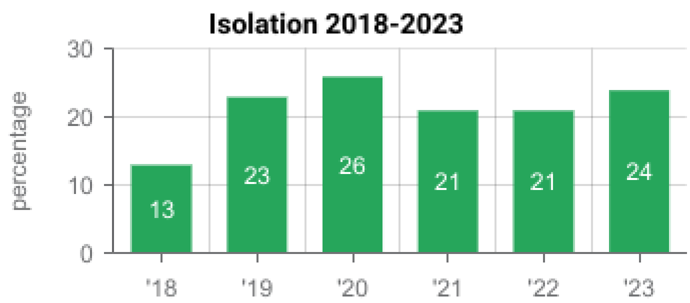
Household Vulnerability 2023

38%



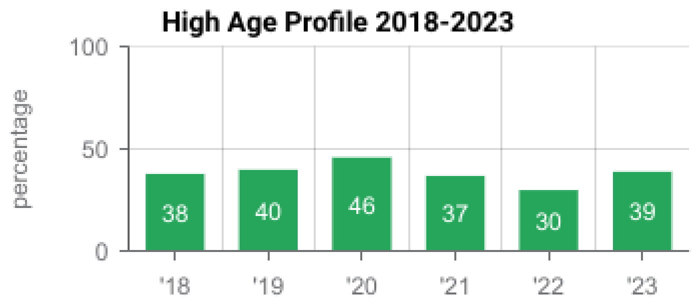
Isolation 2023

24%



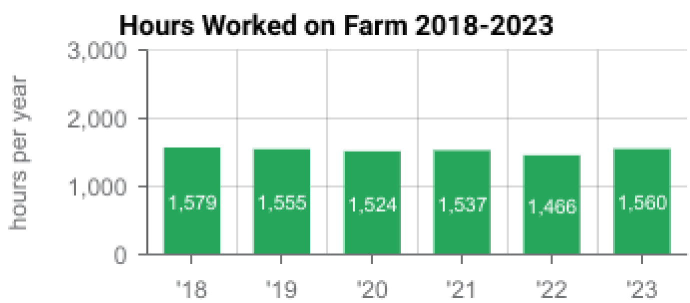
High Age Profile 2023

39%



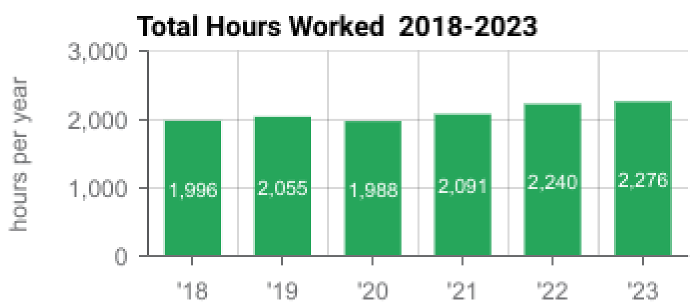
Hours Worked on Farm 2023

1,560



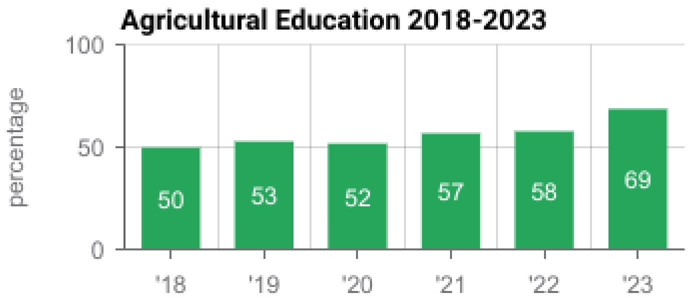
Total Hours Worked 2023

2,276



Agricultural Education 2023

69%

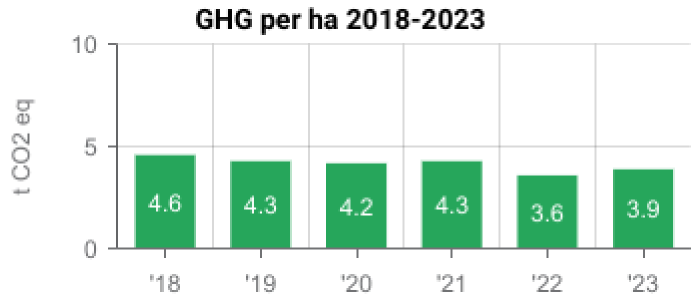


Source: Teagasc National Farm Survey

Sheep: Environmental Sustainability

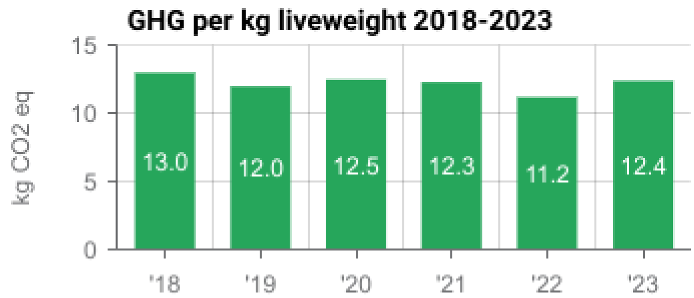
CO2 eq per ha 2023

3.9



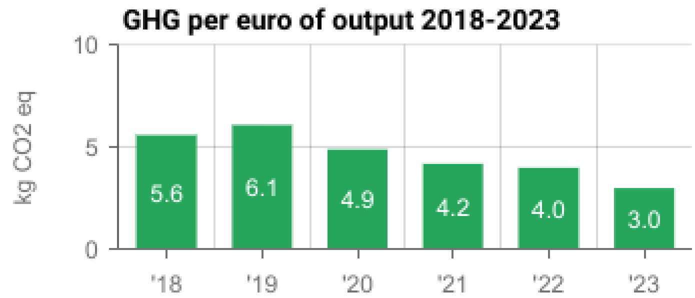
CO2 per kg liveweight 2023

12.4



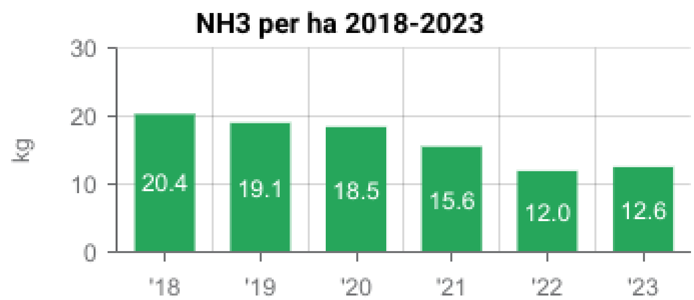
CO2 per euro of output 2023

3.0



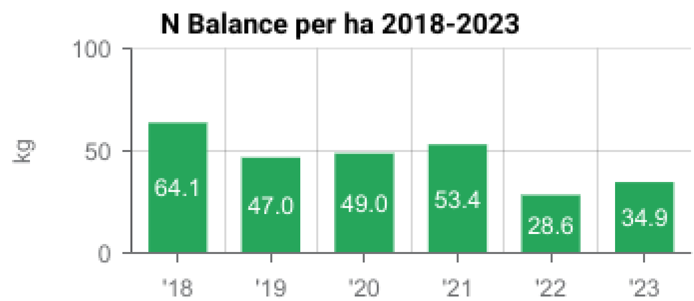
NH3 kg per ha 2023

12.6



N Balance kg per ha 2023

34.9

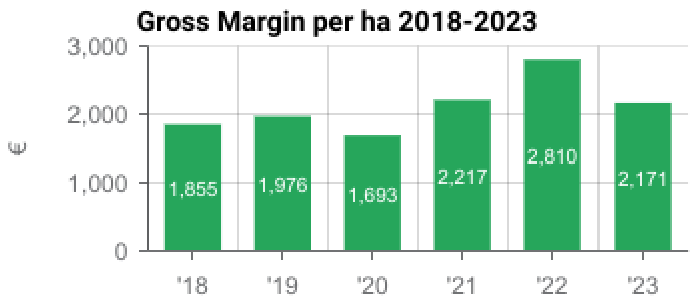


Source: Teagasc National Farm Survey

Tillage: Economic Sustainability

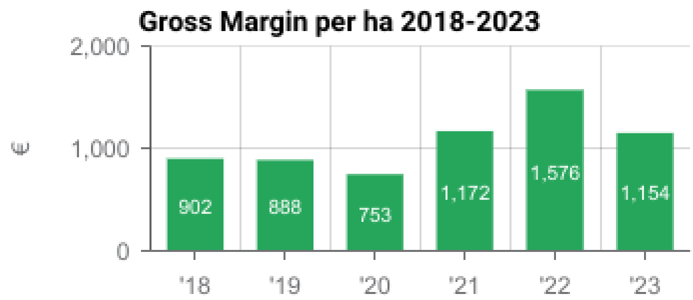
Gross Output per ha 2023

€2,171



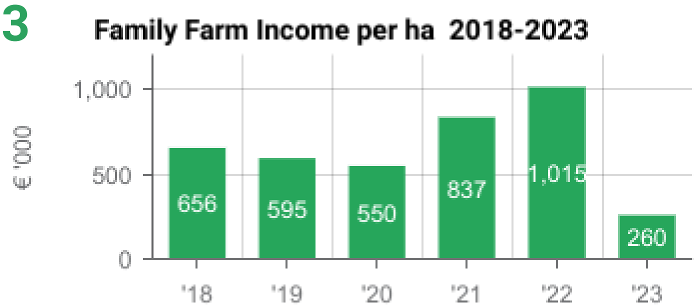
Gross Margin per ha 2023

€1,154



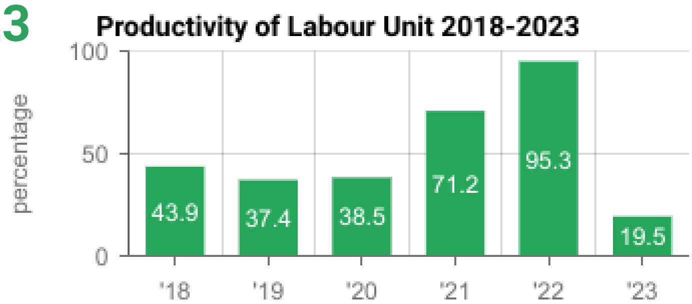
Family Farm Income per ha 2023

€260



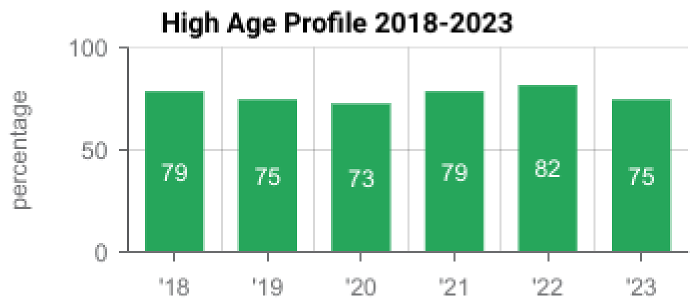
Productivity of Labour Unit 2023

€19,506



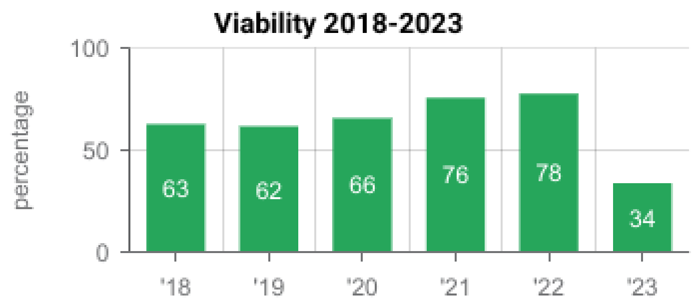
Market Orientation 2023

75%



Viability 2022

34%

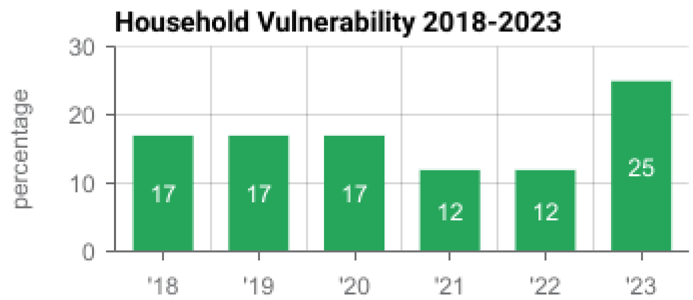


Source: Teagasc National Farm Survey

Tillage: Social Sustainability

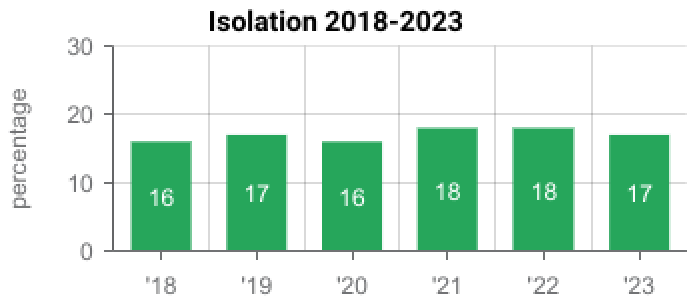
Household Vulnerability 2023

25%



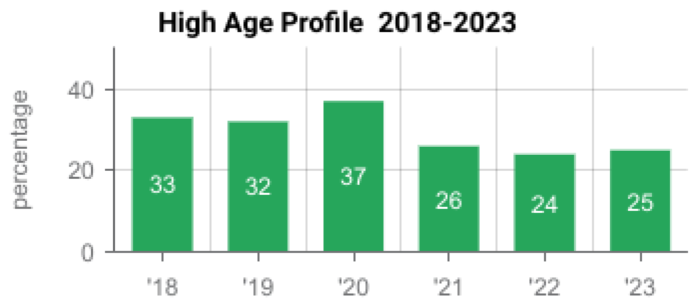
Isolation 2023

17%



High Age Profile 2023

25%

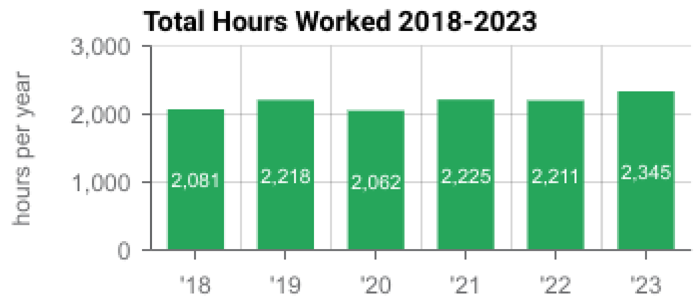


Hours Worked on Farm 2023

1,416

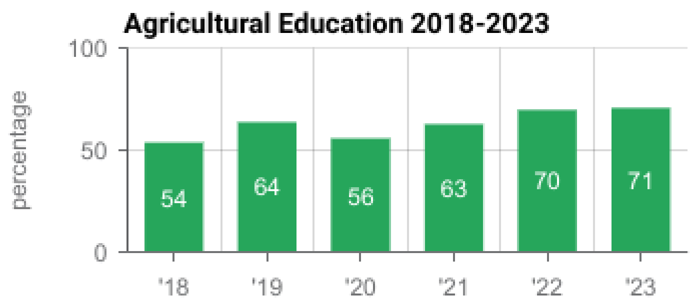
Total Hours Worked 2023

2,133



Agricultural Education 2022

71%



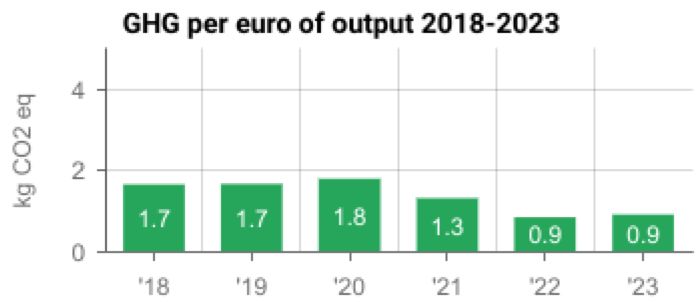
Source: Teagasc National Farm Survey

CO2 eq per ha 2023

1.9

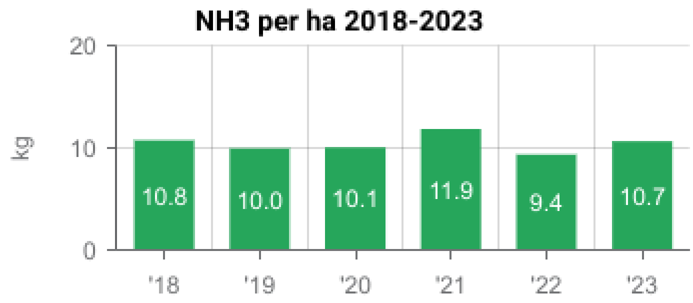
CO2 eq per euro of output 2023

0.9



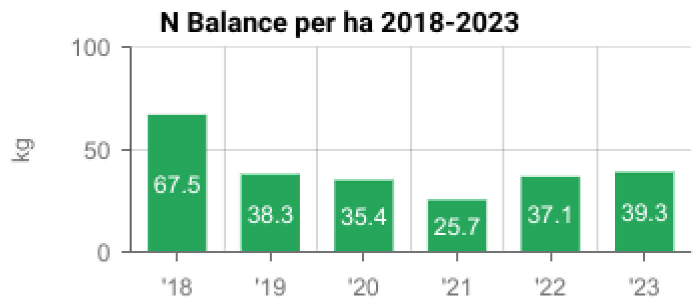
NH3 kg per ha 2023

10.7



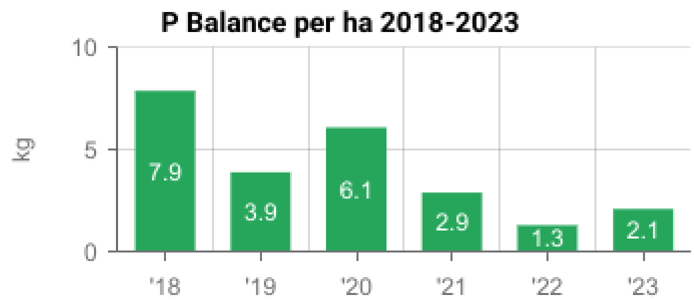
N Balance kg per ha 2023

39.3



P Balance kg per ha 2023

2.1



Source: Teagasc National Farm Survey

Farm Sustainability 2023
Detailed Results

1 Introduction - Agricultural Sustainability

Civilization 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 feed a growing global population in a sustainable way, agricultural output must increase without reducing 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). Separetely, Ireland has passed legislation (Climate Action and Low Carbon Development Act, 2021) which sets down a target of a 51% reduction in national greenhouse gas emissions by 2030, with sectoral ceiling allocated by Government (Government of Ireland, 2023) for the Agricultural sector that are equivalent to a target of a 25% GHG emissions reduction from the sector by 2030. Looking further ahead, proposals for carbon budgets beyond 2030 are already being considered by the Climate Change advisory Council.

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 sustainability** (and its component farm systems) in terms of its **economic, environmental, social** and **innovation** dimensions. The report recognises that the multi-dimensional nature of sustainability means that the exclusive pursuit of improvements in any one of these dimensions alone, is unlikely to deliver a sustainable outcome.

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. In geographic terms, Ireland is small. However, its low human population density and temperate maritime climate means that it has a comparatively large agricultural sector which, given the climate, is focused on grassland agriculture, supporting dairy, cattle and sheep production in particular. Due to climate and topography, Ireland's arable sector is small by comparison with that found in other EU member states.

However, Ireland's grassland systems, are heterogeneous, with substantial variations between the typical farms in each farm system in terms of farm size, stocking rates, input usage, profitability, hours worked on the farms and incidence of off-farm employment. Relevant indicators capturing this diversity, along with other farm (and farmer) characteristics are required to assess the sustainability status of Irish farms through time. Such metrics can highlight trends through time, revealing particular areas of achievement or increasing concern. In particular these metrics can indicate areas where success has been achieved or where improvement may be needed which can then be used by stakeholders as a basis for further action to achieve better outcomes. The need to ensure that robust, comprehensive multi-dimensional sustainability data are available for Irish agriculture was recognised by Teagasc over a decade ago. Ireland is fortunate to be at the forefront in Europe in the development and use of wide ranging sustainability metrics for agriculture. Many EU Member States, including some of those with the largest agricultural sectors, have yet to make significant progress in sustainability data provision. The challenge these Member States face is that the resource requirements involved in sustainability data collection, the creation of associated metrics and their reporting, are considerable. The time scale involved in the development of such metrics can span several years, yet the requirement for progress in this regard at the wider EU level is urgent.

Deriving and maintaining 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 close to 900 farms from 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 (which largely focuses on economic performance), giving the Teagasc NFS dataset much more capacity to measure and track developments in agricultural sustainability in the wider environmental and social sense.

The Teagasc NFS collects data on an ongoing basis, with the results published annually. An important feature to ensure representivity is the farm weighting system, based on data published by the Central Statistics Office (CSO). This weighting system is reflective of the national farm population and 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 population weighting is important to ensure that meaningful and accurate aggregations of farm types are 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.

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 land based farm systems in Ireland, namely, dairy, cattle, sheep and tillage.

It is possible to make cross sectional comparisons of farm performance between farm systems in a given year. However, as the required data are produced on an annual basis, it is possible to generate and compare indicators for individual systems over time, which is of greater relevance. As methodologies used in the derivation of metrics are updated to reflect scientific developments and as data requirements evolve to deliver a wider range of measures, the sustainability metrics and their entire historical time series are revised. The goal in this updating process is to reflect current scientific knowledge, particularly for environmental variables where many gaps in scientific understanding still remain. These revisions are evident in the time-series analysis for key indicators presented in the report, which are updated to reflect recognised developments in the measurement of sustainability. It is expected that, based on scientific advances and emerging areas of interest (e.g. in both a scientific and policy

[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 circa 85,000 farms are represented in this study for 2021.

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.

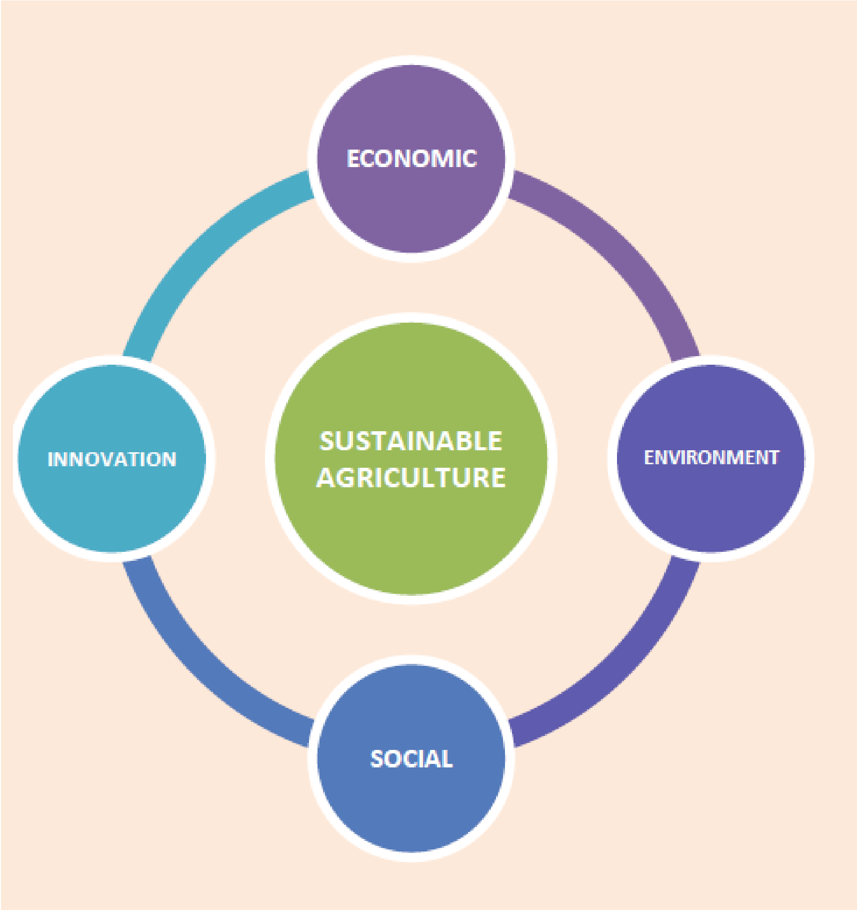
Furthermore, as the NFS is part of the EU FADN, there is scope for comparative analysis with the sustainability performance of farms in other EU Member States as the network transitions to the EU Farm Sustainability Data Network (FSDN) in the coming years. In September 2024, as part of the FSDN transition, EU Member States voted to proceed with an expansion in the range of farm data reported to the European Commission, to better reflect a wider suite of sustainability metrics, particularly with respect to environmental and social aspects. The recently published Strategic Dialogue on the future of the EU Agriculture (European Commission, 2024), contains a broad range of recommendations, including the need to benchmark the economic, environmental and social sustainability performance of EU agriculture.

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; 2020b; 2021, 2022, 2023). Updates presented here reflect methodological refinements, as well as additional data on agricultural activities on Irish farms collected and published by the Teagasc NFS. For instance, some GHG and NH_3 emission factors have been updated in the preparation of this report, leading to an adjustment to GHG results across farm systems relative to previously published values for past years. Hence, the historical time series for some of the sustainability indicators presented in the current report differ and supersede those presented in earlier Teagasc Sustainability reports (Buckley et al., 2019; Buckley & Donnellan, 2020a; 2020b, 2021, 2022, 2023). This approach to revising historic sustainability indicators is to ensure they fully reflect our current scientific knowledge. It mirrors the approach used by Ireland's Environmental Protection Agency (EPA) in their national inventory reporting for Ireland and is hence consistent with international best practice.

As depicted in Figure 3-1 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 in agriculture. At a national level, agriculture is an important component of the Irish economy, particularly in more rural areas. The Teagasc 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 (CAP). The economic sustainability indicator set is, therefore, relatively comprehensive and (largely unconstrained by issues relating to data availability) designed to cover a range of important economic measures. Table 3.1 details the economic indicators presented in the report:

Table 3.1: Overview of Economic Indicators

Indicator	*Measure*	*Unit*
Market based gross output	Gross output per hectare	€ / hectare
Market based gross margin	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) Market based gross output

This 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. A limitation of this measure is that by definition it can change due to output price inflation. It measures change which is due commodity price volatility, in addition to increased physical output. Therefore care is required in interpreting inter annual changes in this metric.

b) Profitability of Agricultural Land Use

The **market based gross margin** (gross margin excluding grants and subsidies), is where gross margin is defined as gross output less direct costs per hectare. Given that it is profit based, this measure is less susceptible to inflation, since inflation on both the output and input side tend to cancel each other out.

c) Productivity of Family Labour

In the NFS, a distinction is made between the labour of farm family members, which is generally unpaid and therefore is not classified as a production cost, and hired labour, which in accounting terms does represents a production cost to the family farm. The return to 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 (to maintain international consistency in the measure, it is not possible to report in excess of one labour unit per person, even where an individual works more than 1,800 hours). Relative to a labour unit for an adult, 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 using 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 be 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. Over time, market based gross output is sensitive to output price inflation and output price volatility, which can contribute to variations in the market orientation measure. By contrast, subsidies, which are the other element of gross output, are far less volatile and are more akin to a fixed value over time.

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. FFI is measured in nominal terms. This needs to be taken into account, when assessing developments in FFI over time, particularly in periods of abnormally high inflation such as occurred in 2023.

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 69% of the State's land area (CSO, 2023). 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, but whose development has been hampered by an absence of data sharing, include, metrics relating to **biodiversity**. Measures of biodiversity, particularly those designed to accurately pick on small changes through time at the individual farm level, are technically challenging to implement and require considerable resources. A measure of biodiversity quantity 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. Table 3.2 summarises the environmental indicators included in this report.

Table 3.2: Overview of Environmental Indicators

Indicator	*Measure*	*Unit*
Ag. GHG emissions per farm	Absolute Ag. based GHG emissions per farm	Tonnes CO_2 equivalent / farm
Ag. GHG emissions per hectare	Absolute Ag. based GHG emissions per hectare	Tonnes CO_2 equivalent / hectare
Ag. GHG emissions per kg of output	Ag. based GHG emissions efficiency	kg CO_2 equivalent / kg output *AND* kg CO_2 e / € output
Energy GHG emissions per farm	Absolute energy GHG emissions per farm	Tonnes CO_2 equivalent / farm
Energy GHG emissions per hectare	Absolute energy GHG emissions per hectare	Tonnes CO_2 equivalent / hectare
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
N use efficiency	N retention efficiency	% N outputs / N inputs
P balance	P transfer risk	kg P surplus / ha
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 38.4% of the national emissions total in 2023 (EPA, 2023a). 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 out an ambition for a climate neutral economy by 2050 for the state. Agriculture now has a sectoral target of a 25% reduction by 2030 (Government of Ireland, 2023).

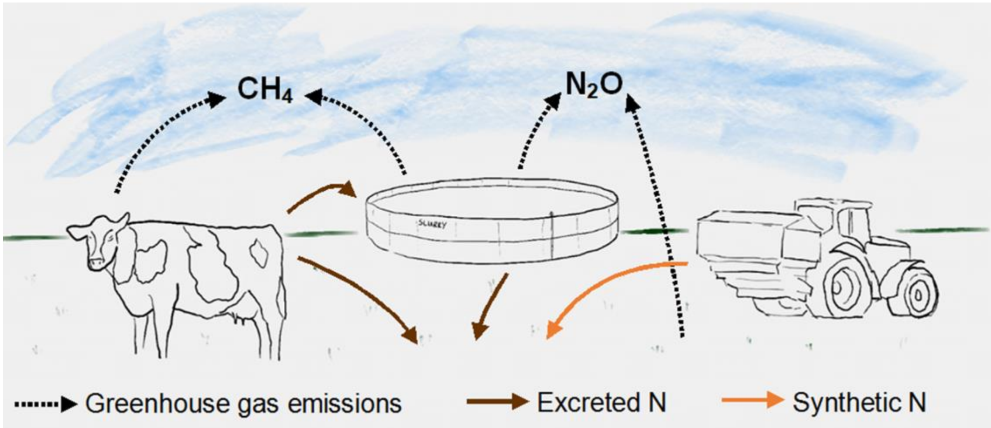
Two dominant measures of greenhouse gas emissions exist - the IPCC methodology and the LCA methodology. They differ in important ways and definitions of both are provided below.

1. **Intergovernmental Panel on Climate Change (IPCC) Methodology***:* The GHG emissions indicators in this report are in the first instance calculated following the IPCC methodology's accounting conventions and Irish emission factors as employed in the 2023 National Inventory Report for Ireland (Duffy et al., 2023). The IPCC based methodology reflects so called territorial emissions by IPCC sector. This means that the IPCC based approach measures the agriculture based emissions that occur on farms in Ireland, but excludes emissions relating to the production of imported farm inputs (e.g. synthetic fertilisers) by Irish agriculture. This definition differs from the more holistic approach that is typically used in the Life Cycle Assessment (LCA) approach (which is explained below), which defines an end output (e.g milk) and capture emissions along the chain of the milk production process, including emissions associated with inputs to the production process, even if those inputs are produced outside the territory (Ireland).

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 **crop residues, application of manures and synthetic fertilisers** to agricultural soils. **Carbon dioxide (CO_2)** emissions associated with **liming** and **urea application, which are small relative to CH_4 and N_2O emissions,** are also included in the analysis presented in this report.

A complicating factor inherent in an individual **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 within a calendar year. Unless this is factored into the calculations, it could lead to an over estimation or underestimation of activity and associated emissions on individual farms. Accordingly, a farm level animal inventory approach is used to address this complication, 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 (non 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 28 and 265 times greater than the GWP of CO_2. In this way, the sum of all three gases can be expressed in comparable terms and can thus be added together.

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). Energy emissions (CO_2 only) are estimated from expenditure on electricity, natural gas and fuels (relevant quantities used are estimated by using national average prices (CSO, 2023a)) 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 calculated for each farm system. These are 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 hectare & € of 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, gas 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.

2. LCA Methodology: An alternative method to the **IPCC approach** of measuring GHG emissions is the **Life Cycle Assessment (LCA) approach**, which, in its broadest definition can account for emissions through the entire food production supply chain. LCA is a holistic systems approach that aims to quantify the potential environmental impact associated with a product, e.g. GHG emissions, generated throughout a product's life cycle, from raw-material acquisition through production, use, recycling and final disposal. The LCA used here accounts for all agricultural 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 Carbon Trust (UK) underpins the carbon footprint results from the Bord Bia Sustainable Dairy Assurance Scheme (SDAS). In LCA analysis system boundaries have to be defined to determine what will and will not be included as part of the calculation. 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 Ireland 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 will be the subject of ongoing revision to reflect developments in scientific understanding. Of greater relevance is the trajectory of the indicator over time. The main objective of this research is to establish indicators through which changes in sustainability performance can be documented and evaluated.

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, 2023). 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 Ireland's EPA (Hyde et al., 2021), in conjunction with activity data from the NFS, is used to estimate 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 calculated for each farm system. These are also disaggregated to show the emissions originating from different farm enterprises (dairy, cattle, sheep and tillage).
b. **Ammonia emissions per unit of output/hectare:** derived so that the total NH_3 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, NH_3 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.

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 the 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 in the absence of knowledge of 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 ongoing 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 Teagasc NFS, the social indicators reported are summarised in Table 3.3:

Table 3.3: Overview of Social indicators

Indicator	*Measure*	*Unit*
Household vulnerability	Farm business is not viable and no off-farm employment in the household	Binary variable: 1= vulnerable
Agricultural education	Formal agricultural training received by the farmer	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
Total hours worked	Total farm and off-farm work load of the farmer	Hours worked

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** which 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 influencing wider farm management decisions that can affect other dimensions of farm sustainability (e.g. willingness to adopt new technologies).

c) High Age Profile

Farm households 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 household 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 measure and evaluate whether 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 or environmental performance, as they will highlight the benefits of specific technologies or behaviours. Table 3-4 summarises the innovation indicators included in this report.

Table 3.4: Overview of Innovation indicators

Dairy	***Cattle***	***Sheep***	***Tillage***
Discussion Group Membership	Discussion Group **Membership**	Discussion Group **Membership**	Discussion Group **Membership**
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 farming 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 use of Calcium Ammonium Nitrate (CAN). Protected urea is also associated with lower ammonia emissions compared to conventional straight urea fertiliser formulations and allows for greater nitrogen recovery for agronomic purposes. The indicator reported is the proportion of chemical N applied in protected urea form.
- ***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. The indicator reported is 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

For sheep and drystock cattle systems a common set of innovation indicators was used. These are:

- ***Discussion group membership*** was selected as indicating the degree of interaction with extension services and farming peers. This is reported in binary (yes/no) format.
- ***Liming* and *Reseeding*** were identified as important practices in grassland management. These indicators are 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. The reported indicator is the proportion of chemical N applied in protected urea form.
- ***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. The indicator reported is 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 farming 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 hypothetical 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, on the basis of gross margin per hectare. This is also demonstrated in the example of 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

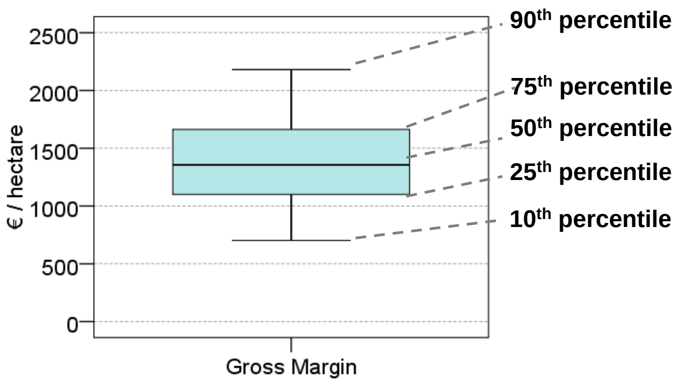
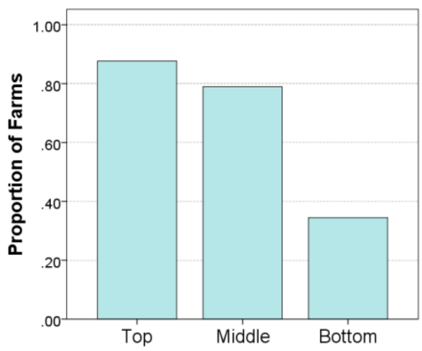


Figure 4.2: Example Bar Chart Proportion of farms



Dairy Farm Sustainability 2023
Key Messages

Economic

Family Farm Income fell sharply to €750 per ha

Environmental

GHG emissions per ha fell by 0.3 tonnes

Social

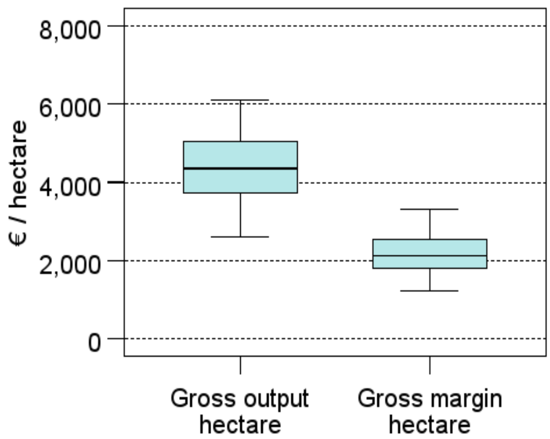
22% of households were considered vulnerable, the highest level in many years

5 Dairy Farm Sustainability 2023

Economic Sustainability Indicators

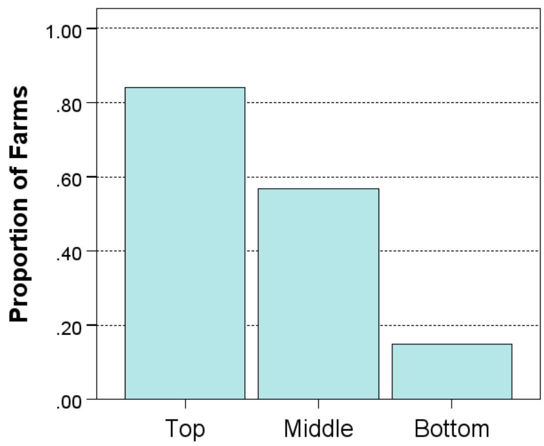
In 2023, the average dairy farm **output per hectare** was €4,456, and the average market based **gross margin per hectare** was €2,209. Median values were slightly lower than the average, as shown in Figure 5.1.

Figure 5.1: Economic Return and Profitability of Land: Dairy Farms



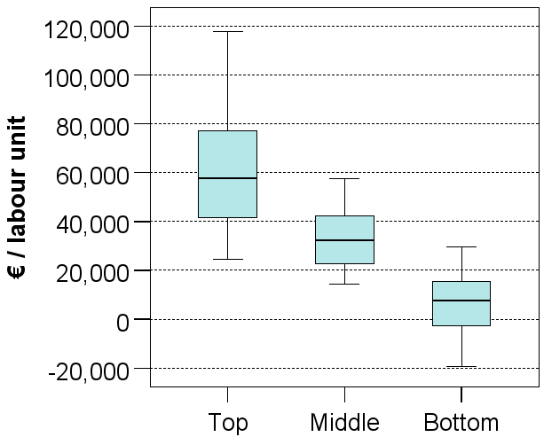
Overall 52% of dairy farms were **economically viable** in 2023. This ranged from 84% for the top one third of economic performing dairy farms, to 15% for the bottom third, as illustrated in Figure 5.2.

Figure 5.2: Economic Viability: Dairy Farms



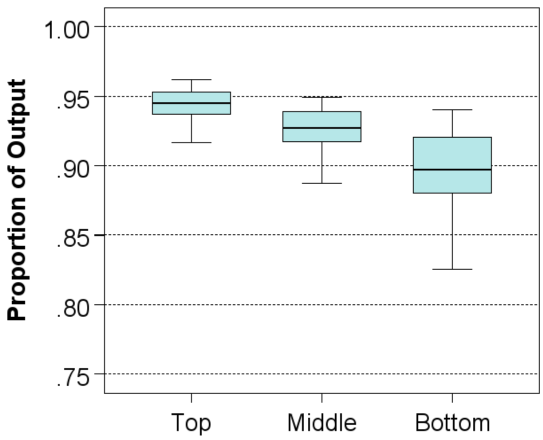
Average **income per labour unit** (unpaid family labour) for dairy farms in 2023 was €33,329. Average incomes per labour unit were €65,596, €34,131 and €400 for the top, middle and bottom performing farm cohorts respectively. However, there was a large range in the return to family labour for dairy farms as shown in Figure 5.3.

Figure 5.3: Productivity of Labour: Dairy Farms



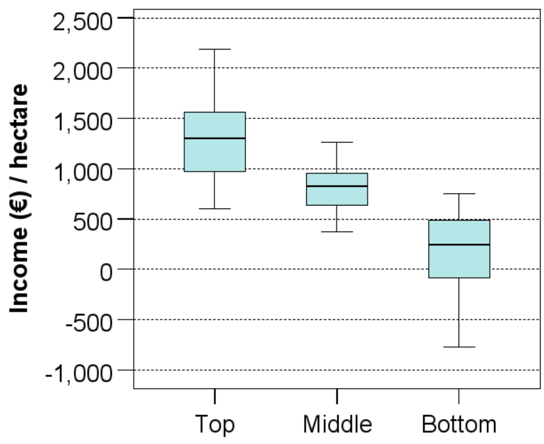
On average, dairy farms derived 91% of gross output directly from the market in 2023. The degree of **market orientation** was highest for the top third of dairy farms and the range was largest among the bottom third, as illustrated in Figure 5.4.

Figure 5.4: Market Orientation: Dairy Farms



For the full dairy farm population, there was a large range in family farm income per hectare across all three groups, as illustrated in Figure 5.5. The average family farm income per hectare on dairy farms was €750 in 2023. Within the farm profitability subcategories, the average income ranged from €1,304 per ha for the top performing cohort to €141 per ha for the bottom performers in economic terms.

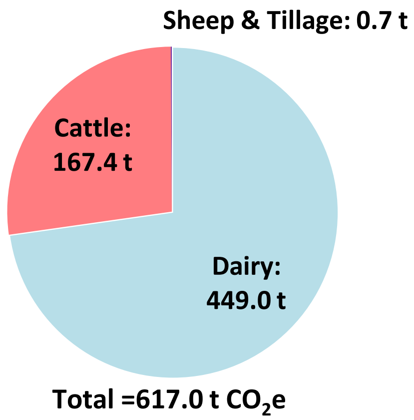
Figure 5.5: Family Farm Income per hectare: Dairy Farms



Environmental Sustainability Indicators

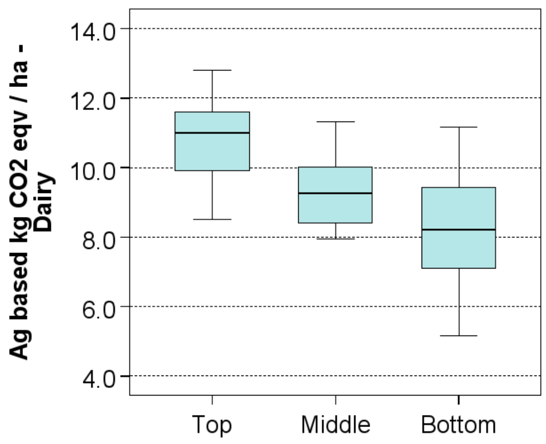
Figure 5.6 indicates that the average dairy farm produced 617.0 tonnes of agricultural **GHG emissions** (in CO_2 equivalent) in 2023. It should be noted that this measure is based on the IPCC definition of emissions. At 72%, most of the average dairy farm's agricultural GHG emissions were associated with the production of milk output. A further 27% of dairy farm GHG emissions were 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 production on dairy farms.

Figure 5.6: Agricultural GHG Emissions for the average Dairy Farm



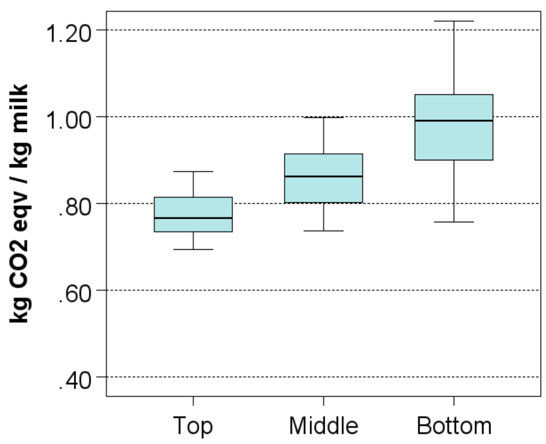
The average dairy farm produced 9.47 tonnes of CO_2 equivalent GHG **emissions per hectare of UAA**. The better performing dairy farms in an economic sense tended to operate at higher intensities and this is reflected in their higher emissions of GHG per hectare, as shown in Figure 5.7.

Figure 5.7: Agricultural GHG Emissions per hectare: Dairy Farms



When GHG emissions allocated to dairy production are expressed per kilogramme (kg) of milk output, the average dairy farm had GHG **emissions** of 0.876 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.

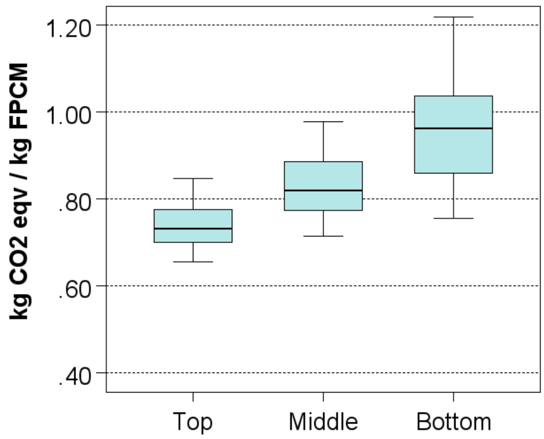
Figure 5.8: Agricultural GHG Emissions per kg of Milk: Dairy Farms



[2] Convert kg to litre by multiplying by 1.03

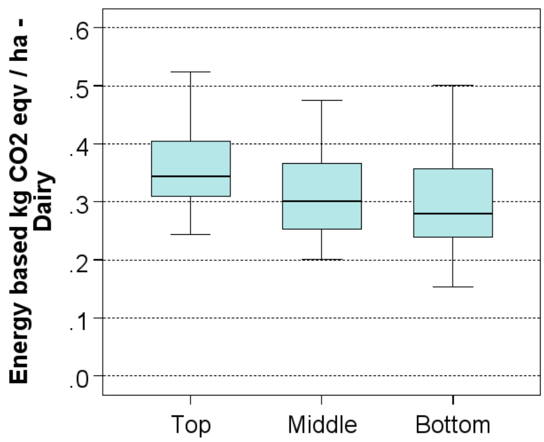
Emissions allocated to dairy output can also expressed **per kg of fat and protein corrected milk** (FPCM), which is standardized to 4% fat and 3.3% true protein per kg of milk. The average farm had GHG emissions of 0.847 kg CO_2 equivalent per kg of FPCM produced in 2023. Figure 5.9 also shows that those farms with better economic performance also have lower emissions intensity per kg of FPCM produced.

Figure 5.9: Agricultural GHG Emissions per kg of FPCM: Dairy Farms



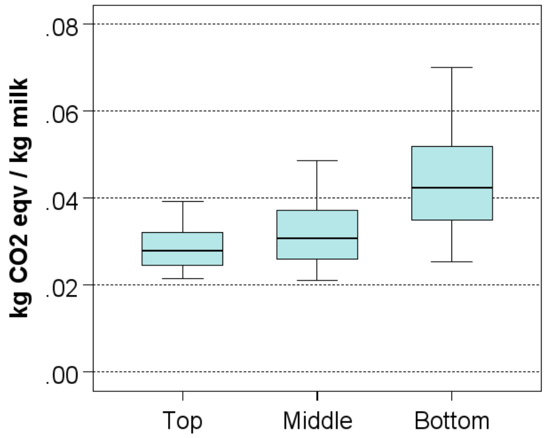
In 2023, the average dairy farm had **energy** based GHG **emissions** of 0.34 tonnes of CO_2 equivalent **per hectare**. In economic terms, the better performing dairy farms tended to operate at higher intensities, reflected in their higher emissions of energy based GHG per hectare, as shown in Figure 5.10.

Figure 5.10: Energy use related GHG Emissions per hectare: Dairy Farms



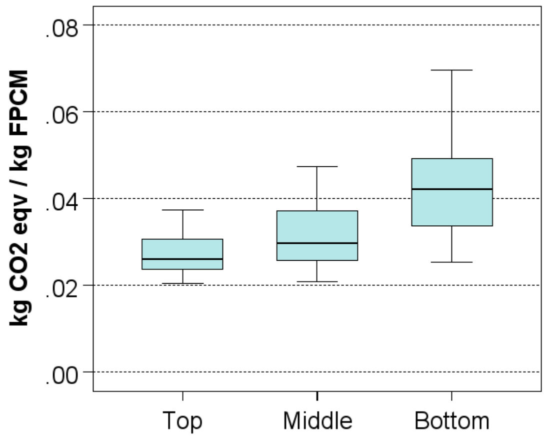
The average dairy farm's **energy** based GHG **emissions** were 0.0364 kg CO_2 equivalent **per kg of milk** in 2023. Figure 5.11 indicates that, similar to agricultural based GHG emissions intensity of milk production, lower energy based GHG emissions per kg of milk produced is evident among farms with better economic performance.

Figure 5.11: Energy use related GHG Emissions per kg of Milk: Dairy Farms



The average dairy farm's energy based GHG emissions was also 0.0354 kg CO_2 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 CO_2 emissions generated.

Figure 5.12: Energy GHG Emissions per kg of FPCM: Dairy Farms



Using the **LCA approach** (including both agricultural and energy based GHG emissions) the average dairy farm **carbon footprint of milk** was 0.99 kg CO_2 equivalent per kg of FPCM in 2023. Figure 5.13 again shows that lower emissions per kg of FPCM (on a LCA basis) was more prevalent among the group of top (economically) performing dairy farms.

Figure 5.13: Total LCA based GHG emissions (Agriculture & Energy) per kg of FPCM: Dairy Farms

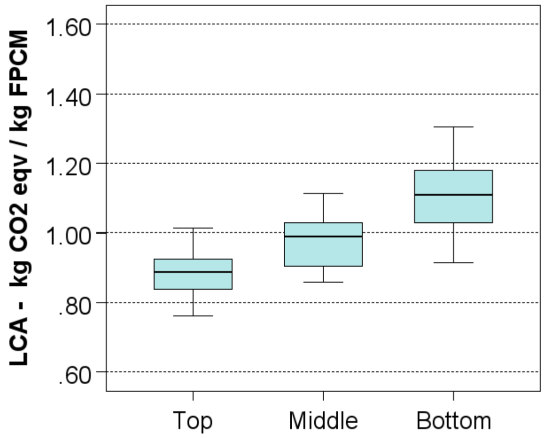
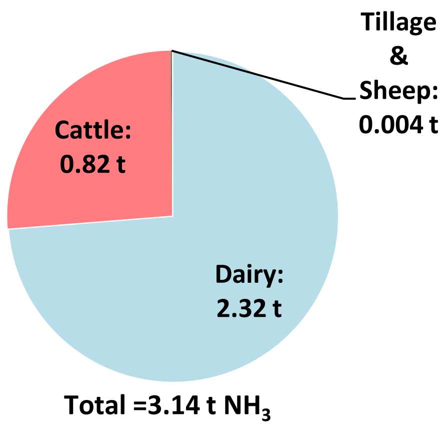


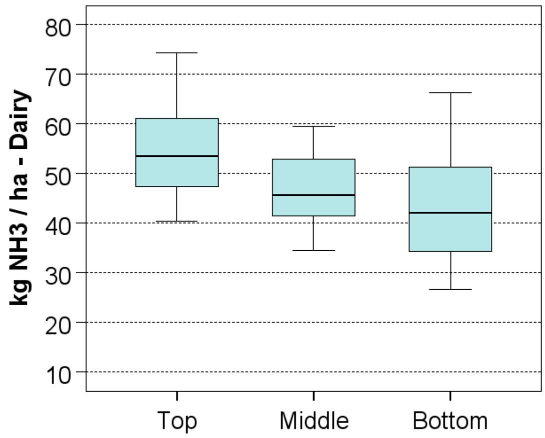
Figure 5.14 indicates that the average dairy farm produced approximately 3.14 tonnes of **ammonia** (NH_3) **emissions** in 2023. This calculation is based on an approach consistent with the EPA national ammonia inventory methodology. The majority of dairy emissions (74%) were from milk based output, with 26% allocated to non-milk producing animal activities and a minor amount allocated to arable production.

Figure 5.14: Total Ammonia Emissions for the average Dairy Farm



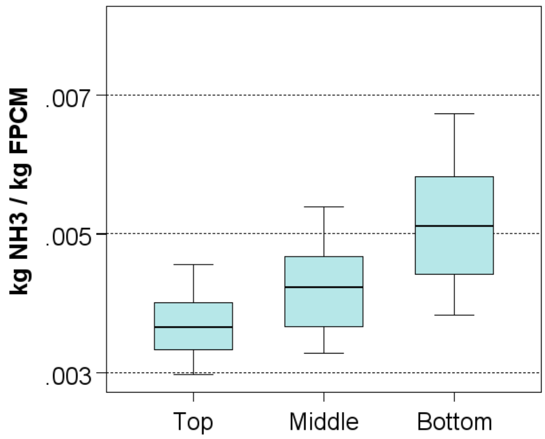
The average dairy farm emitted 48.8 kg of **NH_3 per hectare** across the entire farm. Economically better performing farms tend to operate at higher intensities and this is reflected in higher emission of ammonia per hectare, as shown in Figure 5.15

Figure 5.15: Ammonia Emissions kg per hectare: Dairy Farms



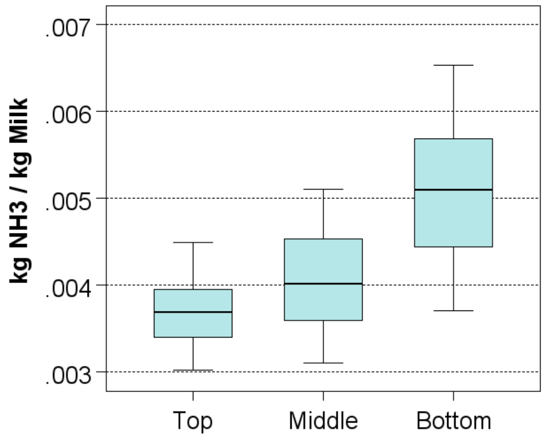
The average dairy farm emitted 0.0044 kg of **NH_3 per kg of FPCM** produced. Figure 5.16 again shows that the top economic performing dairy farms produced milk at a lower NH_3 emissions intensity compared to the middle and bottom cohorts.

Figure 5.16: Ammonia Emissions per kg of FPCM: Dairy Farms



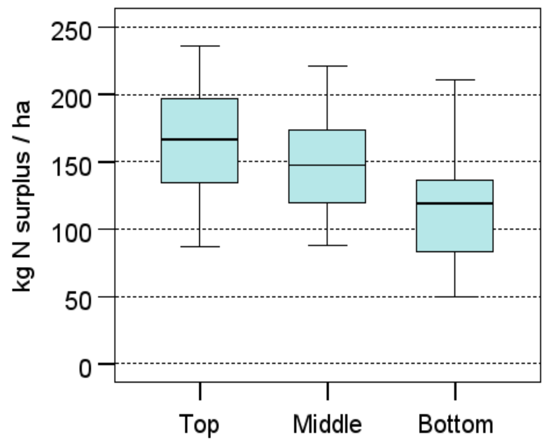
This result was replicated in the outcome on a kg of milk output basis, as shown in Figure 5.17. However, the NH_3 emissions per kg of milk was slightly higher at 0.0046.

Figure 5.17: Ammonia Emissions per kg of Milk: Dairy Farms



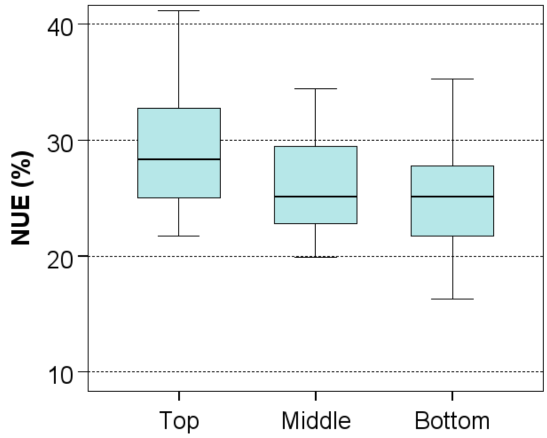
Nitrogen balance (excess of N inputs over outputs) averaged 147.2 kg N surplus per hectare across all dairy farms in 2023. Figure 5.18 indicates that higher N surpluses per hectare are associated with superior economic performance. This is due to the greater production intensity on economically better performing farms.

Figure 5.18: N Balance per ha: Dairy Farms



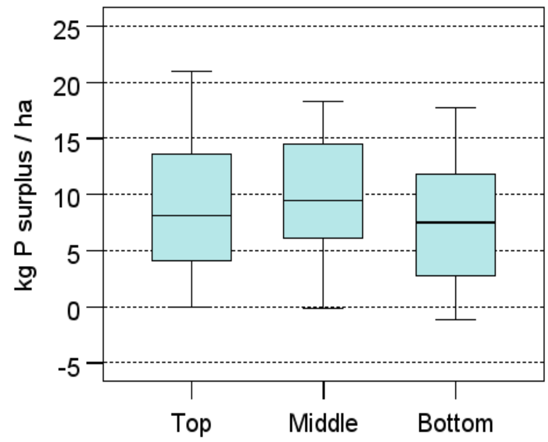
The average dairy farm had an **N use efficiency** (NUE) of 27.8% in 2023. Figure 5.19 demonstrates that a slightly higher NUE was evident among the better economic performing farmers, with the largest range prevalent among the bottom cohort.

Figure 5.19: N Use Efficiency: Dairy Farms



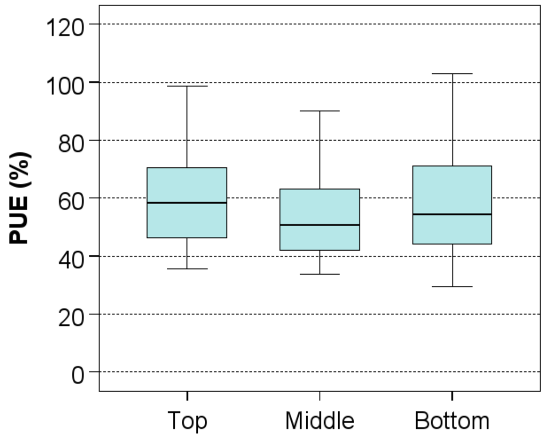
Phosphorus balance (excess of inputs over outputs) averaged 9.7 kg P surplus per hectare across all dairy farms in 2023. Figure 5.20 shows that there was a larger range of results, especially for the top and middle performing cohorts.

Figure 5.20: P Balance per ha: Dairy Farms



The average dairy farm had a **P use efficiency** of 60.5%. Figure 5.21 indicates higher P use efficiency was more prevalent among the better economic performing farms.

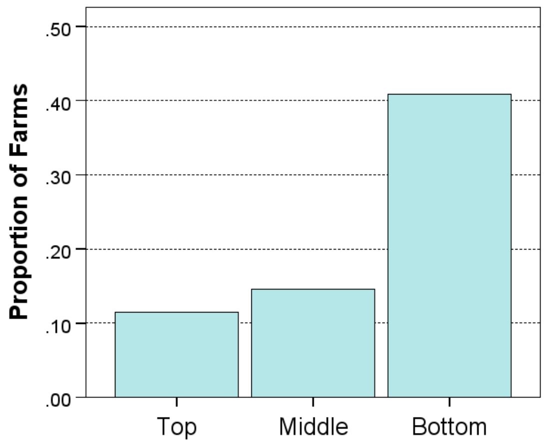
Figure 5.21: P Use Efficiency: Dairy Farms



Social Sustainability Indicators

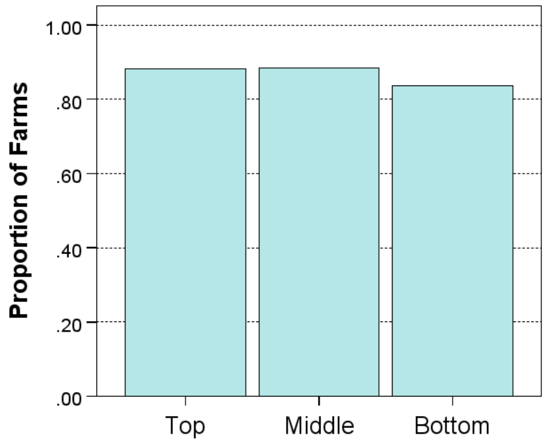
In all, 22% of dairy farm households fell into the **vulnerable household** category (economically non-viable farm business and no off-farm employment). Figure 5.22 shows that there was a considerably larger proportion of households at risk among those farms with the lowest gross margin per hectare (11% among bottom third).

Figure 5.22: Household Vulnerability: Dairy



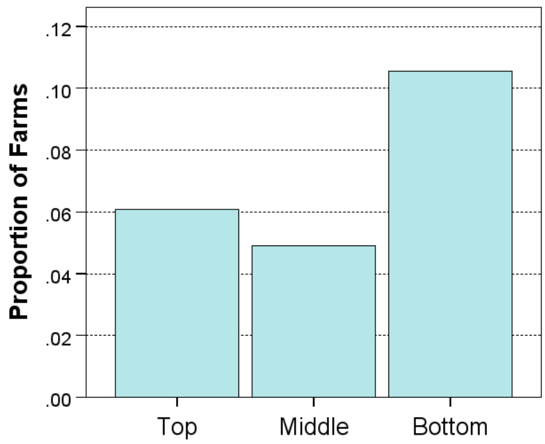
Overall, 87% of dairy farmers had received some formal agricultural education. Figure 5.23 shows that agricultural training rates were very slightly higher across the middle and top performing cohorts.

Figure 5.23: Agricultural Education: Dairy



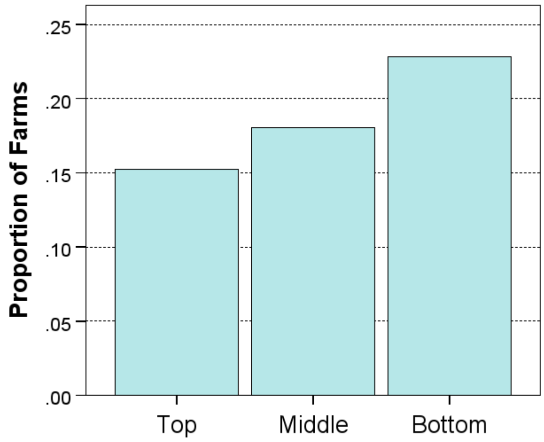
Only 7% of dairy **farmers live alone** and were thus classified as being at risk of isolation. Figure 5.24 indicates that the risk was lowest for the top economic preforming cohort.

Figure 5.24: Isolation Risk: Dairy Farms



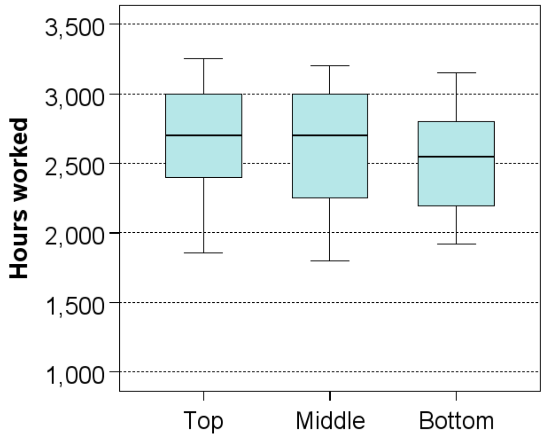
Across all dairy farms, 19% were identified as having a **high age profile**. Figure 5.25 shows that the percentage was slightly higher for the weaker economic performing dairy farms.

Figure 5.25: High Age Profile: Dairy Farms



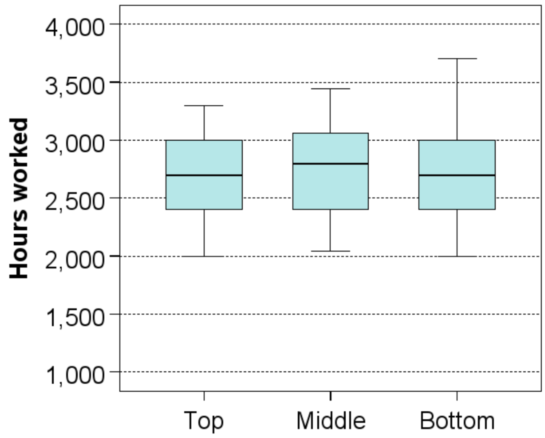
On average, dairy farmers worked 2,537 **hours per year on-farm** (approximately 49 hours per week). Figure 5.26 shows that the number of hours worked was highest for the top and middle performing cohorts by economic performance. However, this figure does not take into consideration off-farm employment, or the share of hours worked by hired staff or other family members.

Figure 5.26: Hours Worked on farm: Dairy Farm Operator



On average, dairy farmers worked 2,707 **hours per year** between on and **off-farm work** (approximately 52 hours per week). Figure 5.27 shows that hours worked was slightly higher for the middle and bottom performing cohorts by economic performance.

Figure 5.27: Total Hours Worked: Dairy Farm Operator

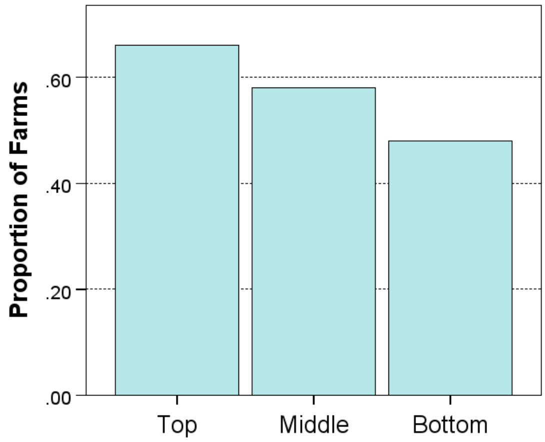


Dairy Innovation Indicators

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 application** occurred the period January to April, use of **low emission slurry spreading** equipment, application of **protected urea fertiliser**, as well as **liming** & grassland **reseeding** rates.

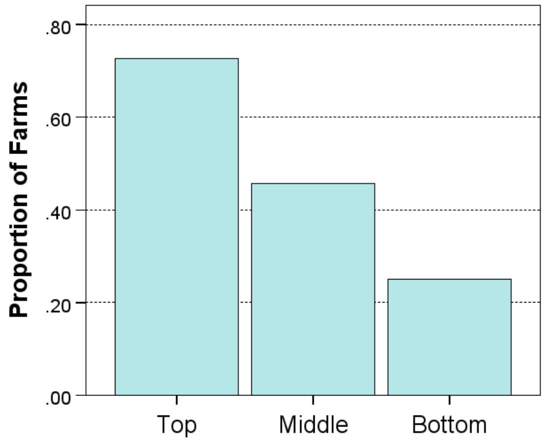
Figure 5.28 shows that those farms with better economic performance were more likely to use **milk recording**. Over 66% of the dairy farmers in the top group were milk recording, compared to 48% in the bottom group.

Figure 5.28: 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 73%, compared to 25% in the bottom cohort, as shown in Figure 5.29.

Figure 5.29: Discussion Group: Dairy Farms



The **application** of the majority of **slurry** in early spring was slightly higher across the top performing cohort at 74%, as shown in Figure 5.30. The middle and bottom cohorts had slightly lower level of spring time slurry application at 59% and 53% respectively.

Figure 5.30: Spring Slurry: Dairy Farms

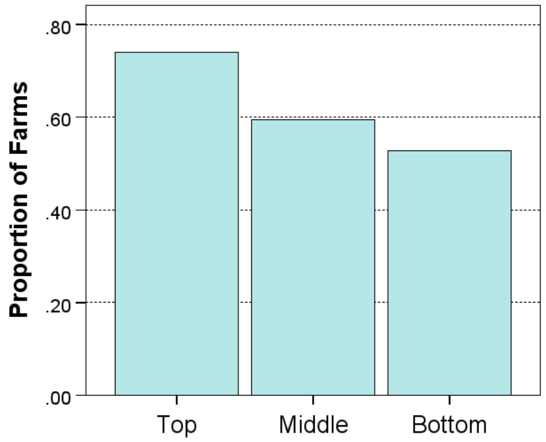
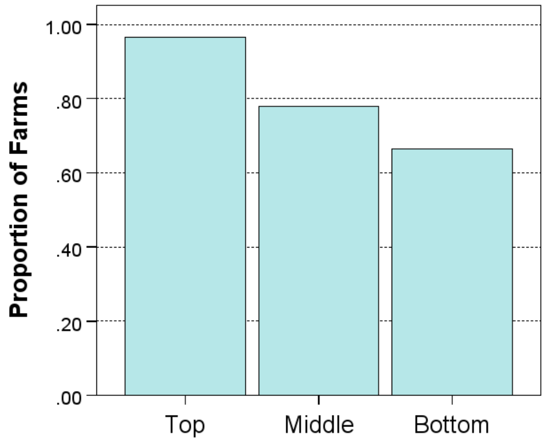


Figure 5.31 illustrates the volume of slurry applied by **low emissions slurry spreading** equipment. On the average dairy farm, over 80% of all slurry applied by dairy farmers was via low emission slurry spreading methods. This ranged from 97% for the top performing cohort to 66% for the bottom performing cohort.

Figure 5.31: Slurry applied by Low emissions slurry spreading methods: Dairy Farms



The percentage of total chemical nitrogen applied in the form of **protected urea** averaged 27% across all dairy farms. This ranged from 40% for the top performing cohorts to 16% for the bottom group as illustrated by Figure 5.32.

Figure 5.32 Protected Urea Use: Dairy Farms

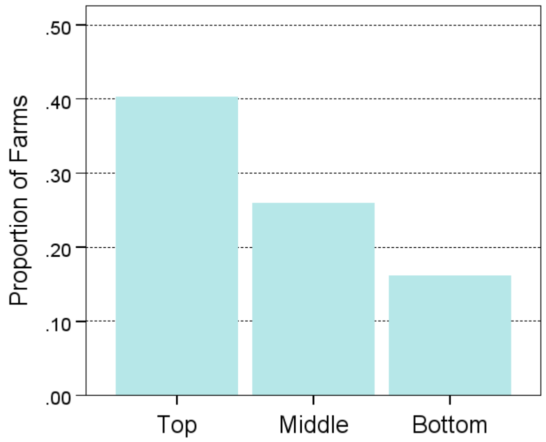


Figure 5.33 shows that **liming** was slightly more prevalent among the middle and better economic performers (50-56%) in 2023, compared to 46% for the bottom group.

Figure 5.33: Liming: Dairy Farms

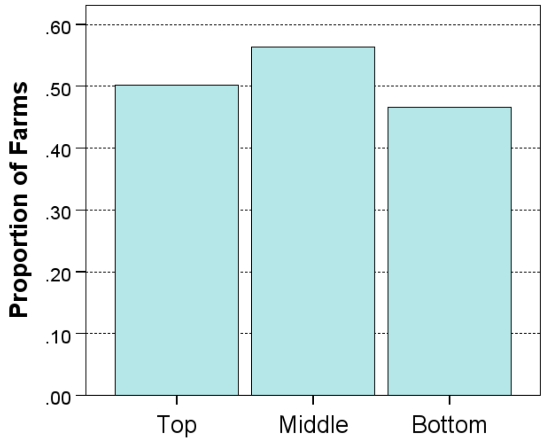
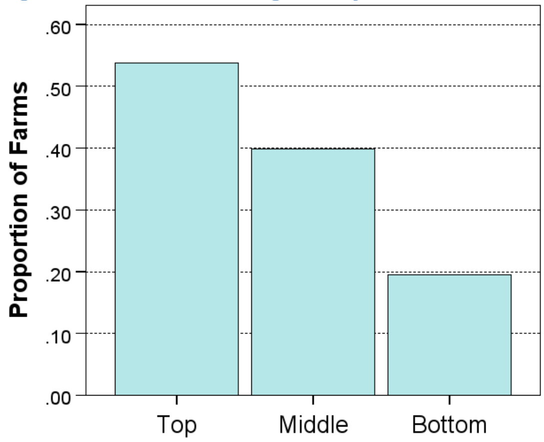


Figure 5.34 shows that **reseeding** was also more common among the better economic performing farms. A higher percentage of farmers in the top group (54%) engaged in reseeding of grassland compared to the bottom group (19%) in 2023.

Figure 5.34: Reseeding: Dairy Farms



Cattle Farm Sustainability 2023
Key Messages

Economic

Family Farm Income was €348 per ha

Environmental

GHG emissions per ha increased by 0.1 tonne

Social

About 1/3 of households were considered vulnerable, unchanged on the previous year

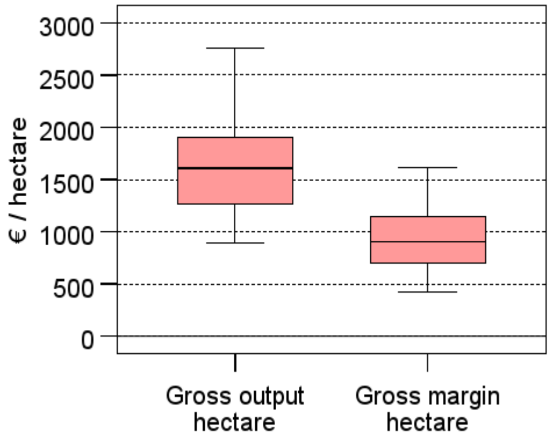
6 Cattle Farm Sustainability 2023

Cattle farms include both cattle rearing (mainly suckler based) and cattle finishing systems. Results for sustainability indicators for these systems in 2023 are presented below.

Economic Sustainability Indicators

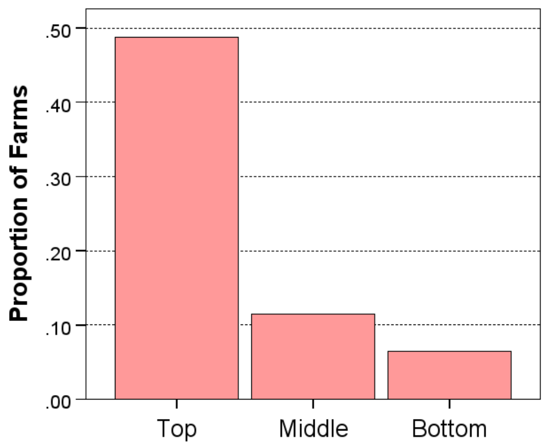
The average **output per hectare** for cattle farms was €1,767, and the average gross margin per hectare was €1,011 in 2023. There was a large range in farm economic performance, as shown in Figure 6.1.

Figure 6.1: Economic Return and Profitability of Land: Cattle Farms



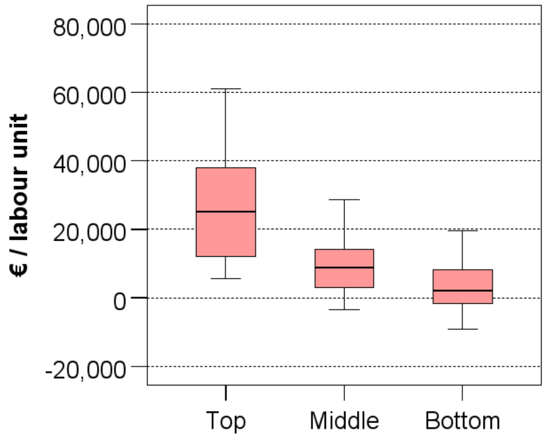
Only 23% of all cattle farms in the Teagasc NFS were defined as **economically viable**. As illustrated in Figure 6.2, the proportions deemed viable were 48%, 12% and 6% for the top, middle and bottom cohorts of farms by economic performance respectively.

Figure 6.2: Economic Viability: Cattle Farms



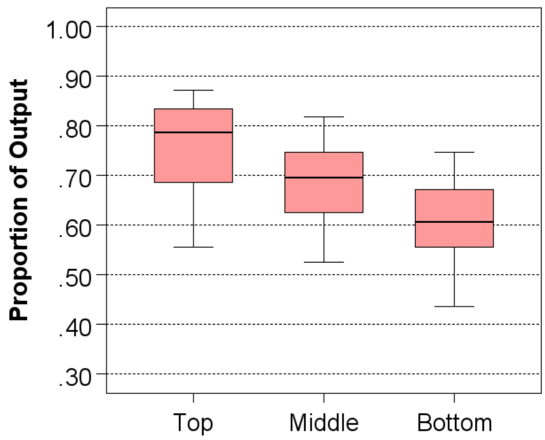
Across all cattle farms, the average **income per labour unit** was €16,747 in 2023. Figure 6.3 shows that this distribution was skewed by the top third of farms, which included a large number of relatively higher earners, with a mean income per labour unit of €33,541, compared with €11,920 and €4,324 for the middle and bottom cohorts of cattle farms respectively.

Figure 6.3: Productivity of Labour: Cattle



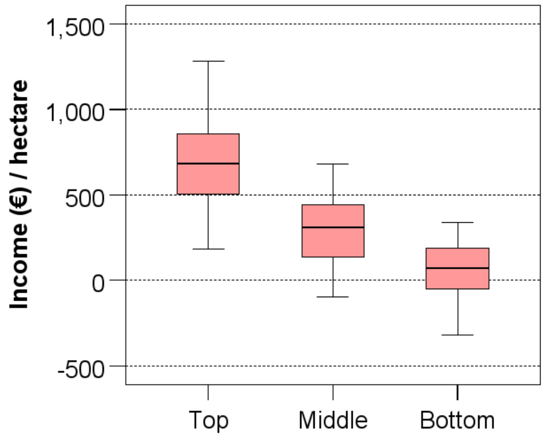
Market based output accounted for 68% of gross output across all cattle farms, with the remaining 32% accounted for by direct payment receipts. Figure 6.4 shows greater market orientation was exhibited across farms with better economic performance.

Figure 6.4: Market Orientation: Cattle Farms



The average family farm **income per hectare** on cattle farms was €348 in 2023. Across the subgroups, the average ranged from €733 for the top performing cohort to €31 for the bottom performers economically. Figure 6.5 shows significant ranges in income per hectare within and across the three groups, with a negative income per hectare returned by a section of the bottom performing cohort.

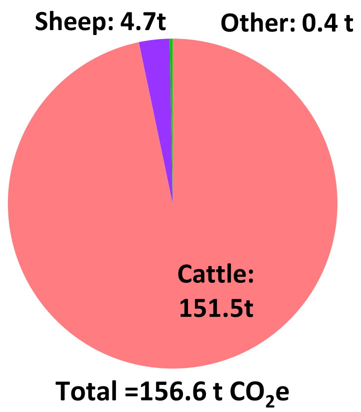
Figure 6.5: Family Farm Income per hectare: Cattle Farms



Environmental Sustainability Indicators

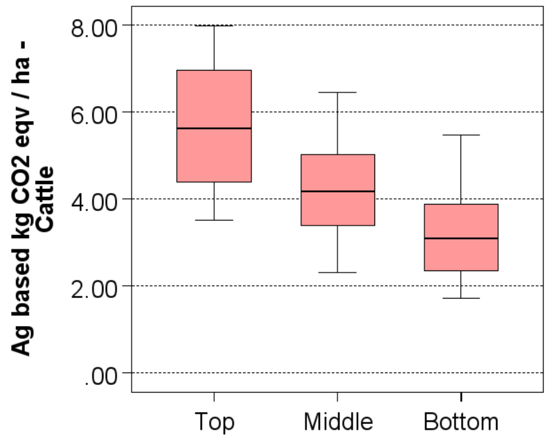
The average **cattle farm** produced 156.7 tonnes CO_2 equivalent of agricultural **GHG emissions** in 2023. Figure 6.6 shows that beef production was the principal source, generating 96.7% of these emissions. Sheep production was responsible for approximately 3% of total emissions on Irish cattle farms, and a very small proportion (circa 0.3%) was derived from other enterprises on these farms.

Figure 6.6: Agricultural GHG Emissions for the average Cattle Farm



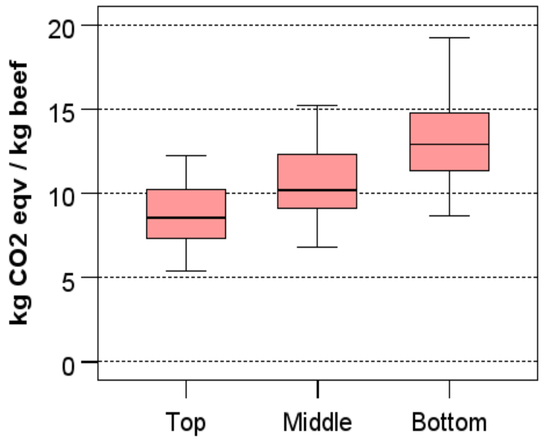
The average cattle farm emitted 4.51 tonnes of CO_2 equivalent of agriculturally generated **GHG emissions per hectare** in 2023. Emissions per hectare were higher for the more profitable cattle farms, which tended to be stocked at a higher intensity.

Figure 6.7: Agricultural GHG Emissions per hectare: Cattle Farms



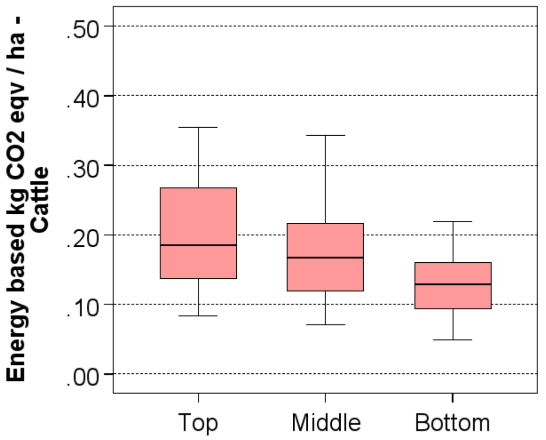
The **emissions** generated by cattle can be expressed in terms of their **live-weight output** (estimated using CSO price data). Figure 6.8 illustrates that there is a large range of **emissions per kg of beef live-weight** output. A positive association exists between emissions efficiency and economic 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 13.2 kg for the bottom performing third of cattle farms. The average level of GHG emissions across all farms was 10.8 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



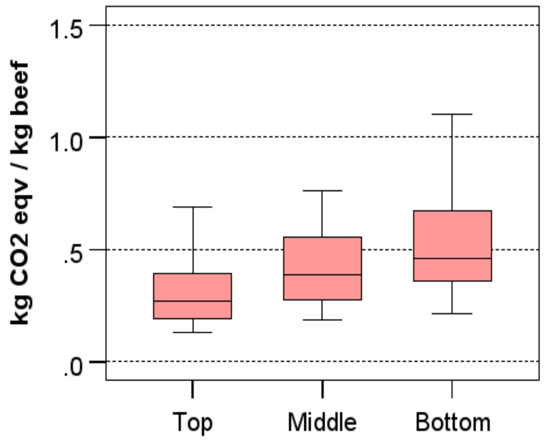
The average cattle farm emitted 0.20 tonnes of CO_2 equivalent of **energy based GHG emissions per hectare** in 2023, as illustrated in Figure 6.9. Emissions per hectare were higher for the more profitable cattle farms, which tended to be stocked at a higher intensity.

Figure 6.9: Energy GHG Emissions per hectare: Cattle Farms



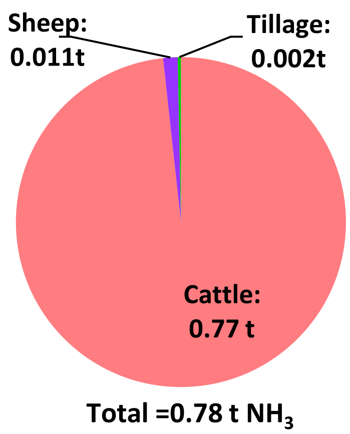
On average, **energy based GHG emissions** across all cattle farms was 0.49 kg of CO_2 equivalent **per kg beef live-weight** produced. Figure 6.10 illustrates that energy based GHG emissions per unit of product were also lower on farms with better economic performance. The top third produced an average of 0.42 kg CO_2 energy-based emissions per kg of live-weight beef produced, while for the bottom performing third this figure was 0.59 kg.

Figure 6.10: Energy use related GHG Emissions per kg live-weight beef: Cattle Farms



The average **cattle farm** emitted 0.78 tonnes of **ammonia (NH_3)** in 2023. Over 98% of total NH_3 emissions were linked to 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 kg of **NH_3 per hectare** in 2023. This ranged from 27.1 kg per hectare for the top performing cohort, to 17.6 kg 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

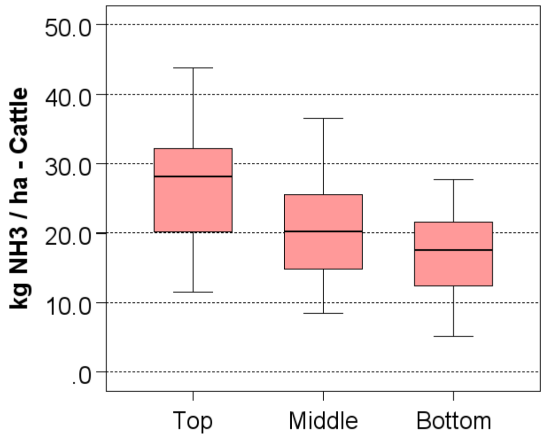


Figure 6.13 illustrates that, in terms of **live-weight** of beef produced, the more profitable cattle farmers have a lower level of **ammonia emissions**. There was a large range within the results, especially for the bottom performing cohort of cattle farmers. On average, a kg of live-weight beef was produced at an intensity of 0.057 kg of NH_3.

Figure 6.13: Ammonia Emissions per kg live-weight beef produced: Cattle Farms

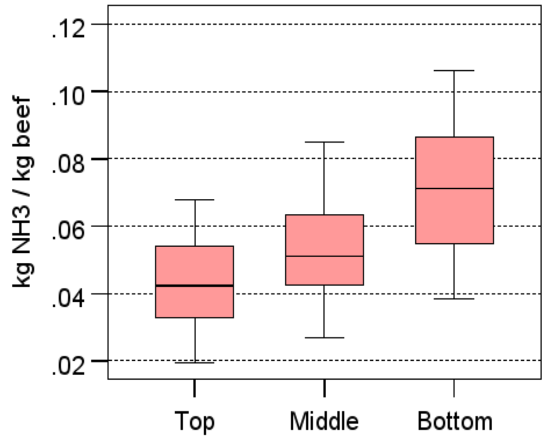
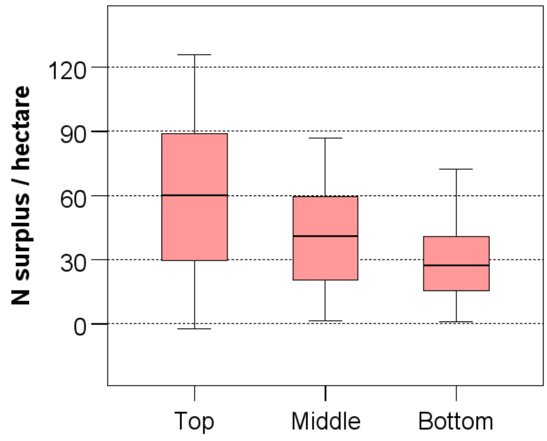


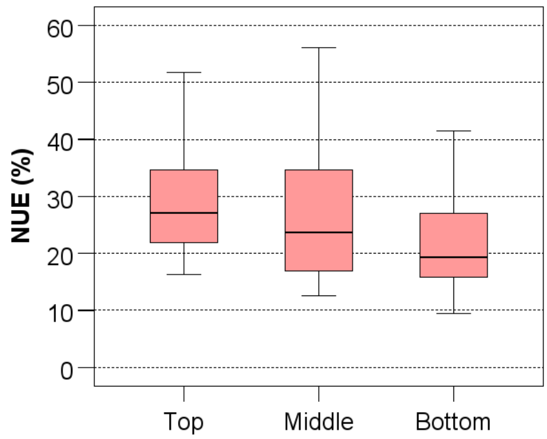
Figure 6.14 indicates that the **nitrogen surplus per hectare** tended to be higher on cattle farms that performed better economically. In general, these farms are operated more intensively. The top performing third of cattle farms had an average nitrogen surplus of 61.6 kg N per hectare, compared to 34.6 kg N per hectare for the bottom third of farms.

Figure 6.14: N Balance per ha: Cattle Farms



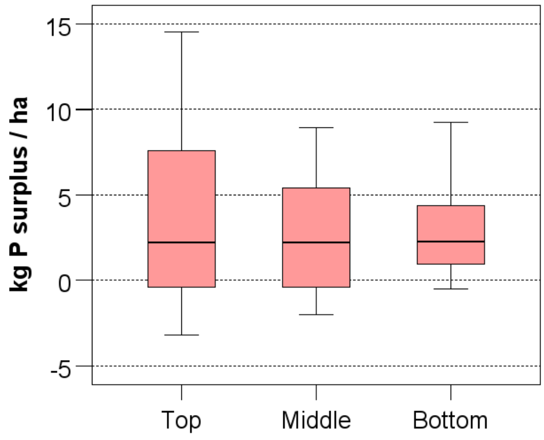
The average **N use efficiency** (NUE) across all cattle farms was 28.4%, but the range in NUE across the sample of cattle farms was significant, as shown in Figure 6.15. Despite the higher application rates, NUE tended to be higher across the middle and top economic performing cohorts.

Figure 6.15: N Use Efficiency: Cattle Farms



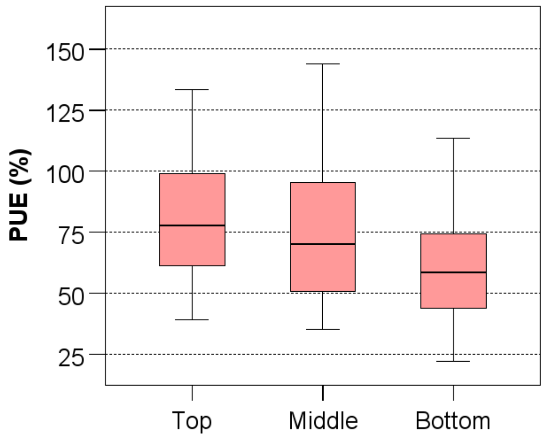
At the farm gate boundary, the **P surplus** across all cattle farms averaged 3.4 kg of P per hectare. There was a large range in P surpluses, especially across the better performing farms economically, as shown in Figure 6.16.

Figure 6.16: P Balance per ha: Cattle Farms



At the farm gate boundary, the average farm **P use efficiency** (PUE) across all cattle farms was 77%. Figure 6.17 shows that higher PUE was again more prevalent on farms that performed better in economic terms. Average PUE ranged from 84.4% for the top third to 68.5% for the bottom third of cattle farmers.

Figure 6.17: P Use Efficiency: Cattle Farms



Social Sustainability Indicators

Overall, 32% of all cattle farm households were considered **vulnerable** (a non-viable farm business with no off-farm employment). Figure 6.18 confirms that this vulnerability was associated with weaker economic performance, with 39% and 46% of the middle and bottom third of farms deemed vulnerable, compared to 13% of the top third.

Figure 6.18: Household Vulnerability: Cattle

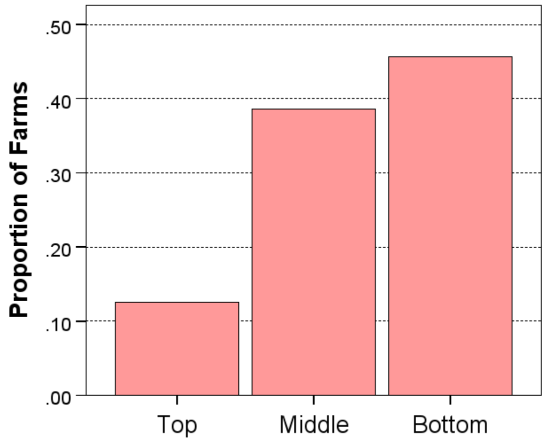
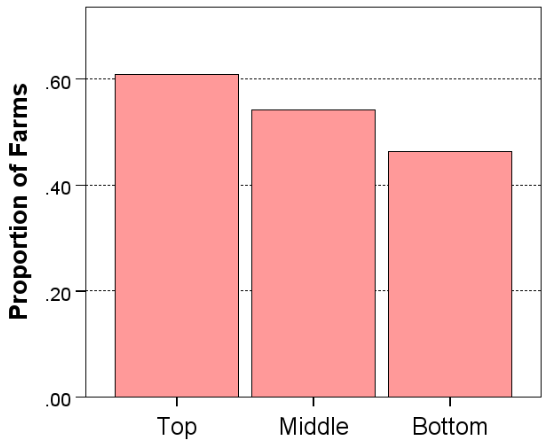


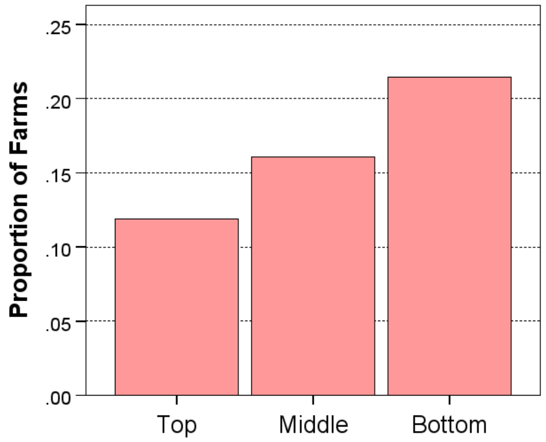
Figure 6.19 indicates that **educational attainment** was positively associated with the better economic performing farms. A total of 54% of cattle farmers had some level of formal agricultural education.

Figure 6.19: Agricultural Education: Cattle Farms



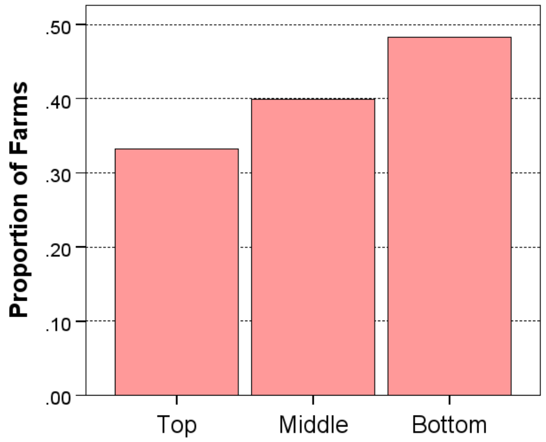
Overall, 16% of cattle farm operators were classified as being at **risk of isolation**; i.e. where the farmer lives alone. This was especially prevalent among farms in the lower profitability cohorts, where 21% of farmers live alone, as shown in Figure 6.20.

Figure 6.20: Isolation Risk: Cattle Farms



Additionally, 40% of cattle farms were classified as having a **high age profile**. High age profile was highest for the bottom cohort as shown in Figure 6.21.

Figure 6.21: High Age Profile: Cattle Farms



The average cattle farm operator had 1,432 **hours worked on farm** over the year (an average of 27.5 hours per week). The top economically performing cohort worked on average of 1,392 hours on farm compared to 1,460 and 1,444 for middle and bottom groups as outlined in Figure 6.22.

Figure 6.22: Hours Worked on Farm: Cattle Farm Operator

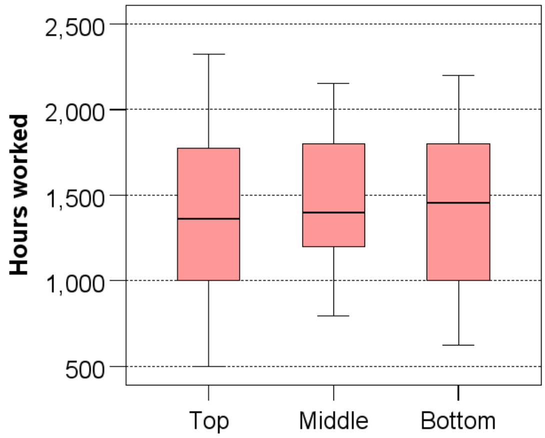
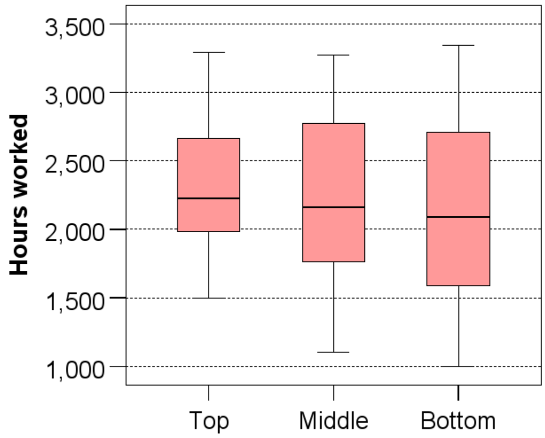


Figure 6.23 shows total **hours worked on and off-farm** was slightly higher for the middle and top compared to the bottom cohort. On average, cattle farmers worked 2,247 hours in 2023 between on and off-farm work (approximately 43 hours per week).

Figure 6.23: Total Hours Worked: Cattle Farm Operator



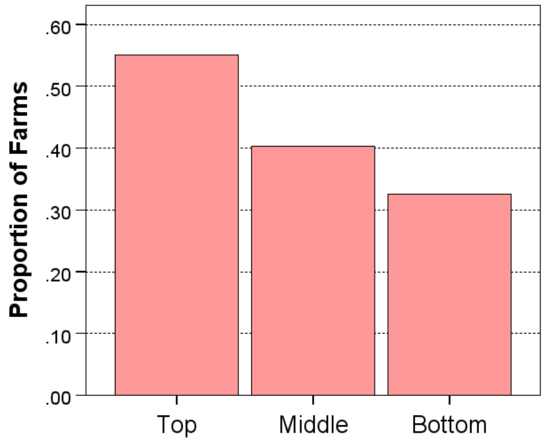
Cattle Farm Innovation Indicators

Six innovation indicators were examined for cattle farms: whether at least 50% of **slurry application** occurred in the period January to 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 6.24 shows that those in the top and economic performing group applied a lot more **slurry application** in springtime (55%)

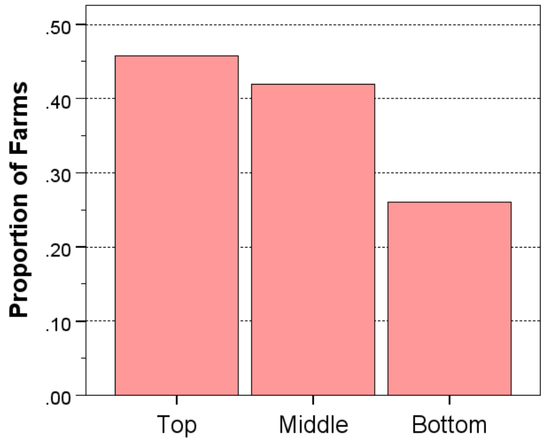
compared to the middle (40%) and bottom (32%) cohort.

Figure 6.24: Spring Slurry Application: Cattle Farms



On average, nearly 38% of all slurry applied by cattle farmers was via **low emission slurry spreading** methods. This ranged from 45-41% for the top & middle performing cohort to 26% for the bottom performing cohort, as shown in Figure 6.25.

Figure 6.25: Low emission slurry spreading: Cattle Farms



The percentage of total chemical nitrogen applied in the form of **protected urea** averaged 6% across all cattle farms in 2023. This ranged from 11.6% for the top performing cohorts to less than 1% for the bottom group as illustrated in Figure 6.26.

Figure 6.26: Protected Urea use: Cattle Farms

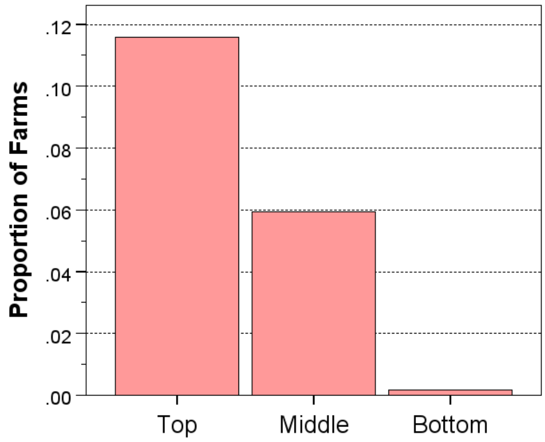


Figure 6.27 shows that **liming** rates were higher for the top performing cattle farm, at 37%, compared to 15% for the bottom cohort.

Figure 6.27: Liming: Cattle Farms

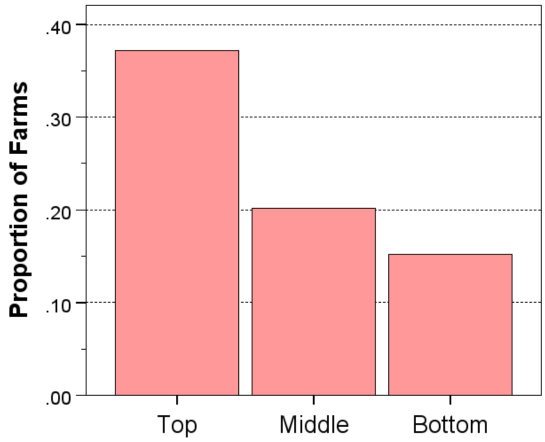
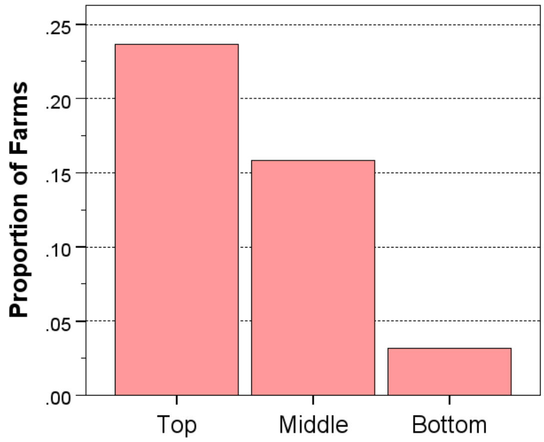


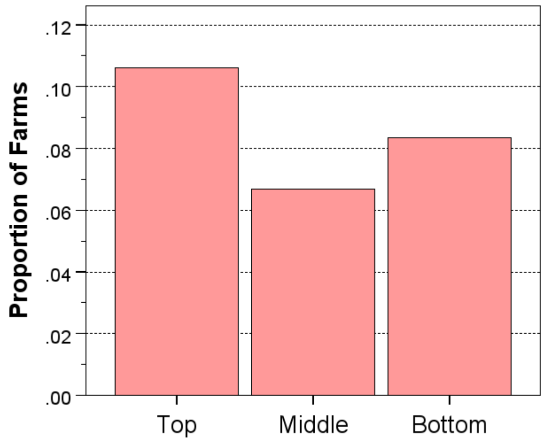
Figure 6.28 shows that 24% of the top economic performing cohort were members of a **discussion group**, compared to 15% and 3% in the middle and bottom cohort respectively.

Figure 6.28: Discussion Group: Cattle Farms



Reseeding levels ranged from just over 10% for the top cohorts to 7-8% for the middle and bottom performing cohort as shown in Figure 6.29.

Figure 6.29: Re-seeding: Cattle Farms



Sheep Farm Sustainability 2023
Key Messages

Economic

Family Farm Income fell significantly to €251 per ha

Environmental

GHG emission increased by 0.3 tonnes per ha

Social

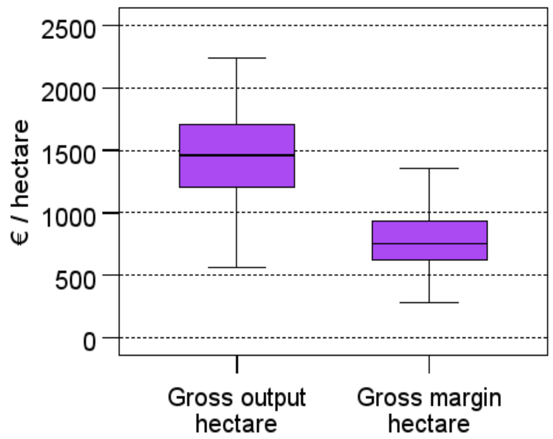
Close to 40% of households were considered vulnerable

7 Sheep Farm Sustainability 2023

Economic Sustainability Indicators

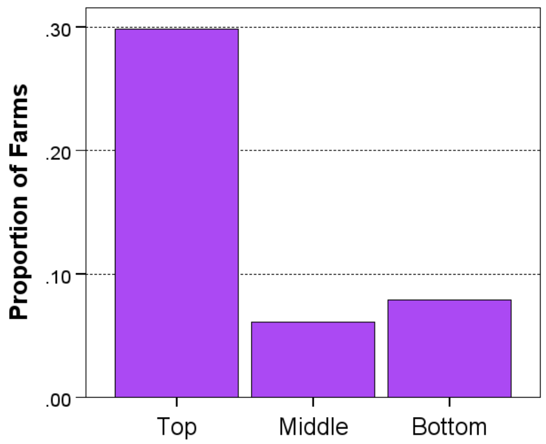
The average **gross output per hectare** for sheep farms was €1,455 in 2023, and the average **gross margin** was €766 per hectare.

Figure 7.1: Economic Return and Profitability of Land: Sheep Farms



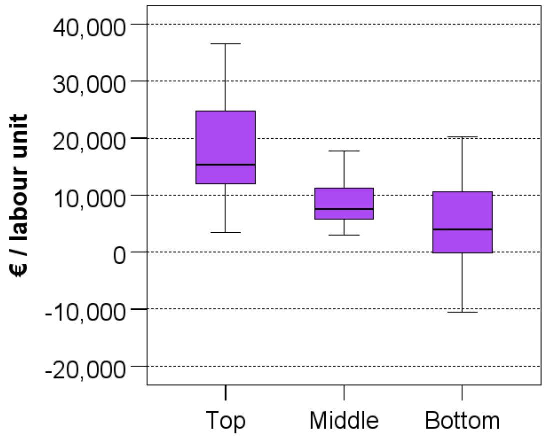
Across all sheep farms, 14% were defined as economically **viable**. Figure 7.2 shows that, ranked by economic performance, the proportion of viable sheep farms ranged from 30% for the top third to 6-8% for the middle and bottom cohort of farms.

Figure 7.2: Economic Viability: Sheep Farms



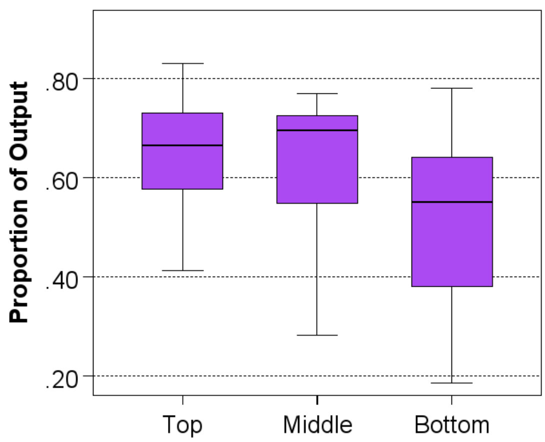
The average **income per unpaid labour unit** on sheep farms was €13,011. In common with cattle farms, there was a large range in economic performance, with the top third of sheep farms earning a mean income per labour unit of €25,324, compared with €4,903 for the bottom third (see Figure 7.3). Median income for the three cohorts was €15,473, €6,770 and €2,106 respectively.

Figure 7.3: Productivity of Labour: Sheep Farms



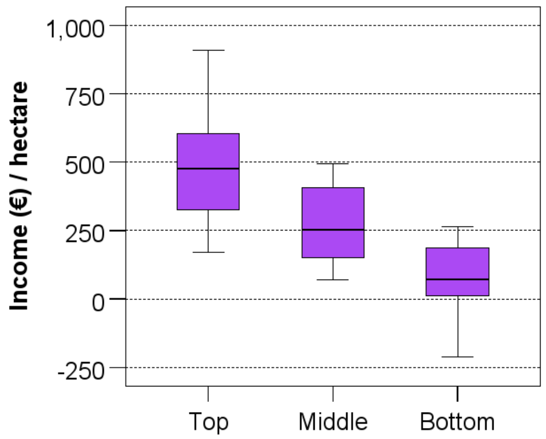
For the average sheep farm, approximately 59% of output was generated from the market, with the remaining 41% derived from direct payments. Figure 7.4 indicates that **market orientation** was positively associated with economic performance, with the top third of farms, based on economic performance, producing 65% of output from the market, compared with 53% on average for bottom third. Figure 7.4 also indicates a significant range in market orientation 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 €251 in 2023. Across the subgroups, this average ranged from €522 for the top performing cohort to minus €18 for the bottom performers economically. Figure 7.5 shows significant ranges in income per hectare across the three groups.

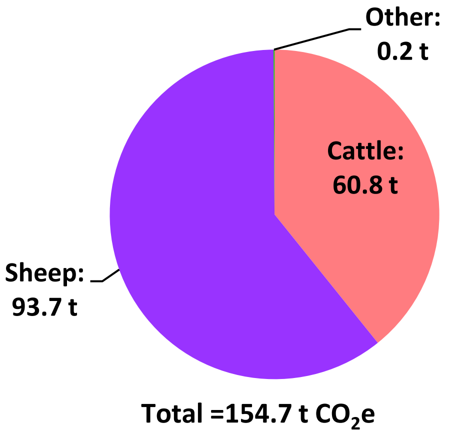
Figure 7.5: Family Farm Income per hectare: Sheep Farms



Environmental Sustainability Indicators

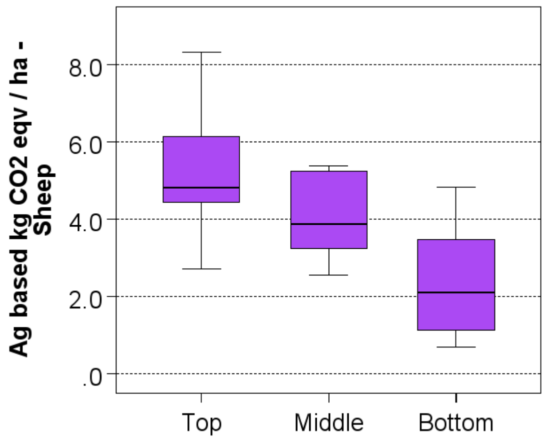
In 2023, the average **sheep farm** produced 154.7 tonnes CO_2 equivalent of agricultural **GHG emissions**. Figure 7.6 indicates that 60.6% of these emissions were generated by the sheep enterprise, with the remaining emissions (39%) generated by a cattle enterprise present on specialist sheep farms, with the remainder coming from other sources (minor arable enterprise).

Figure 7.6: Agricultural GHG Emissions for the average Sheep Farms



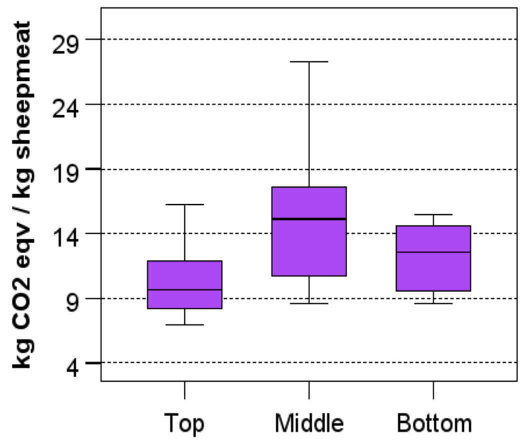
On average, sheep farms produced **GHG emissions** of 3.9 tonnes of CO_2 equivalent **per hectare**. Higher emissions per hectare were associated with the more profitable sheep farms, as shown in Figure 7.7. However, there was a large range of results.

Figure 7.7: Agricultural GHG Emissions per hectare: Sheep Farms



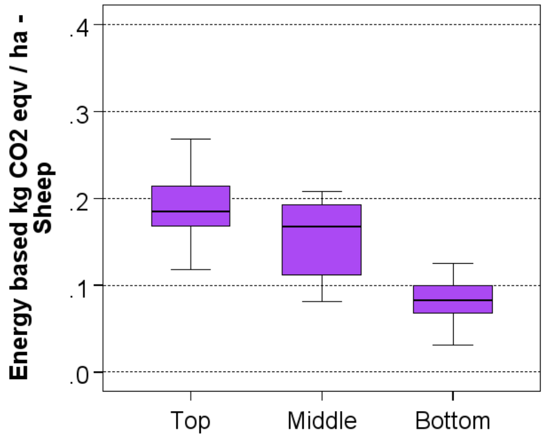
The **GHG emissions** generated by sheep are shown **per kg of live-weight** output produced (estimated using CSO price data). Figure 7.8 shows that the emissions intensity per kg of live-weight produced were negatively associated with economic performance. The top third of farms generated 10.0 kg CO_2 equivalent per kg live weight produced respectively, compared to 12-15 kg CO_2 equivalent for the bottom and middle cohorts on average. There was a noticeably large range in the emissions per kg of live-weight across the farms in the bottom cohort.

Figure 7.8: Agricultural GHG Emissions per kg live-weight produced: Sheep Farms



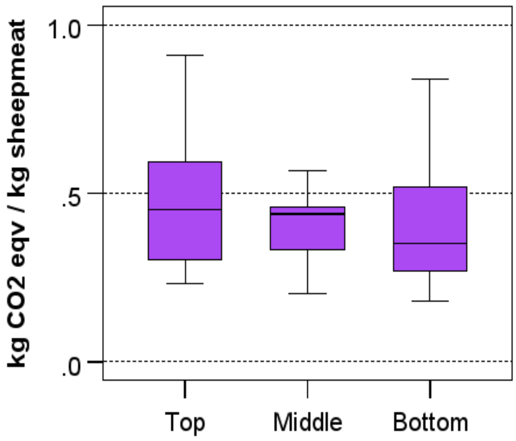
The average sheep farms had **energy related GHG emissions** of 0.16 tonnes CO_2 equivalent **per hectare**. Higher emissions per hectare were associated with the more profitable sheep farms, as shown in Figure 7.9.

Figure 7.9: Energy GHG Emissions per hectare: Sheep Farms



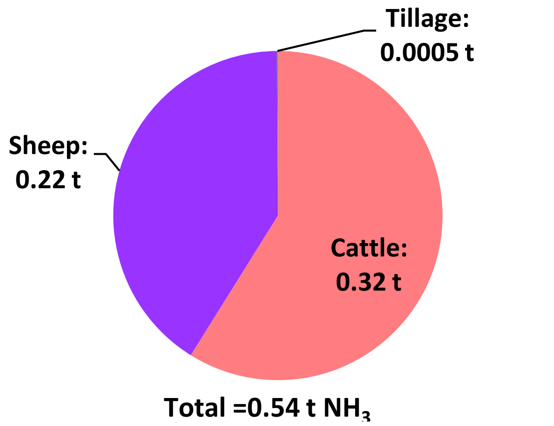
Better economic performance was also linked with lower **energy** related **GHG emissions per unit of output**, as shown in Figure 7.10. The top third of farms in economic terms emitted 0.5 kg CO_2 equivalent per kg live-weight sheep meat produced from energy based emissions, compared to 0.6 kg CO_2 for the middle and bottom third respectively.

Figure 7.10: Energy use related GHG Emissions per kg live-weight produced: Sheep Farms



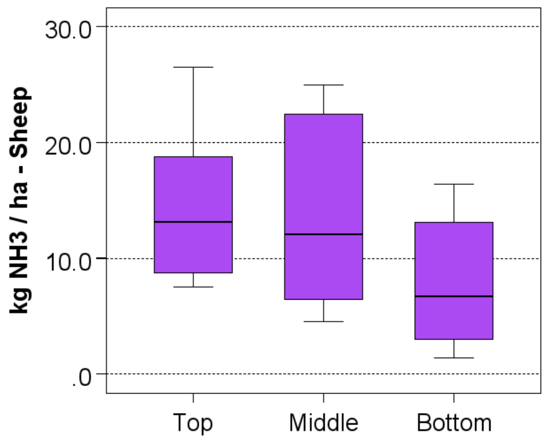
On average, specialist **sheep farms** had 0.54 tonnes of **NH_3 emissions** in 2023. Even though the main output on these farms is sheep based, the majority of the NH_3 emissions related to cattle production (59%), with 41% relating to sheep production. The remaining residual portion related to production of tillage crops.

Figure 7.11: Total Ammonia Emissions for the average Sheep Farm



On average, a specialist sheep farm emitted 12.6 kg of **NH_3 per hectare** in 2023. 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.

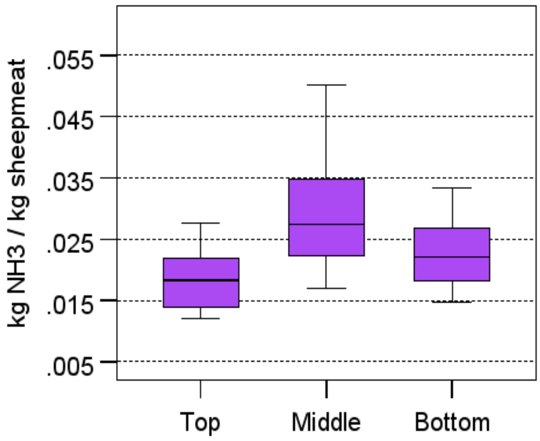
Figure 7.12: Ammonia Emissions per hectare: Sheep Farms



Lower ammonia emissions intensity of production was again more common among the better economically performing sheep farms. Farms in the top performing cohort in economic terms were found to produce a kg of live-weight sheep meat with a lower NH_3

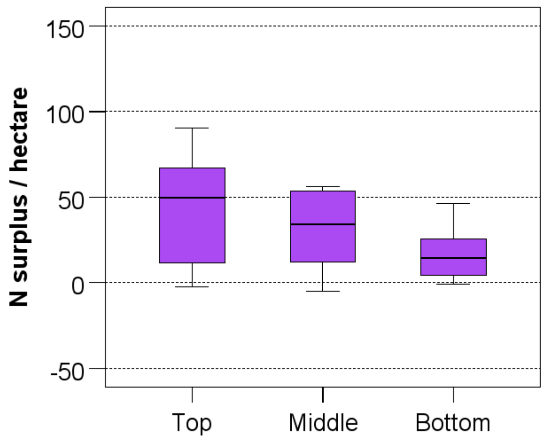
emission footprint, as shown in Figure 7.13. On average, sheep farmers produced 0.024 kg of NH_3 emissions per kg of live-weight sheep meat.

Figure 7.13: Ammonia Emissions per kg live-weight produced: Sheep Farms



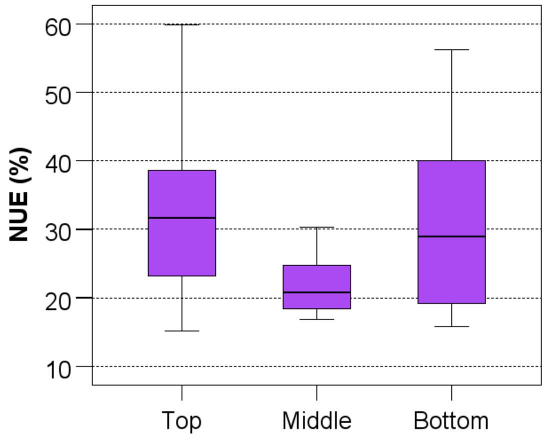
As with cattle farms, the sheep farm based **nitrogen surplus per hectare** was positively associated with economic performance, due to greater production intensity on the more profitable sheep farms (as shown in Figure 7.14). The top third of farms, ranked by gross margin per hectare, had an average nitrogen surplus of 42.9 kg per hectare, compared with 34.9 and 24.6 kg per hectare for the middle and bottom cohorts respectively.

Figure 7.14: N Balance per ha: Sheep Farms



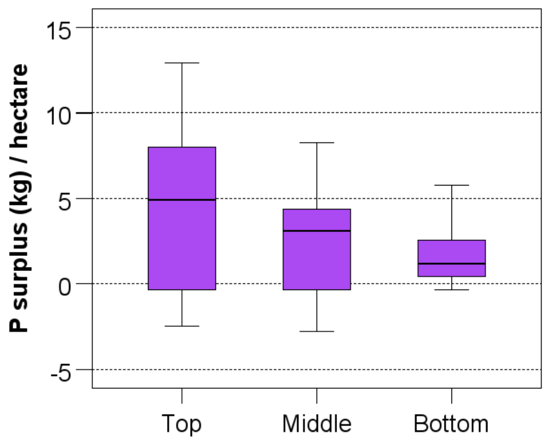
The average **N use efficiency** (NUE) across all sheep farms was 31.4%. Lower NUE was associated with middle cohort of sheep farmers as shown in Figure 7.15.

Figure 7.15: N Use Efficiency: Sheep Farms



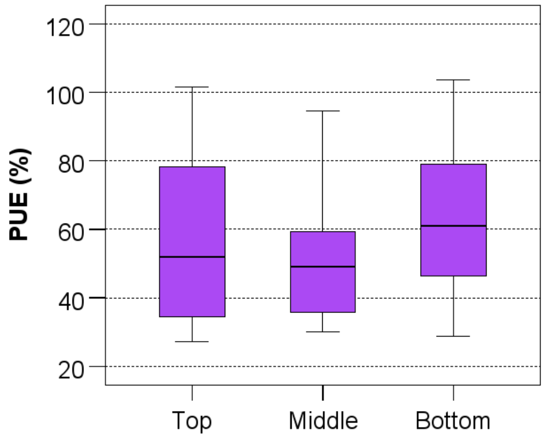
P balances across all specialist sheep farms were 2 to 5 kg per ha on average. There was a large range of results across the three cohorts, especially the top performing group, as shown by Figure 7.16.

Figure 7.16: P Balance per ha: Sheep Farms



Farm gate level **P use efficiency** (PUE) averaged 68.5% across all sheep farms in 2023. Figure 7.17 shows that higher PUE was associated with farms with better economic performance.

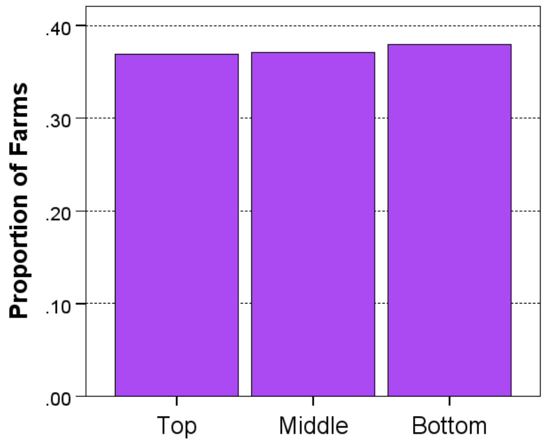
Figure 7.17: P use efficiency: Sheep Farms



Social Sustainability Indicators

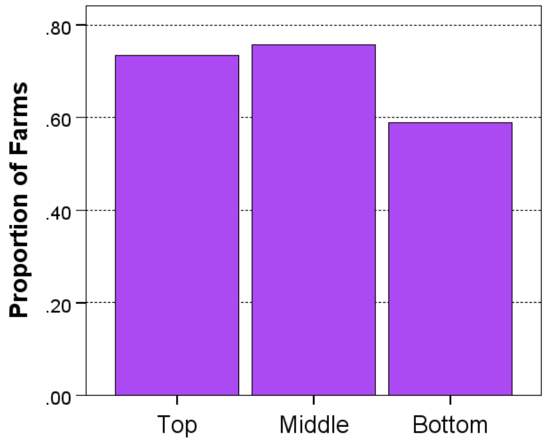
Over 38% of all sheep farm households were considered **vulnerable** in 2023. Figure 7.18 shows that levels were consistent across all three cohorts.

Figure 7.18: Household Vulnerability: Sheep Farms



Overall, 69% of sheep farmers had received formal **agricultural education**. Figure 7.19 shows that agricultural education was higher among the top and middle third of farms when ranked by economic performance.

Figure 7.19: Agricultural Education: Sheep Farms



On average, 24% of all specialist sheep farms were classified as being at **risk of isolation**. Figure 7.20 shows that this was significantly higher among the middle and bottom performing cohorts of sheep farms at 29-30%.

Figure 7.20: Isolation Risk: Sheep Farms

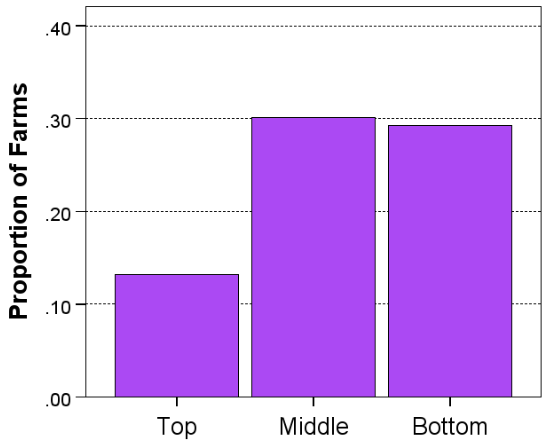
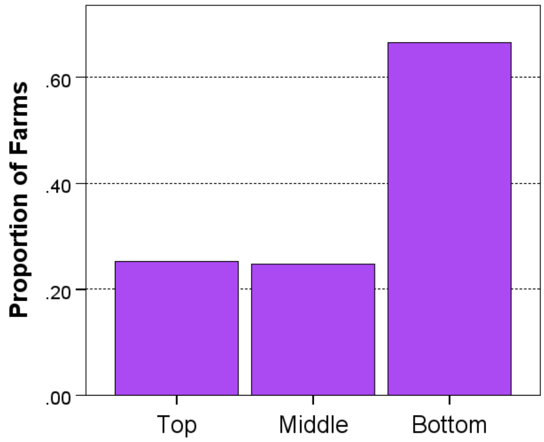


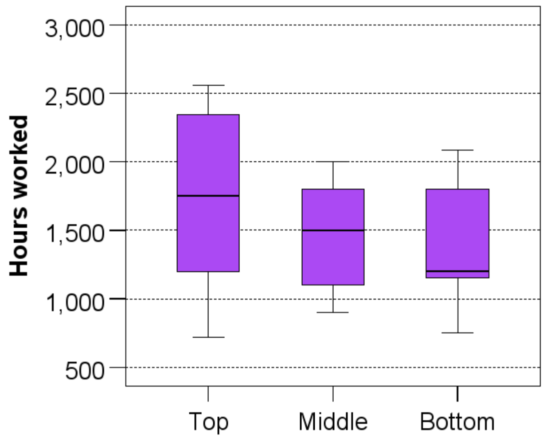
Figure 7.23 shows that the proportion of all specialist sheep farms with a high age profile was 39%. The bottom performing group had the highest age profile on average.

Figure 7.21: High Age Profile: Sheep Farms



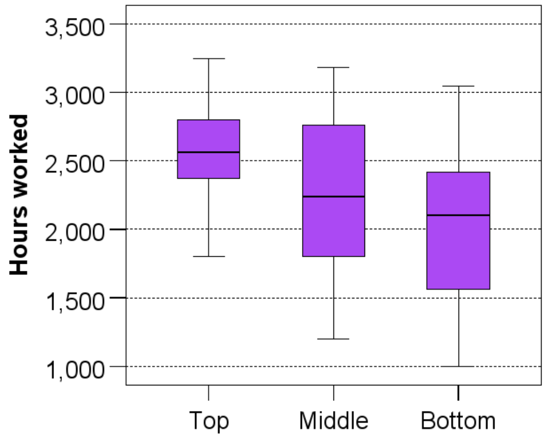
Sheep farmers had an average of 1,560 **hours worked on farm** per year in 2023 (or 29.7 hours a week). The top performing cohort tend to work the most hours on farm at 1,732, compared to 1,471 and 1,406 hours for the middle and bottom group respectively (Figure 7.22).

Figure 7.22: Hours Worked On Farm: Sheep Farm Operators



On average, in 2023, sheep farmers had 2,276 **hours worked on and off-farm work** (approximately 43.8 hours per week). Figure 7.23 shows that total hours worked was lower across the bottom cohort by economic performance.

Figure 7.23: Total Hours Worked: Sheep Farm Operator

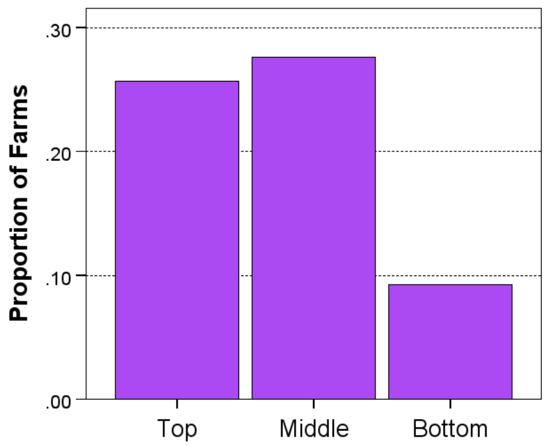


Sheep Farm Innovation Indicators

The five innovation indicators selected for sheep farms were whether at least 50% of **slurry application** occurred in the period January to 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 7.24 shows that those in the top and middle economic performing group (23 to 26%) undertook more **slurry application** in the springtime, compared to the bottom cohort (9%). However, it should be noted that sheep farms tend to be more associated with farmyard manure (i.e. solid) type storage systems, which do not lend themselves to early season application.

Figure 7.24: Spring Slurry: Sheep Farms



As illustrated in Figure 7.25, the use of protected urea fertiliser by sheep farmers was very limited. On average only 3% of chemical N fertiliser applied was in the form of protected urea in 2023.

Figure 7.25: Protected Urea use: Sheep Farms

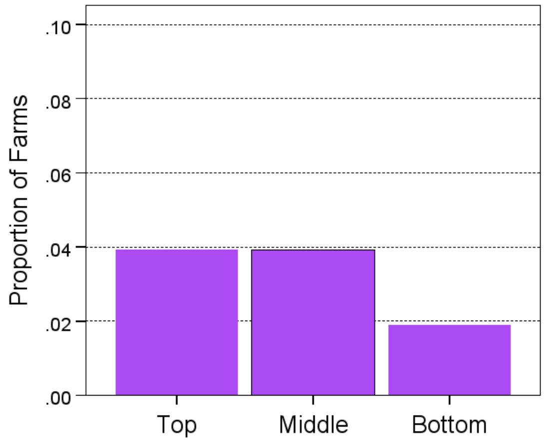


Figure 7.26 shows that **liming** activity was again more prevalent across the better economic performing farms, with 57% of the middle performing cohort by economic performance engaged in liming, compared to 15% of the bottom group.

Figure 7.26: Liming: Sheep Farms

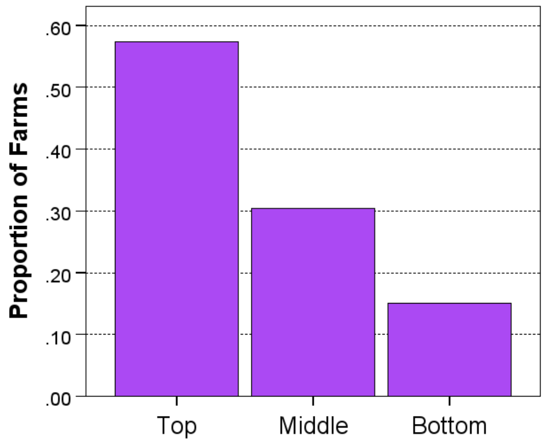


Figure 7.27 shows that higher levels of **reseeding** were associated with the sheep farms that performed better in economic terms.

Figure 7.27: Reseeding: Sheep Farms

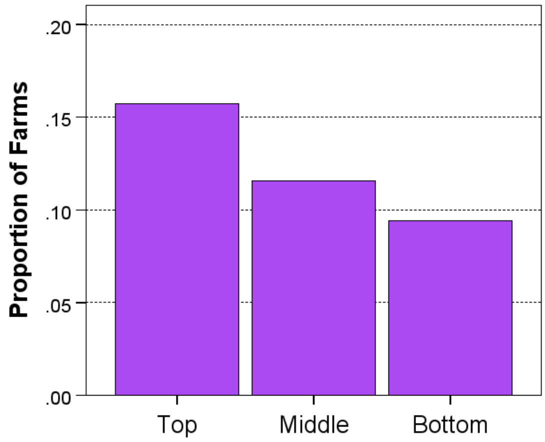
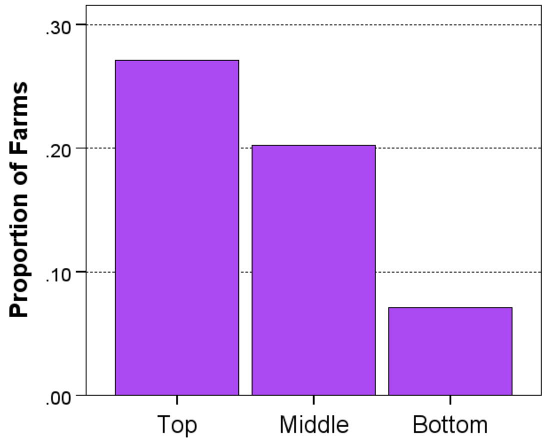


Figure 7.28 shows that membership of a **discussion group** was higher (27%) among the top cohorts versus 10% for bottom group.

Figure 7.28: Discussion Group: Sheep Farms



Tillage Farm Sustainability 2023
Key Messages

Economic

Family Farm Income fell sharply to €260 per ha

Environmental

GHG emissions per ha were unchanged on the previous year

Social

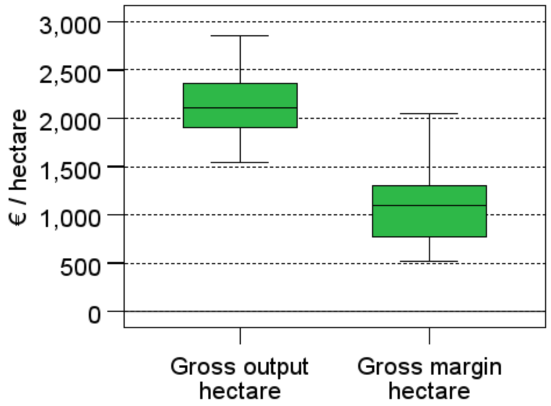
The share of households considered vulnerable rose sharply to 25%

8 Tillage Farm Sustainability 2023

Economic Sustainability Indicators

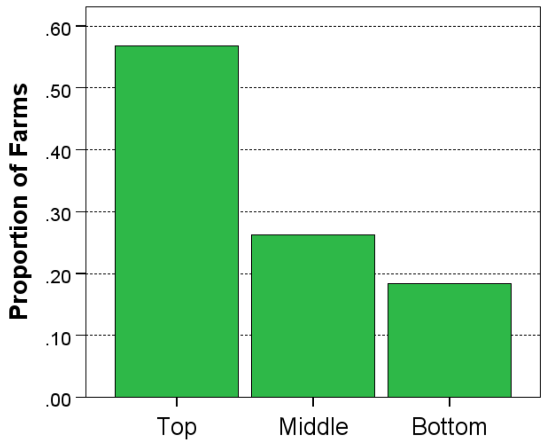
The average **gross output** and **gross margin per hectare** for tillage farms was €2,171 and €1,154 respectively in 2023. However, there was a large distribution around the average, as illustrated by Figure 8.1.

Figure 8.1: Economic Return and Profitability of Land: Tillage Farms



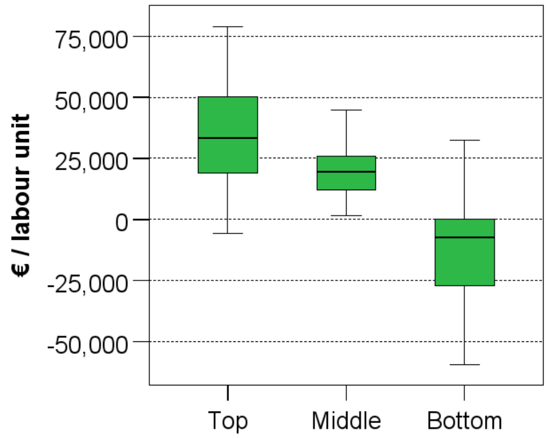
In 2023, 34% of tillage farms were classified as economically **viable**. Figure 8.2 shows that the bottom group had lower levels of viability, at 18% compared to 57% for the top performing group.

Figure 8.2: Economic Viability: Tillage Farms



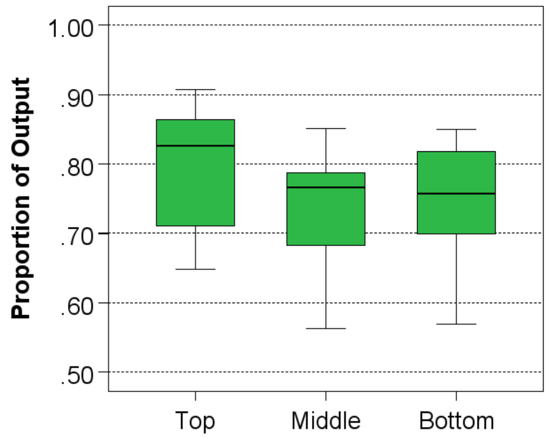
The average tillage **farm income per unpaid labour unit** (for unpaid family labour) was €19,506 in 2023. Figure 8.3 shows that there is a large range in incomes on tillage farms, with the top one-third (ranked by gross margin per hectare) earning significantly more than the middle and bottom cohorts per labour unit provided. For some of the most profitable tillage farms, income per family 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



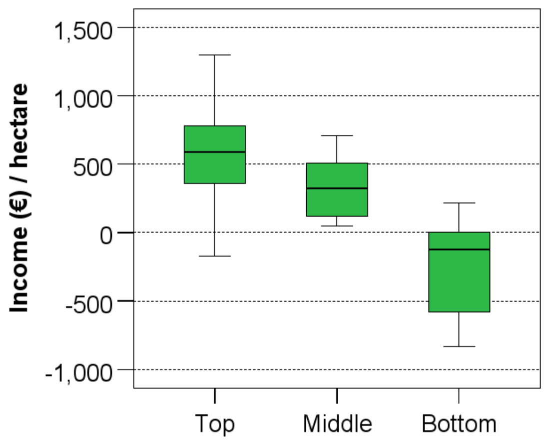
In 2023, on average tillage farms generated 75% of their output value from the market on average. Figure 8.4 shows that the top third of tillage farms had a **market orientation** of 79% compared to 74% for the bottom group on average.

Figure 8.4: Market Orientation: Tillage Farms



The **average family farm income per hectare** on tillage farms was €260 in 2023. Median income ranged from €639 from the top performing cohort to -€123 for the bottom performers economically. Figure 8.5 shows significant ranges in income per hectare across the three groups.

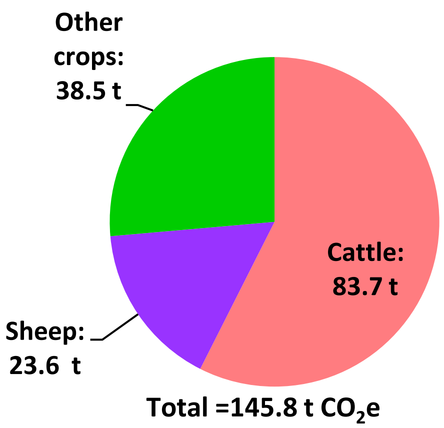
Figure 8.5: Family Farm Income per hectare: Tillage Farms



Environmental Sustainability Indicators

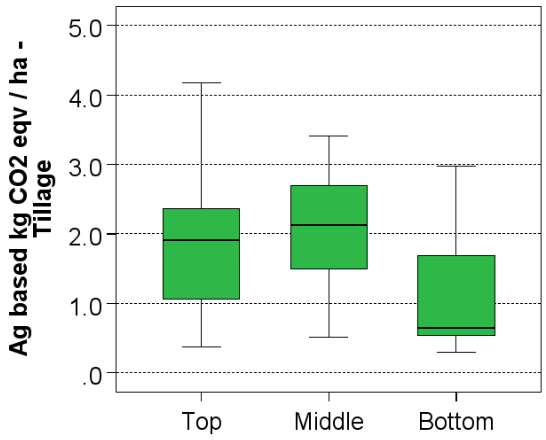
The average **tillage farm** produced 145.8 tonnes CO_2 equivalent of agricultural **GHG emissions** in 2023 as illustrated in Figure 8.6. However, only 26.4% of GHG emissions on these farms were generated from crop production. Despite being specialised in crop production, 57.4% of tillage farm emissions were from cattle present on these farms, with a further 16.2% from sheep.

Figure 8.6: Agricultural GHG Emissions for the average Tillage Farm



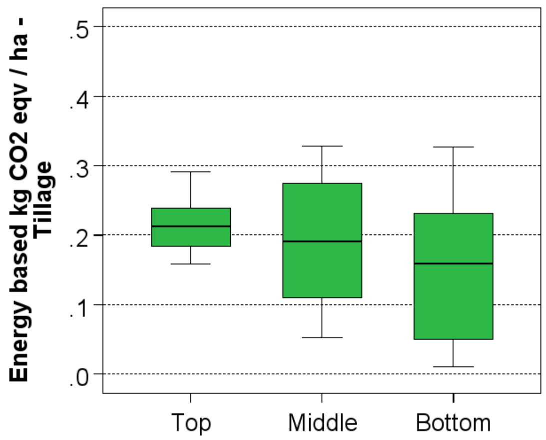
The average specialist tillage farm had agricultural **GHG emissions** of 1.9 tonnes CO_2 equivalent **per hectare** in 2023. Emissions per hectare tended to be lower for the better performing economic cohorts as illustrated by Figure 8.7.

Figure 8.7: Agricultural GHG Emissions per hectare: Tillage Farms



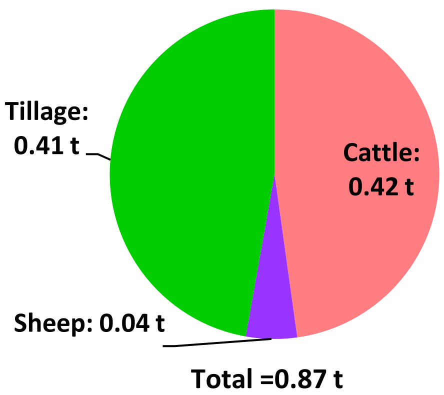
Specialist tillage farms on average produced 0.21 tonnes of **energy based GHG emissions per hectare** in 2023. Higher emissions per hectare were associated with higher economic performance as illustrated in Figure 8.8.

Figure 8.8: Energy GHG Emissions per hectare: Tillage Farms



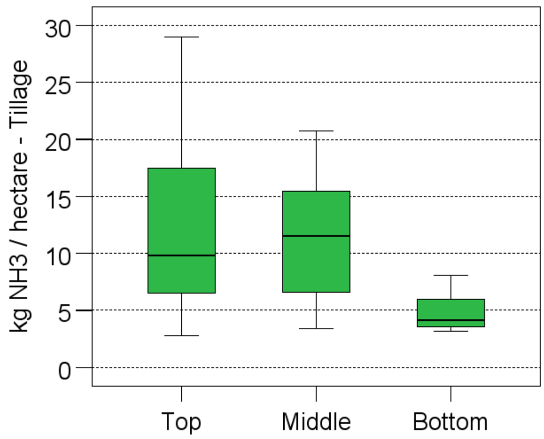
Tillage farms on average had **NH_3 emissions** of 0.87 tonnes in 2023. Again, even though the main farm output on such farms is crop related, the bulk of NH_3 emissions are associated with cattle rearing, at 47.8%. Of the remaining emissions, 47.2% were associated with tillage production and 5% with a sheep enterprise.

Figure 8.9: Total Ammonia Emissions for the average Tillage Farm



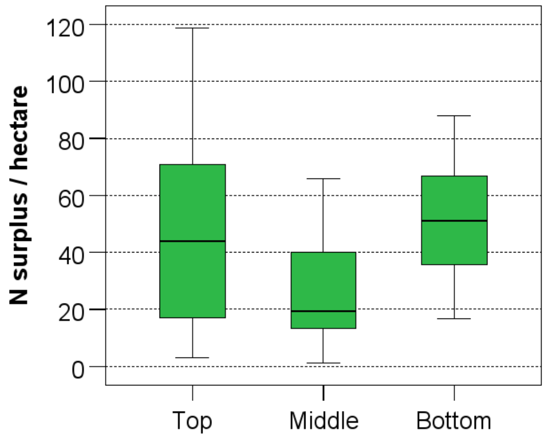
The average specialist tillage farm emitted 10.7 kg of **NH_3 per hectare** in 2023. Emissions per hectare were highest for the top and middle cohorts.

Figure 8.10: Total Ammonia Emissions per hectare: Tillage Farms



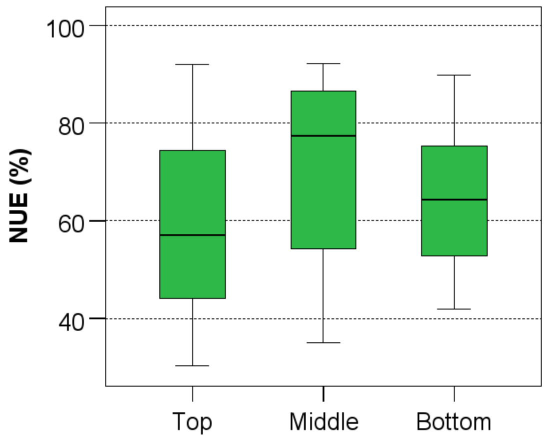
The average N surplus was 45.8 kg per hectare, but there was a large range in the farm results as seen in Figure 8.11. The bottom cohort indicated higher N surpluses per hectare on average.

Figure 8.11: N Balance per hectare: Tillage Farms



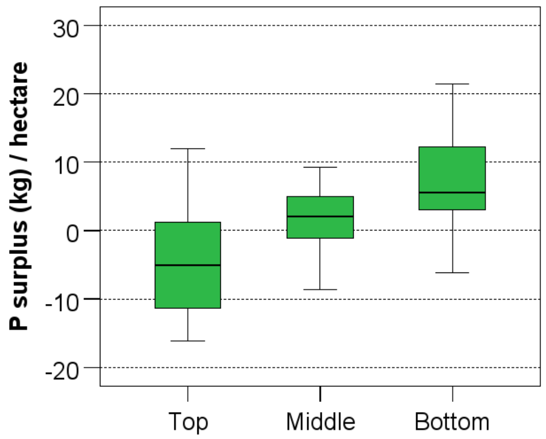
Across all tillage farms, the average **N use efficiency** (NUE) was 65.7%. There was a large distribution in NUE across the three groups as illustrated in Figure 8.12.

Figure 8.12: N Use Efficiency: Tillage Farms



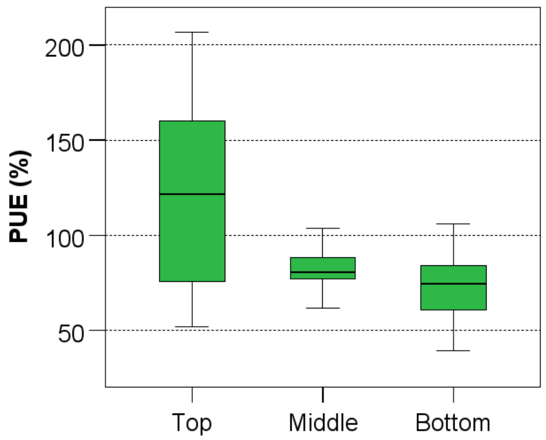
The average **P balance** across all tillage farms was 2.1 kg per hectare. However, as illustrated in Figure 8.13, there was again a large range of results around these group averages. Better farms, in economic terms, tended to have slightly lower P balances.

Figure 8.13: P Balance per hectare: Tillage Farms



P use efficiency (PUE) averaged 93.8% across all tillage farms. PUE tended to be higher across the top performing group, compared to the middle and bottom cohorts, as illustrated by Figure 8.14.

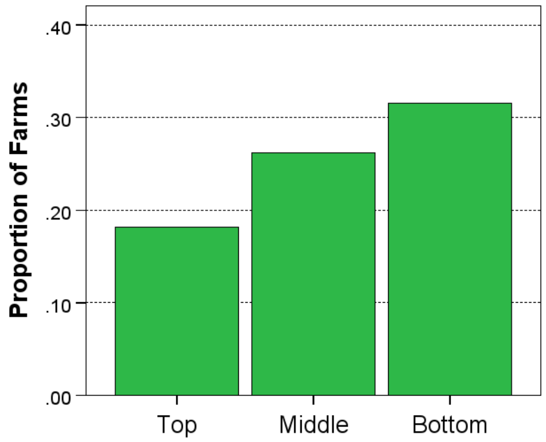
Figure 8.14: P Use Efficiency: Tillage Farms



Social Sustainability Indicators

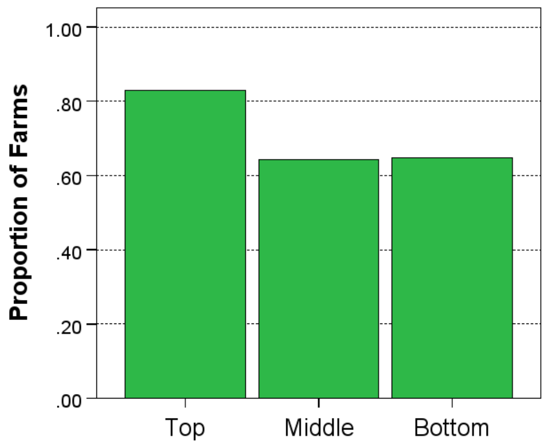
On average, 25% of tillage farm households are considered economically **vulnerable**. Figure 8.15 indicates that household vulnerability was highest across the bottom cohort, at 31% compared to 18% for the top performing cohort.

Figure 8.15: Household Vulnerability: Tillage



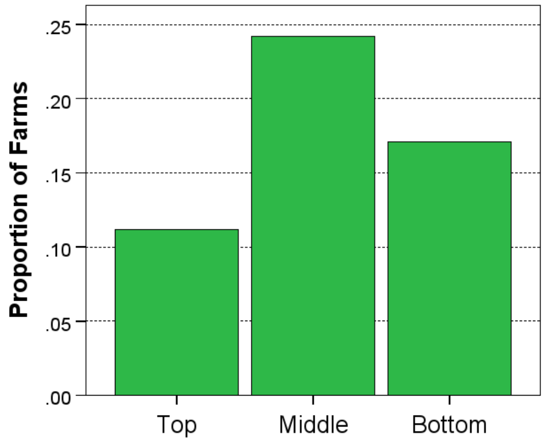
A total of 71% of tillage farmers had received some level of formal **agricultural education** or training. Figure 8.16 shows that this rate was higher for the better performing tillage farms economically.

Figure 8.16: Agricultural Education: Tillage Farms



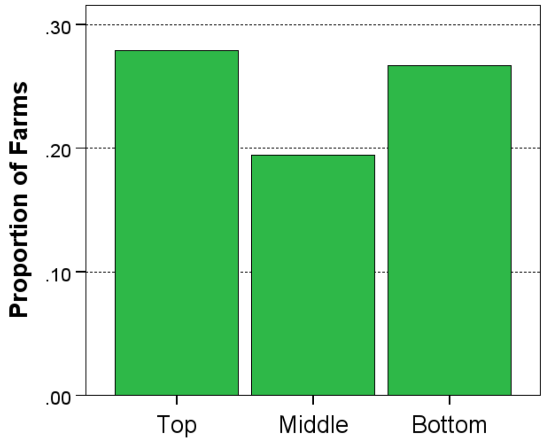
Overall, 17% of tillage farms were identified as being at **risk of isolation** (i.e. where the farm operator lived alone). At 24%, this rate was highest for the middle performing cohort, as illustrated by Figure 8.17.

Figure 8.17: Isolation Risk: Tillage Farms



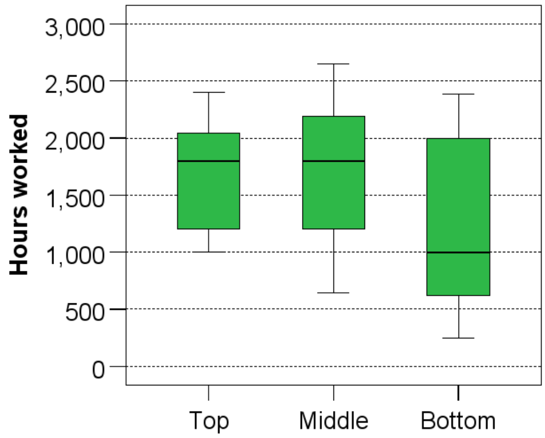
An average of 25% of tillage farms were identified as having a **high age profile**. Figure 8.18 shows that the top and bottom cohorts had 26-27% of farm households with a high age profile.

Figure 8.18: High Age Profile: Tillage Farms



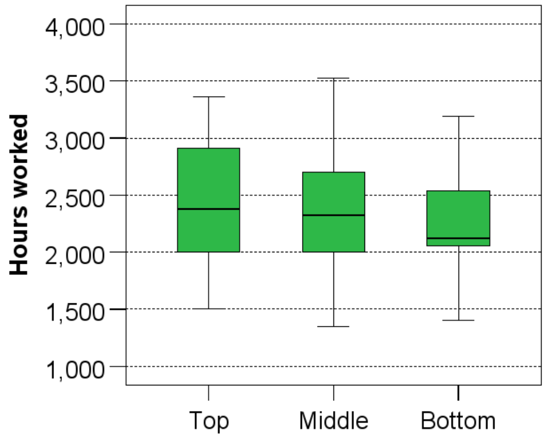
The average tillage farmer had 1,529 **hours worked on farm** in 2023 (29.4 hours per week). However, Figure 8.19 shows that there is significant variables in results across the different cohorts.

Figure 8.19: Hours Worked on Farm: Tillage Farms



On average, tillage farmers had 2,345 **hours worked on and off-farm** per year in 2023 (approximately 45 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

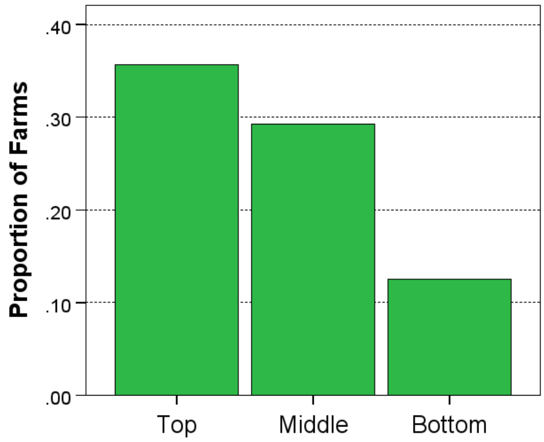


Tillage Innovation Indicators

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 and middle performing cohorts (29-36%) compared to the bottom (13%) performing cohort.

Figure 8.21: Liming: Tillage Farms



On average between 22% of tillage farms were in **discussion groups**. This ranged from 21-26% for the middle and top group compared to 19% for bottom performing cohort. However, this includes all types of discussion groups (e.g. beef and sheep).

Figure 8.22: Discussion Group: Tillage Farms

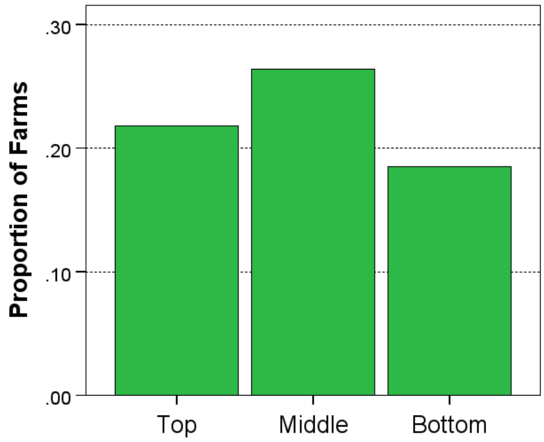
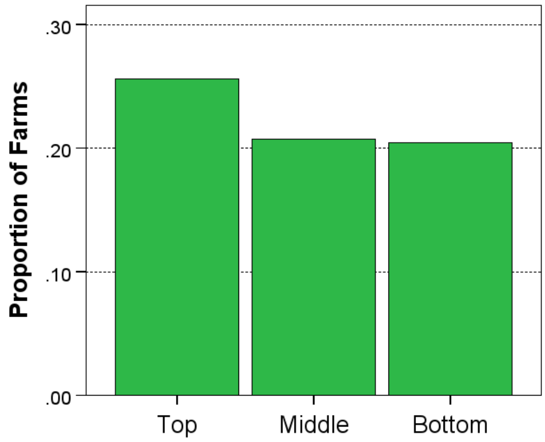


Figure 8.23 shows that on average 22% of specialist tillage farmers grew a **break crop**. The figure was highest among the top performing cohort at 26%.

Figure 8.23: Break Crops: Tillage



Farm System Comparisons 2023
Key Messages

Economic

Profitability on Dairy, Tillage and Sheep farms fell sharply, but remained unchanged on Beef farms

Environmental

GHG emissions per ha fell on Dairy farms, but remained relatively stable in other farm systems

Social

The rate of household vulnerability remained high on Beef and Sheep farms and while less severe, showed an increase on Diary and Tillage farms

9 Farm System Comparisons 2023

Economic Indicators

A comparison of economic sustainability indicators across different farm types is shown in Figure 9.1. Even though the profitability of milk production was low by reference to recent years in 2023, specialist dairy farms still showed 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.

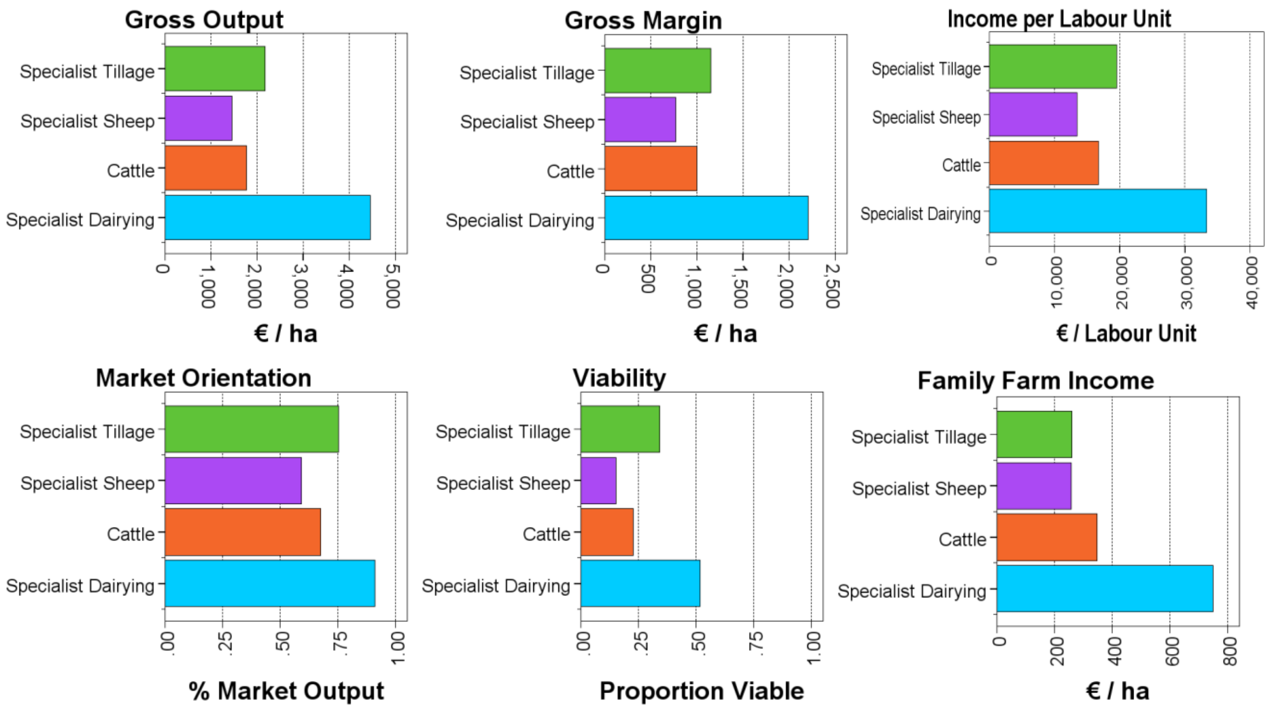
Output, Margins and Income: A poor year for tillage production and prices in 2023, meant that tillage farms were only slightly ahead of both cattle and sheep farms in terms of gross output, gross margin and family farm income per hectare. Tillage, sheep and cattle farms returned significantly lower income per labour unit in comparison to dairy farms and tillage farms in 2023.

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 14% of sheep farms and 23% of cattle farms classed as economically viable in 2023. Dairy farms were the most economically viable (52%), followed by tillage systems (34%).

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 2023 (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.

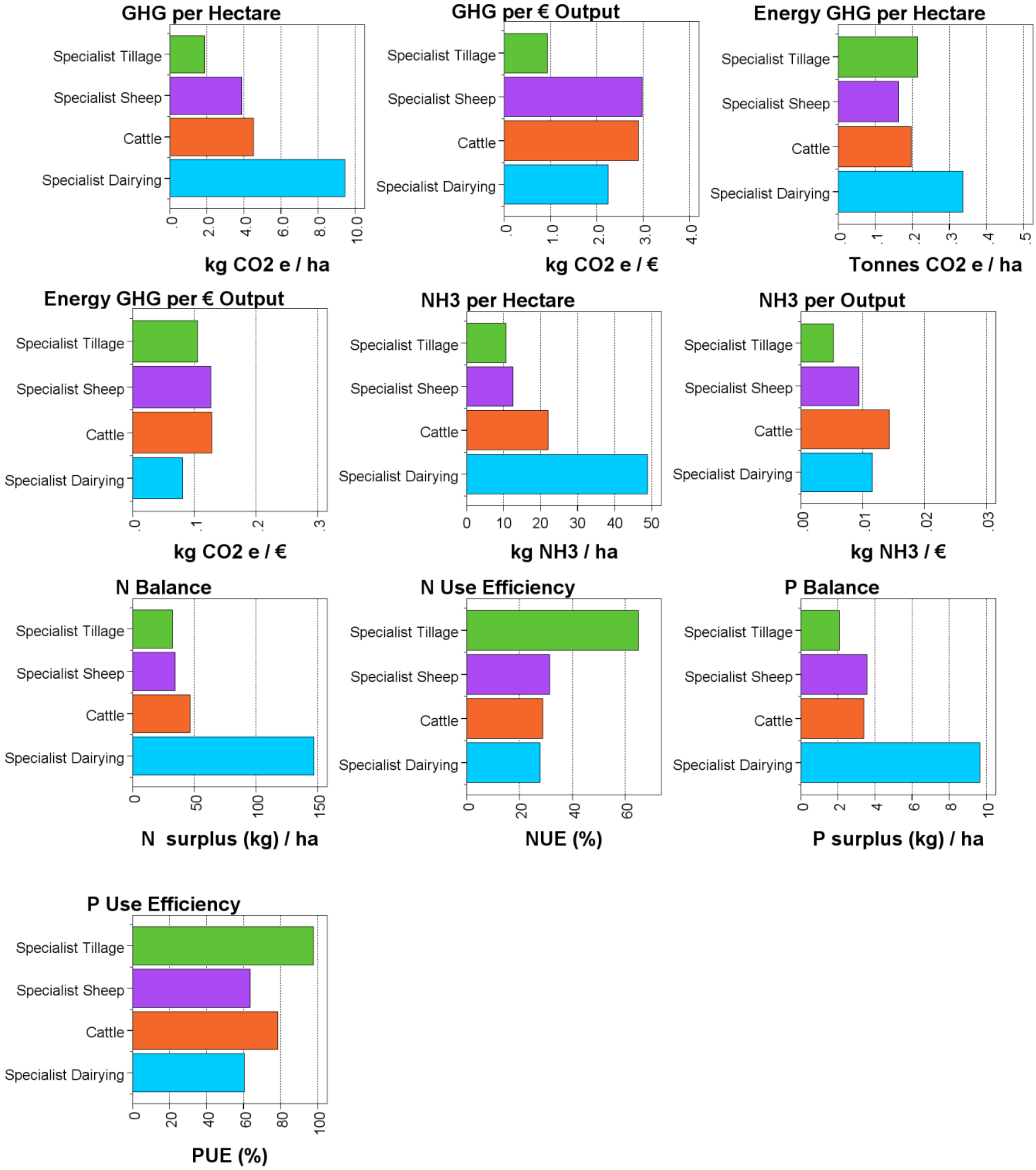
Greenhouse Gas Emissions: Animal based farming systems typically have higher greenhouse gas emissions per hectare than tillage systems, but this is to be expected due to the greater emissions associated with animal as opposed to crops production, especially in ruminant systems. Dairy farms show the highest emissions on a per hectare basis, significantly greater (double) than any other system. This is attributable to the greater production intensity on these farms. The higher level of dairy emissions per hectare, compared to other farm systems is a function of higher stocking rates, more energy intensive diets for dairy cows and greater use of chemical fertilisers than is found in other livestock systems. In terms of kg of GHG emissions per euro of output generated, livestock farms (especially cattle) had much higher emissions due to the lower value of output generated in beef and sheep production 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 (more than double). Cattle farms had the next highest level of emissions per hectare (though on average these were less than half those of the average dairy farms) followed by sheep and tillage farms. In terms of ammonia (NH_3) emissions per euro of market output generated, cattle farms exhibited the highest ammonia emissions intensity (due to the generally lower levels of output) followed by sheep farms. Tillage farms have the lowest level of ammonia emission per euro of output generated due to the low number of livestock on these farms on average.

Nitrogen use: Dairy farms have the largest N surplus per hectare due to the higher livestock production intensity per hectare in this system. In terms of the input-output accounting NUE metric, dairying is more similar to the other livestock systems (but still lower), 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 in tillage production is not cycling through an animal (and hence is not subject to the various loss pathways).

Phosphorus use: Dairy farms also had the highest level of farm gate 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 the optimal P balance on a farm 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 2023 (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.

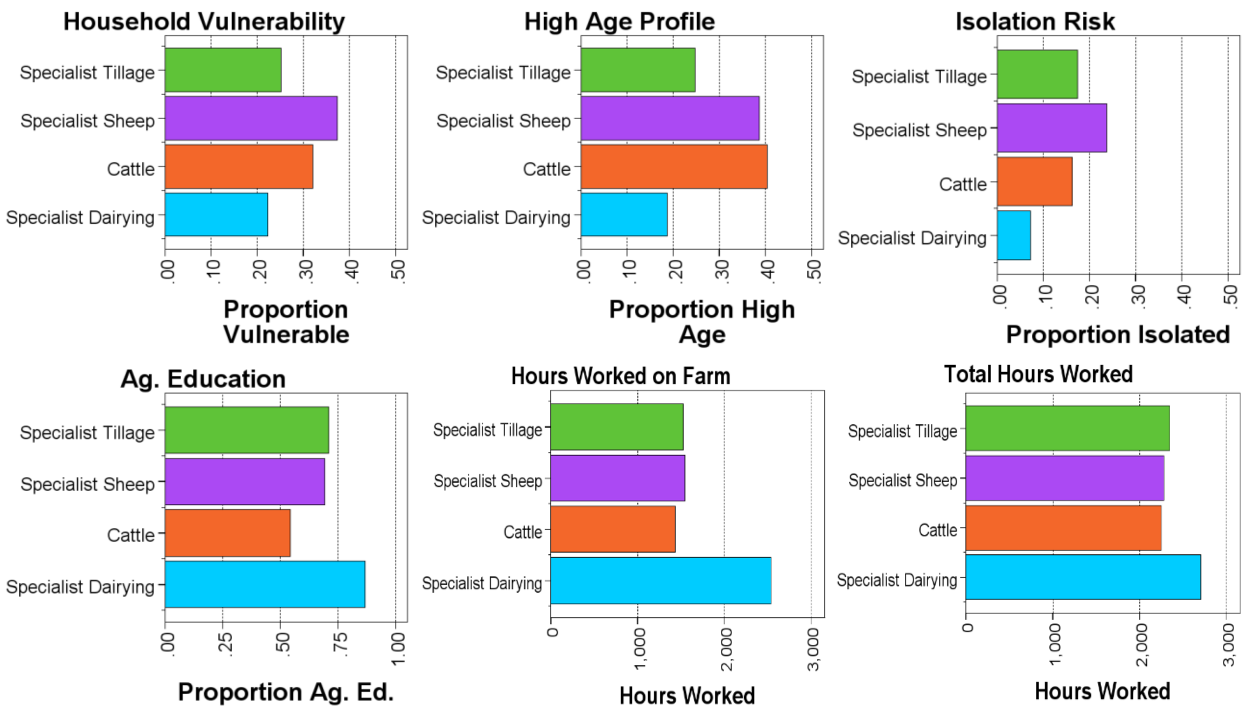
Hours Worked: The greater labour intensity of dairying is illustrated by the longer hours worked on farm. When accounting for total hours worked (on and off-farm employment), dairy farmers still have the highest number of hours worked on average, but the gap between dairy farms and other farm systems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

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 farm business 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 tillage farms were more likely to be operated by farmers living alone. However, there was less variation within these measures than for other social sustainability indicators.

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

Figure 9.3: Social Sustainability: Farm System Comparison 2023 (average per system)



Time Series Comparisons by Farm System Key Messages

Economic

The decline in Dairy and Tillage farm incomes brought income levels closer to those on Beef and Sheep farms

Environmental

Key environmental indicators remained relatively stable

Social

Household vulnerability reached unusually high levels on Dairy and Tillage farms, but remained below the levels found on Beef and Sheep farms

10 Time Series Comparisons with a three year rolling average: 2018-2023

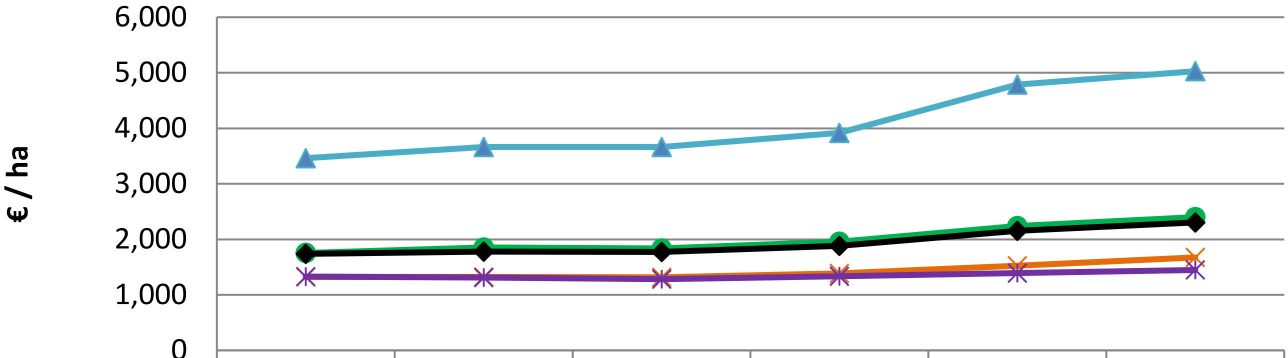
Building on research presented in previously published Teagasc Sustainability reports (Hennessy et al., 2013; Lynch et al., 2016; Buckley and Donnellan., 2019; 2020a; 2020b; 2021; 2022, 2023), the evolution of farm-level sustainability indicators can be tracked over time. The figures presented below 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 2018 is based on the average of the years 2016 to 2018 inclusive and is labelled as such). For reference, the **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 annual data contain 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, especially towards the end of the study period. Tillage farmers were next highest, ahead of cattle and sheep systems. Additionally over the period studied the rate of growth in output value per hectare on dairy farms was considerably higher than on all other farm types. It should be noted that some of the increases in moving averages observed, particularly on dairy farms relates to the increase in the price of milk in some recent years rather than the volume of output produced.

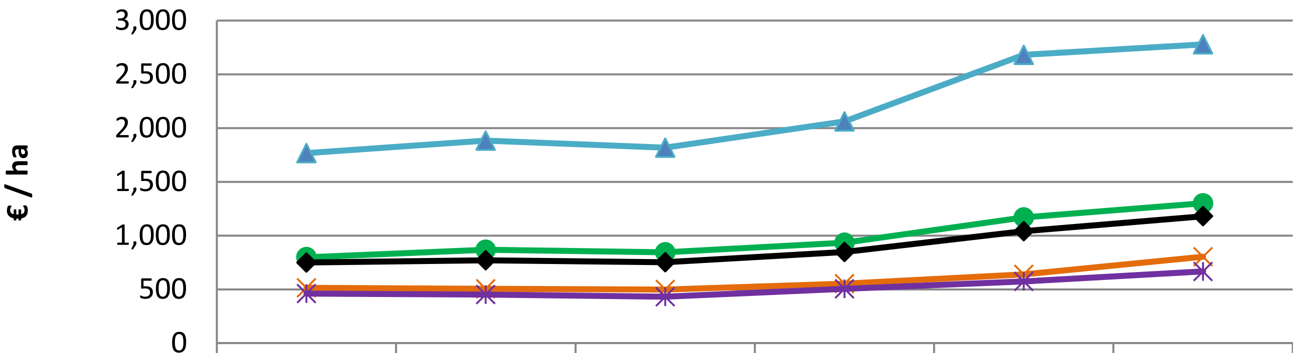
Figure 10.1: Economic Returns to Land: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	3,462	3,661	3,664	3,918	4,785	5,027
Cattle	1,323	1,321	1,316	1,388	1,527	1,674
Sheep	1,331	1,312	1,283	1,334	1,394	1,448
Tillage	1,754	1,852	1,838	1,959	2,240	2,400
All Farms	1,738	1,780	1,776	1,882	2,154	2,305

The profitability of land (gross margin per hectare) in dairying is again significantly higher than for all other systems and tended to increase over the years, significantly so at the end of the study period. Tillage farms again 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.

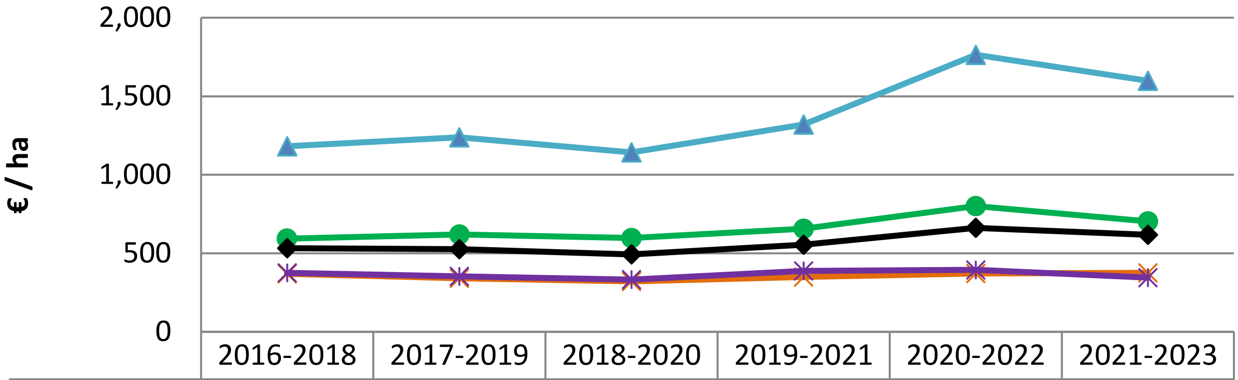
Figure 10.2: Profitability of Land: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	1,767	1,882	1,817	2,061	2,682	2,778
Cattle	512	506	497	553	640	803
Sheep	461	451	431	505	574	666
Tillage	797	867	845	935	1,167	1,301
All Farms	750	771	752	848	1,042	1,179

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 again ranked second. The lowest family farm income per hectare are on cattle and sheep farms, as illustrated by Figure 10.3. The family farm income on dairy, in particular, as well as other farms was seen to significantly increase towards the end of the study period but prices shocks in 2023.

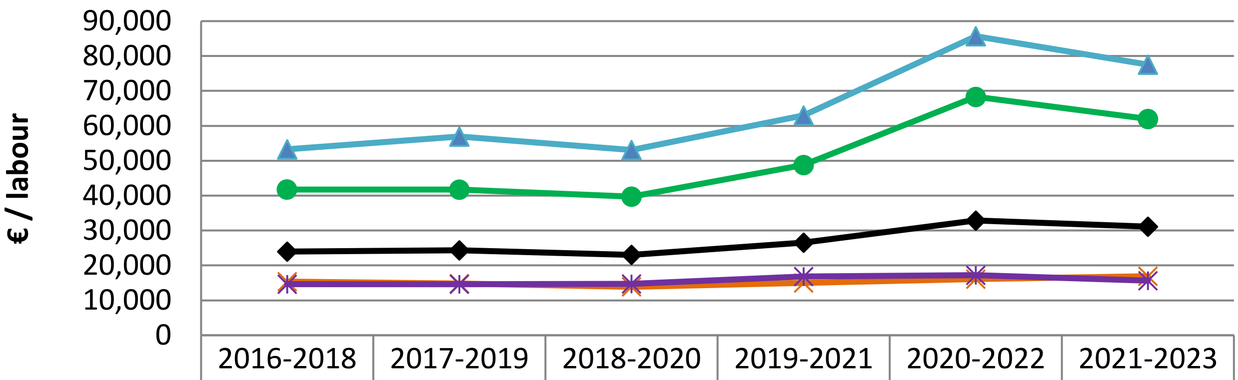
Figure 10.3: Family Farm income: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	1,182	1,239	1,143	1,321	1,764	1,598
Cattle	369	341	321	350	371	376
Sheep	376	354	332	388	395	345
Tillage	593	619	597	657	801	704
All Farms	532	525	493	556	662	619

Figure 10.4 illustrates that farm income per unpaid labour unit broadly follows a similar trend to the gross output, gross margin and family farm income per hectare indicators. However, the differences between farm types when income per family labour unit is considered are less pronounced relative to the differences in gross output, gross margin and family farm income per hectare. This is due to the adjustment made 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. Again, returns to labour at the end of the study period were affected by income pressures in 2023.

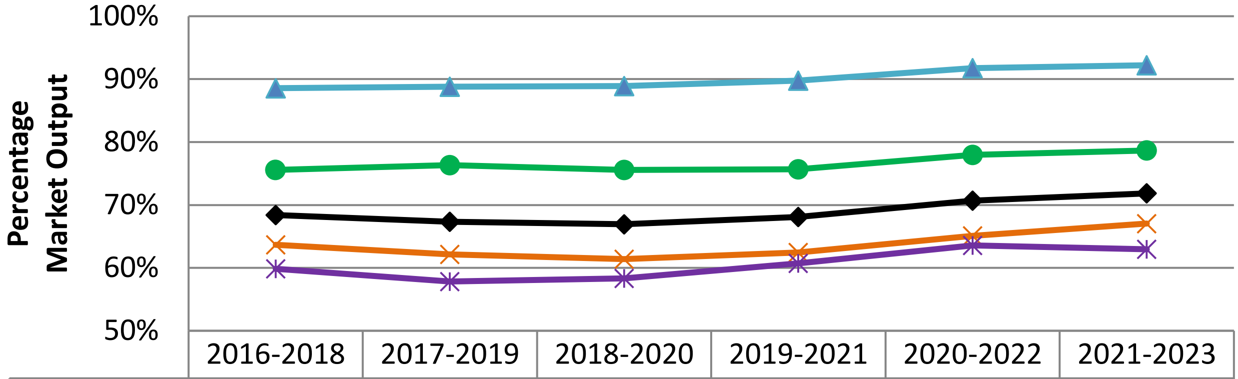
Figure 10.4: Productivity of Labour: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	53,300	56,961	53,082	62,959	85,677	77,516
Cattle	15,361	14,792	13,866	15,008	16,082	16,913
Sheep	14,676	14,614	14,757	16,844	17,220	15,673
Tillage	41,734	41,734	39,716	48,799	68,333	61,989
All Farms	24,001	24,330	23,024	26,522	32,883	31,132

Figure 10.5 illustrates that dairying is the most market orientated of all the systems (89 to 92%) followed by tillage systems (76 to 79%). The market orientation of cattle and sheep systems was the lowest at between 58% and 67%.

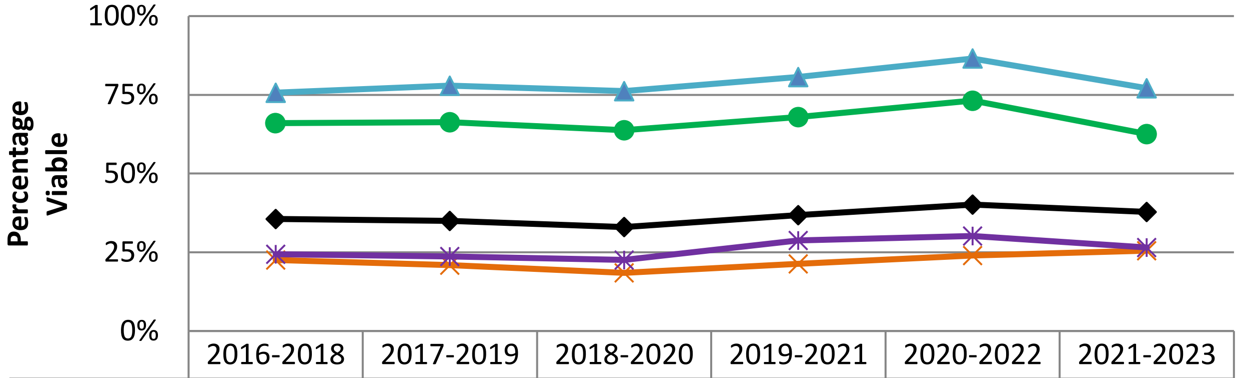
Figure 10.5: Percentage of Output Derived from Market: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	89%	89%	89%	90%	92%	92%
Cattle	64%	62%	61%	62%	65%	67%
Sheep	60%	58%	58%	61%	64%	63%
Tillage	76%	76%	76%	76%	78%	79%
All Farm	68%	67%	67%	68%	71%	72%

The same trends over time are also observed in terms of farm economic viability. Dairy and tillage systems have significantly higher levels of viability compared to cattle or sheep farms over the period examined. Viability, as with the other economic indicators, is effected by variations in sectoral input and output prices over the period.

Figure 10.6: Economic Viability: 3 year rolling average 2018-2023

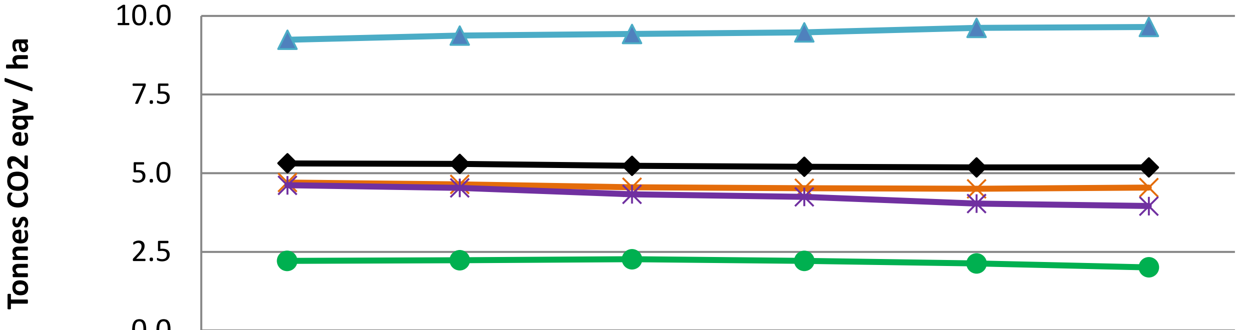


	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	76%	78%	76%	81%	87%	77%
Cattle	23%	21%	18%	21%	24%	26%
Sheep	24%	24%	23%	29%	30%	26%
Tillage	66%	66%	64%	68%	73%	63%
All Farm	36%	35%	33%	37%	40%	38%

10.2 Environmental sustainability indicators

Figure 10.7 shows that the overall farm average agricultural GHG emissions per hectare have stabilised over the study period (5.2 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 2 to 4 times higher compared to other farm systems. The main trends observed are a slight increase in dairy emissions per hectare and the relative stability or reduction in emission intensity per hectare across the other farm systems.

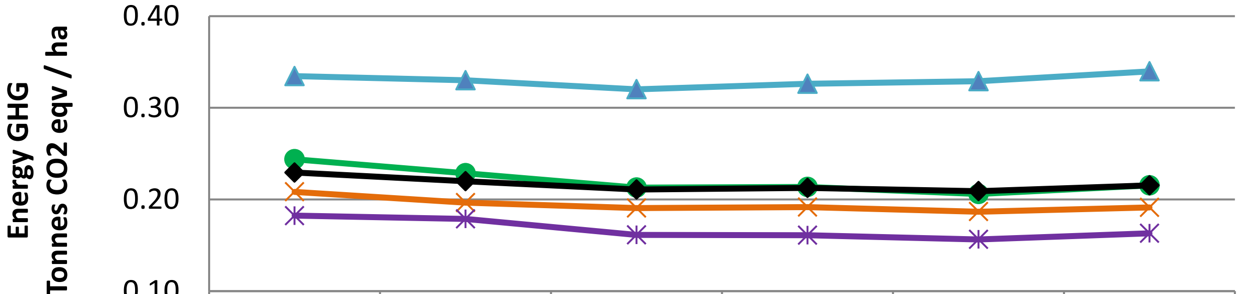
Figure 10.7: Ag. Greenhouse Gas Emissions per hectare: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2019-2022	2021-2023
Dairy	9.2	9.4	9.4	9.5	9.6	9.6
Cattle	4.7	4.6	4.6	4.5	4.5	4.5
Sheep	4.6	4.5	4.3	4.2	4.0	4.0
Tillage	2.2	2.2	2.3	2.2	2.1	2.0
All Farms	5.3	5.3	5.2	5.2	5.2	5.2

Figure 10.8 shows that energy based GHG emission have generally remained stable over the study period. Energy based emissions were highest on dairy farms, since they are greater users of fuel and electricity.

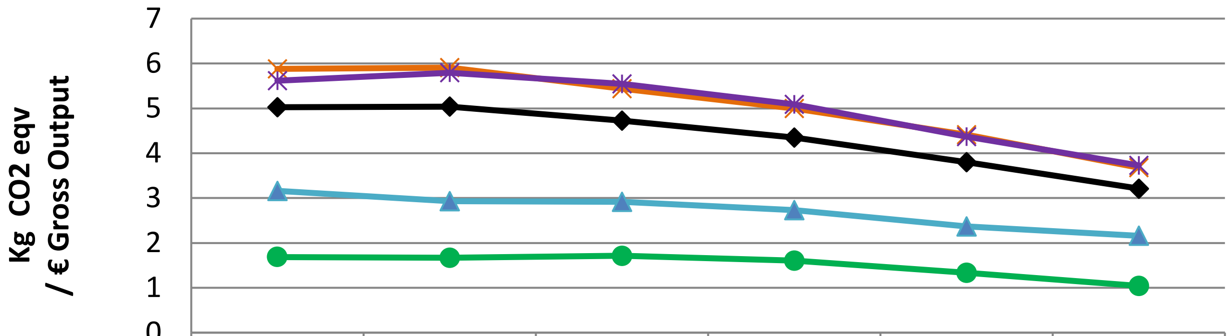
Figure 10.8: Energy Greenhouse Gas Emissions per hectare: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	0.33	0.33	0.32	0.33	0.33	0.34
Cattle	0.21	0.20	0.19	0.19	0.19	0.19
Sheep	0.18	0.18	0.16	0.16	0.16	0.16
Tillage	0.24	0.23	0.21	0.21	0.21	0.22
All Farms	0.23	0.22	0.21	0.21	0.21	0.22

Figure 10.9 illustrates indicates that emissions per euro of output generated are significantly higher across livestock rearing farms. These results are reflective of the greater value of output produced in dairying and the lower emissions associated with tillage. The increase in dairy emissions per hectare, shown in Figure 10.7, is not reflected in a similar evolution in the emissions per euro output here as output prices have increased significantly towards the end of the study period as illustrated in Figure 10.9. It should be noted that agricultural output prices have increased by over 43% between 2016 and 2023 (CSO, 2024).

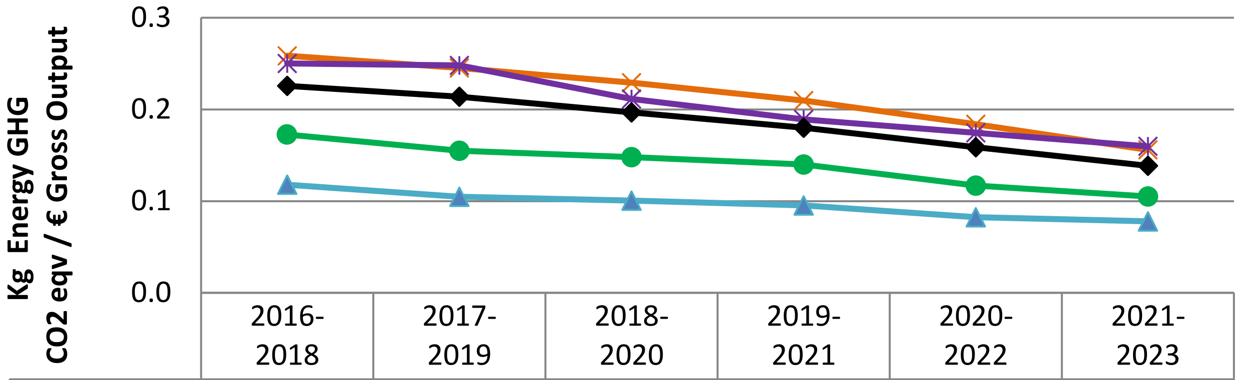
Figure 10.9: Ag. GHG Emissions per Euro output: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	3.2	2.9	2.9	2.7	2.4	2.2
Cattle	5.9	5.9	5.4	5.0	4.4	3.7
Sheep	5.6	5.8	5.5	5.1	4.4	3.7
Tillage	1.7	1.7	1.7	1.6	1.3	1.0
All Farms	5.0	5.0	4.7	4.3	3.8	3.2

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/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. Again, it should be noted that noted that agricultural output prices have increased by over 43% between 2016 and 2023 (CSO, 2024).

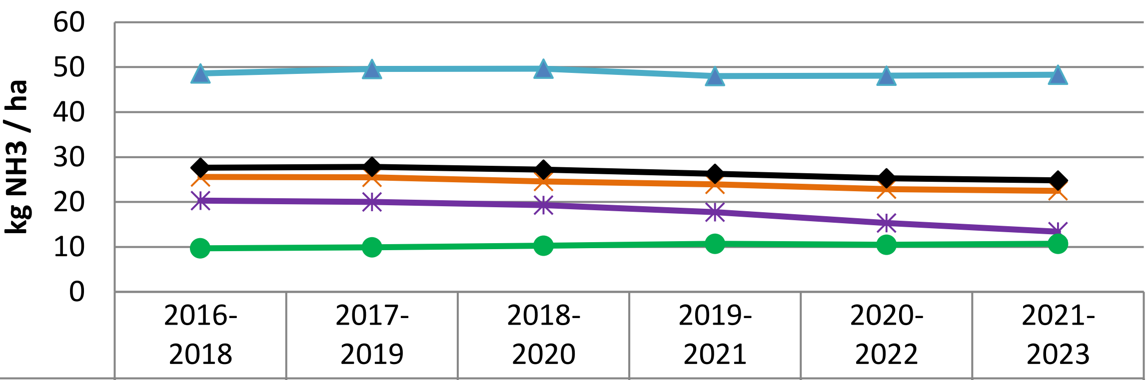
Figure 10.10: Energy related GHG Emissions per Euro output: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	0.12	0.10	0.10	0.10	0.08	0.08
Cattle	0.26	0.25	0.23	0.21	0.18	0.16
Sheep	0.25	0.25	0.21	0.19	0.17	0.16
Tillage	0.17	0.15	0.15	0.14	0.12	0.11
All Farms	0.23	0.21	0.20	0.18	0.16	0.14

Figure 10.11 illustrates that on a three-year rolling average basis across all farms, ammonia (NH_3) emissions per hectare increased slightly over the early part of the study period before levelling off and then decreasing slightly towards the end of the period. 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.

Figure 10.11: Kg of Ammonia Emissions per hectare: 3 year rolling average 2018-2023

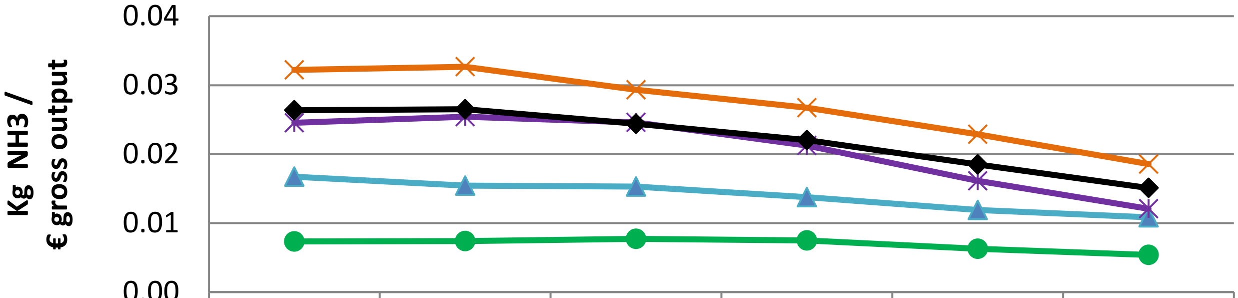


	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	48.6	49.6	49.7	48.0	48.1	48.3
Cattle	25.6	25.5	24.6	23.9	22.9	22.5
Sheep	20.3	20.0	19.3	17.7	15.3	13.4
Tillage	9.7	9.9	10.3	10.7	10.5	10.7
All Farms	27.7	27.8	27.2	26.3	25.3	24.8

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 and sheep farms compared to all other systems over the study period. This is a function of the low levels of output on these farms. Dairy had the second lower levels of NH_3 emissions per euro of output generated (due to high output value). Tillage farms had the

lowest emissions per euro of market based output. Again, it should be noted that agricultural output prices have increased by over 43% between 2016 and 2023 (CSO, 2024).

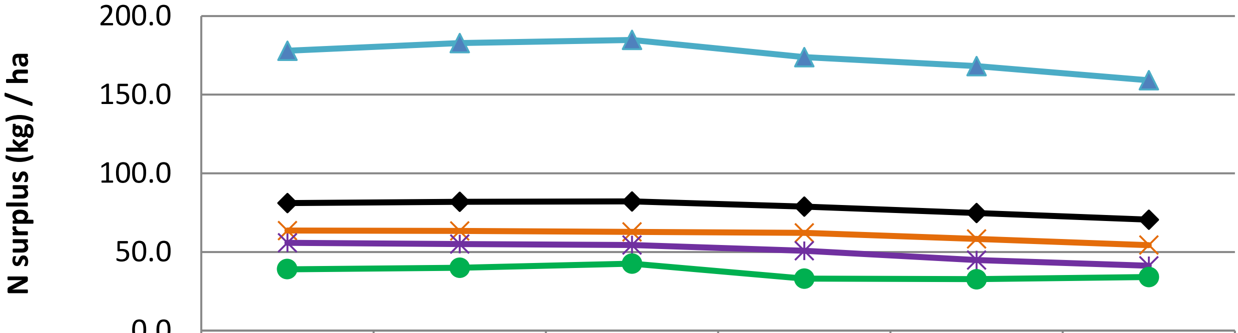
Figure 10.12: Ammonia (NH_3) Emissions per Euro Output: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	0.017	0.015	0.015	0.014	0.012	0.011
Cattle	0.032	0.033	0.029	0.027	0.023	0.019
Sheep	0.025	0.025	0.025	0.021	0.016	0.012
Tillage	0.007	0.007	0.008	0.008	0.006	0.005
All Farms	0.026	0.027	0.024	0.022	0.018	0.015

Across all farm systems, the N balance per hectare was lower 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 weather conditions.

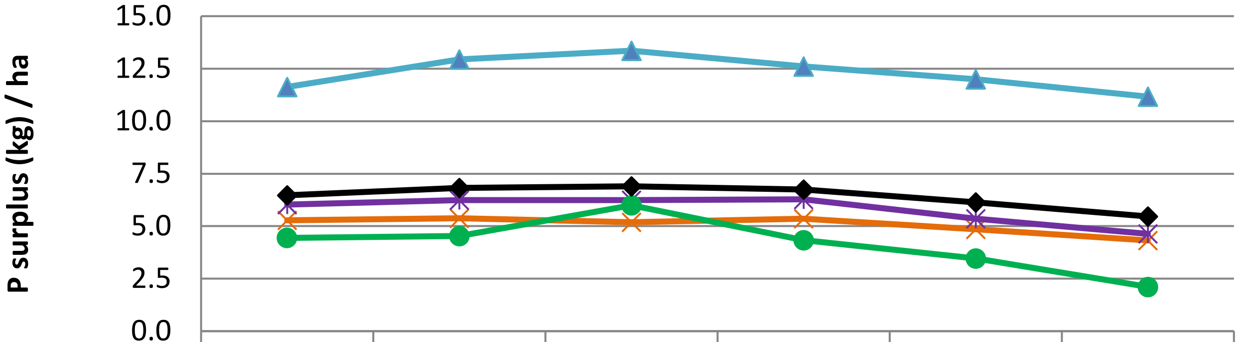
Figure 10.13: Nitrogen Balance per ha: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	177.9	182.9	184.8	173.9	168.2	159.2
Cattle	63.6	63.3	62.7	62.1	58.2	54.3
Sheep	55.8	55.0	54.5	50.7	44.8	41.2
Tillage	39.0	40.0	42.6	33.1	32.7	34.0
All Farms	81.0	81.9	82.2	78.8	74.7	70.6

Figure 10.14 illustrates that P balances have tended to decrease 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 2023, Teagasc analysed a total 38,143 soil samples comprising of dairy, drystock and tillage farm enterprises (Teagasc, 2023). Results indicate that 50% of samples taken are P deficient (at either index 1 or 2).

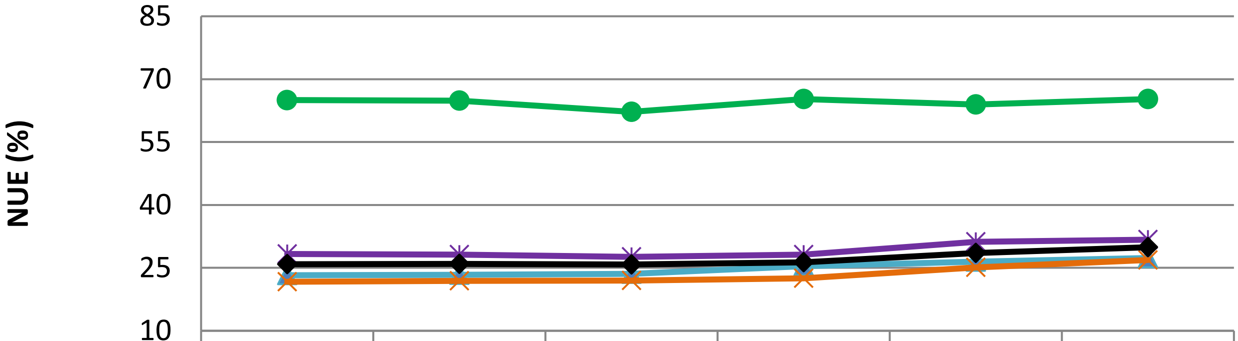
Figure 10.14: Phosphorus (P) Balance per ha: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	11.6	12.9	13.4	12.6	12.0	11.2
Cattle	5.3	5.4	5.2	5.3	4.8	4.3
Sheep	6.0	6.2	6.2	6.3	5.3	4.6
Tillage	4.4	4.5	6.0	4.3	3.5	2.1
All Farms	6.5	6.8	6.9	6.8	6.1	5.5

Figure 10.15 illustrates that dairy and cattle farms tended to have the lowest NUE over the study period. Tillage system NUE was generally significantly higher than all other systems due to the mainly non-livestock nature of this system.

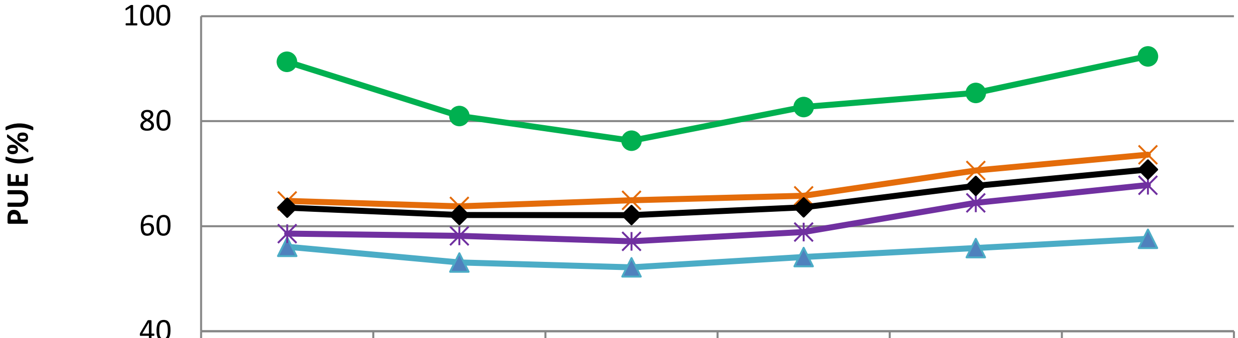
Figure 10.15: Nitrogen Use Efficiency: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	23.2	23.4	23.6	25.4	26.5	27.4
Cattle	21.7	21.9	22.0	22.5	25.1	26.9
Sheep	28.3	28.2	27.6	28.1	31.2	31.7
Tillage	65.0	64.9	62.2	65.2	63.9	65.3
All Farms	25.9	25.9	25.8	26.4	28.5	29.9

Figure 10.16 illustrates that, on a three year rolling average basis across all farm systems, PUE (P outputs / P inputs) has generally increased from the start to the end of the study period. However, farm gate PUE measures must be interpreted with care, since establishing true PUE at the individual far level requires a soil test.

Figure 10.16: Phosphorus Use Efficiency: 3 year rolling average 2018-2023

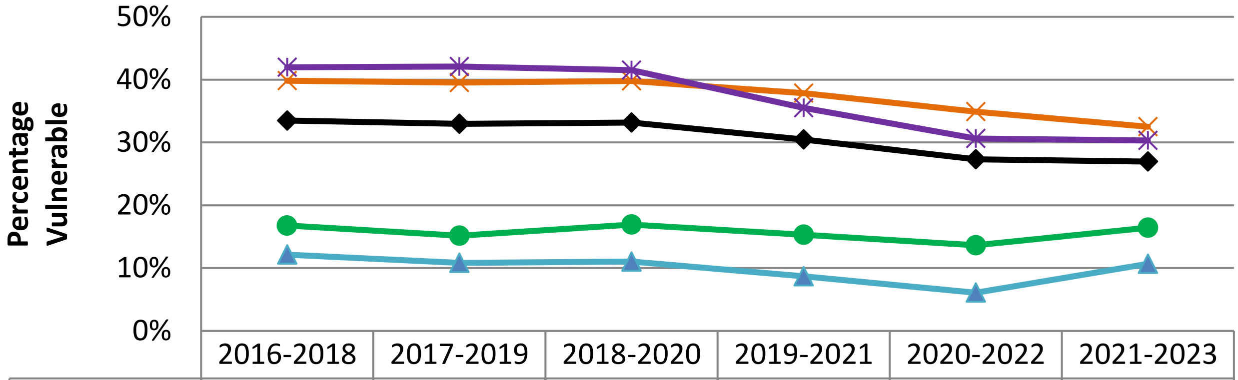


	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	56.1	53.1	52.2	54.1	55.8	57.6
Cattle	64.8	63.8	65.0	65.8	70.6	73.6
Sheep	58.6	58.1	57.1	58.9	64.5	67.8
Tillage	91.3	81.0	76.3	82.7	85.4	92.4
All Farms	63.5	62.1	62.1	63.6	67.7	70.8

10.3 Social Sustainability Indicators

Figure 10.17 shows that on a three-year rolling average basis the rate of vulnerability (non-viable farm business and no off-farm employment) of all farming households has remained stable over the 2016-2020 period across all systems at between 33% but declined to 27% at the end. Dairying and tillage systems tend to have significantly lower levels of household vulnerability than cattle and sheep systems.

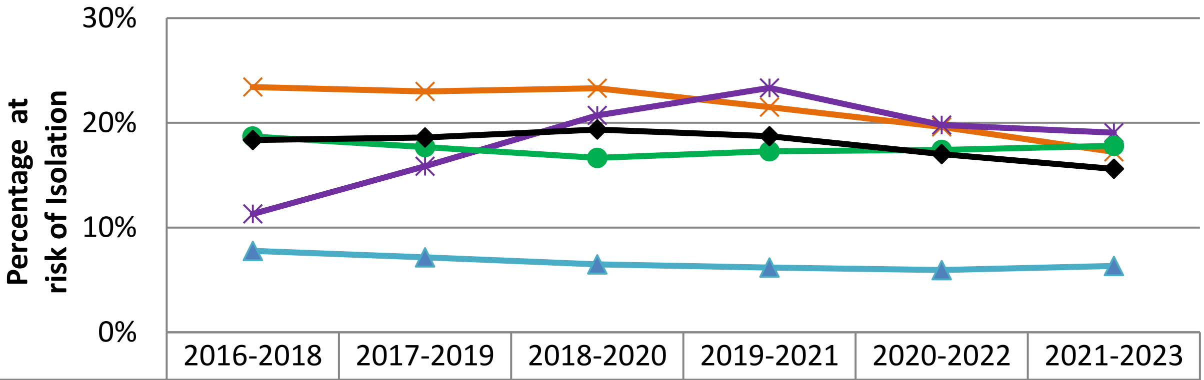
Figure 10.17: Farm Household Vulnerability: 3 year rolling average 2018-2023



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	12%	11%	11%	9%	6%	11%
Cattle	40%	40%	40%	38%	35%	33%
Sheep	42%	42%	42%	36%	31%	30%
Tillage	17%	15%	17%	15%	14%	16%
All Farms	33%	33%	33%	30%	27%	27%

Figure 10.18 shows that on a three-year rolling average basis the percentage of farmers at risk of isolation was relatively static from the start to the end of the study period across all systems (except for sheep). However, overall isolation risk tends to be higher on non-dairy farms.

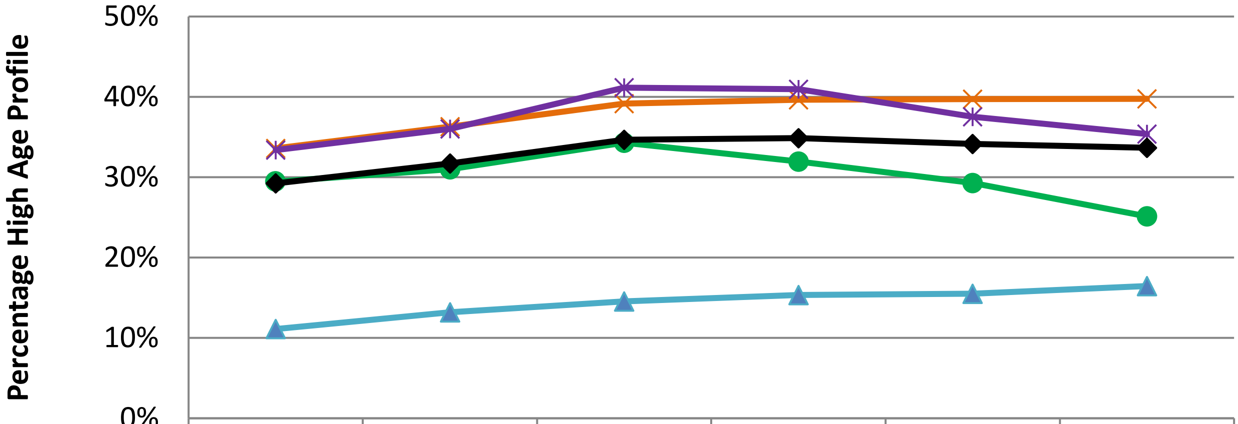
Figure 10.18: Isolation Risk: 3 year rolling average 2018-2023 (average per system)



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	8%	7%	6%	6%	6%	6%
Cattle	23%	23%	23%	21%	20%	17%
Sheep	11%	16%	21%	23%	20%	19%
Tillage	19%	18%	17%	17%	17%	18%
All Farms	18%	19%	19%	19%	17%	16%

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 (25% to 34%). Dairy farms tend to have the lowest age profile across all the farm systems compared to other systems (15-17% towards the end of the study period) which tend to be double or treble this rate.

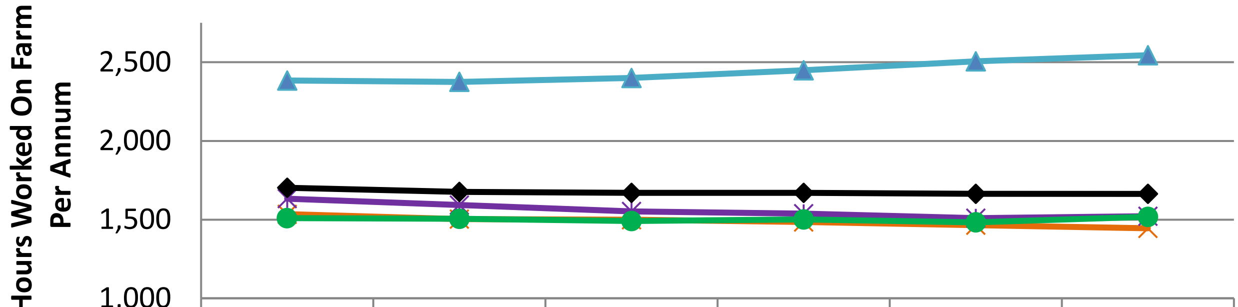
Figure 10.19: High Age Profile: 3 year rolling average 2018-2023 (average per system)



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	11%	13%	15%	15%	15%	16%
Cattle	34%	36%	39%	40%	40%	40%
Sheep	33%	36%	41%	41%	38%	35%
Tillage	29%	31%	34%	32%	29%	25%
All Farm	29%	32%	35%	35%	34%	34%

Figure 10.20 shows that the hours worked on-farm per annum has declined slightly across all farms systems except dairying between 2017 and 2023. Hours worked on farm per annum is significantly higher on dairy farms, compared to all other farm systems.

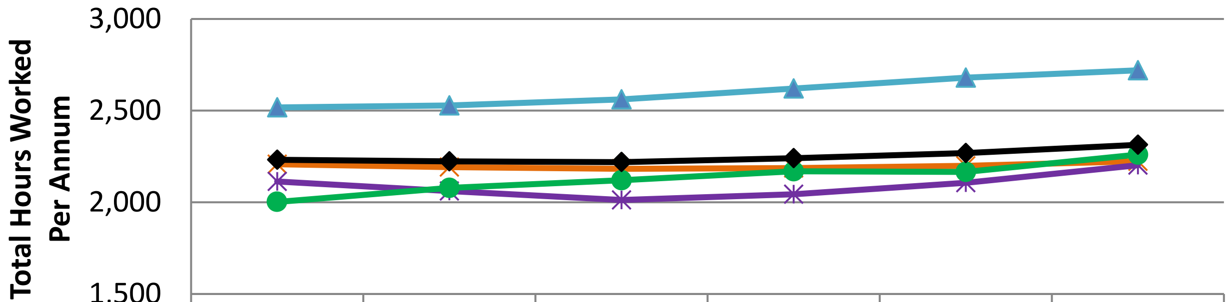
Figure 10.20: Hours Worked On Farm Per Annum: 3 year rolling average 2018-2023 (average per system)



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	2,383	2,374	2,400	2,449	2,506	2,545
Cattle	1,535	1,503	1,498	1,486	1,465	1,445
Sheep	1,633	1,593	1,553	1,539	1,509	1,521
Tillage	1,509	1,505	1,491	1,501	1,482	1,518
All Farms	1,702	1,675	1,671	1,671	1,664	1,663

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.

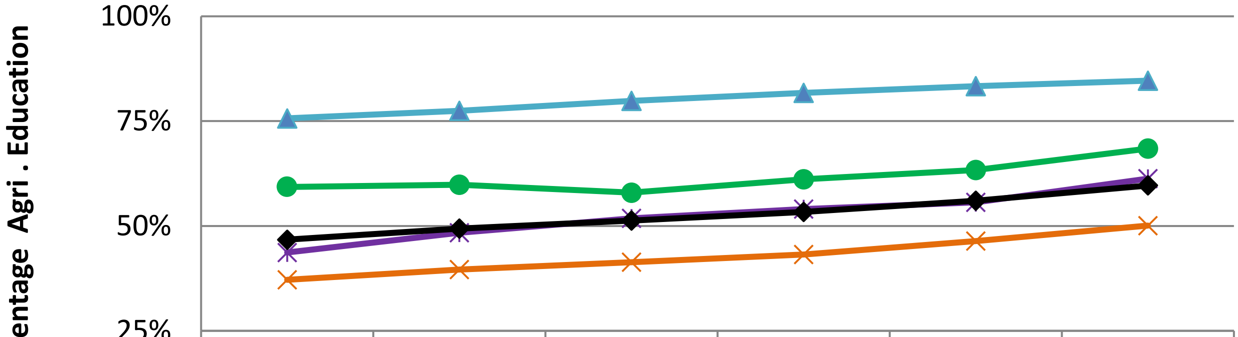
Figure 10.21: Total Hours Worked Per Annum: 3 year rolling average 2018-2023 (average per system)



	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022	2021-2023
Dairy	2,517	2,528	2,561	2,621	2,680	2,720
Cattle	2,207	2,193	2,183	2,187	2,199	2,224
Sheep	2,113	2,061	2,013	2,044	2,106	2,202
Tillage	2,002	2,079	2,121	2,169	2,166	2,260
All Farms	2,233	2,223	2,219	2,241	2,269	2,313

Figure 10.22 indicates that the percentage of all famers who have received some form of agricultural education has increased over the period 2018-2023, from 47% to 60%. Significantly, higher levels of formal agricultural education are observed for dairy farmers.

Figure 10.22: Formal Agricultural Education: 3 year rolling average 2018-2023 (average per system)



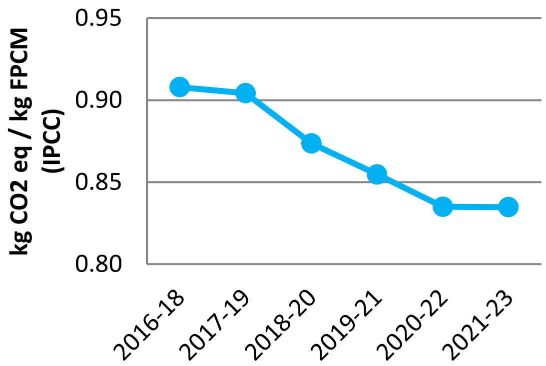
	2015-2017	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022
Dairy	76%	77%	80%	82%	83%	85%
Cattle	37%	40%	41%	43%	46%	50%
Sheep	44%	48%	52%	54%	56%	61%
Tillage	59%	60%	58%	61%	63%	68%
All Farms	47%	49%	51%	53%	56%	60%

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 2016-2018 results are the average of 2016, 2017 and 2018 results). Results for individual years are reported in the appendices for each farm system.

Results presented in Figure 10.23 show that, the kg of CO_2 equivalent per kg of FPCM (IPCC based) has generally followed a declining trend since the start of the period analysed.

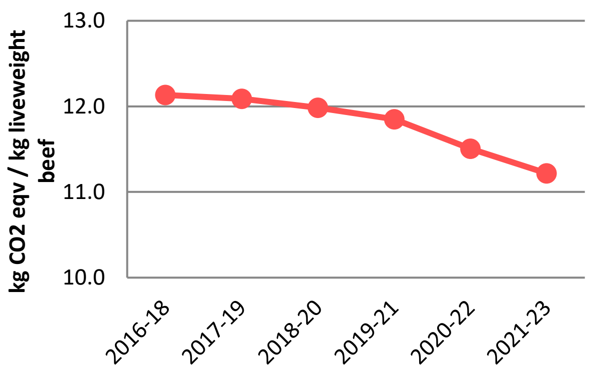
Figure 10.23: Ag. GHG Emissions per kg FPCM: 2018-2023 Dairy Farms



Note: (IPCC approach) 3 year rolling average

Figure 10.24 indicates that kg of CO_2 equivalent per kg of live-weight beef produced on cattle farms also tended to follow a declining trend towards the end of the period analysed.

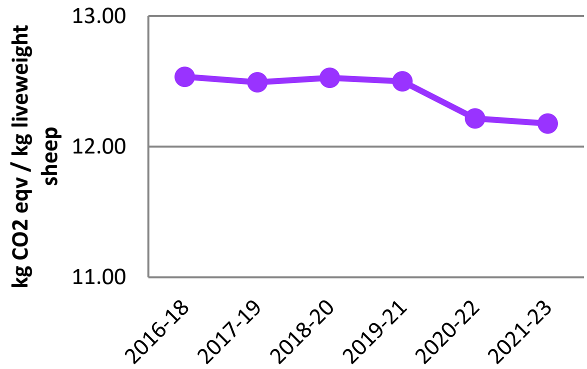
Figure 10.24: Ag. GHG Emissions per kg live-weight beef produced: 2018-2023 (Cattle Farms)



Note: (IPCC approach) 3 year rolling average

Figure 10.25 indicates, on a three year rolling average basis, a steady declining trend in terms of kg of CO_2 emitted per kg of live-weight sheep over the study period.

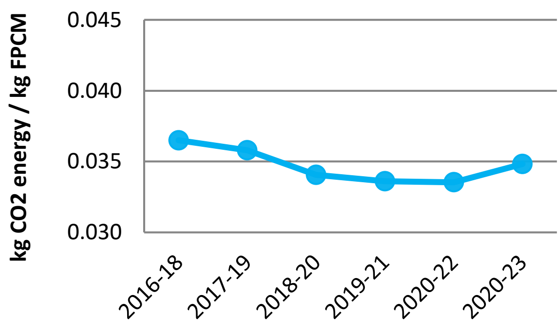
Figure 10.25: Ag. GHG Emissions per kg live-weight sheep produced: 2018-2023 Sheep Farms



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 from the start to the middle of the study period with a slight increase towards the end.

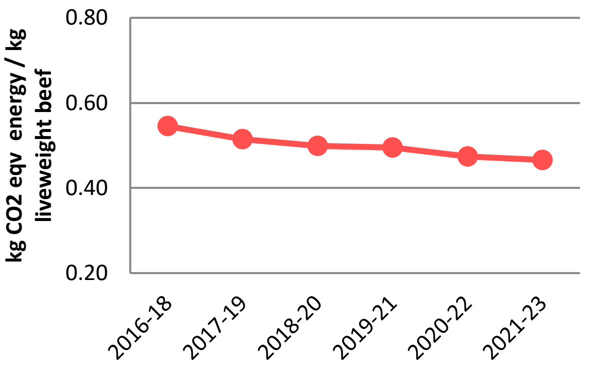
Figure 10.26: Energy use related GHG emissions per kg FPCM: 2018-2023 Dairy Farms



Note: (IPCC approach) 3 year rolling average

Energy based CO_2 emissions related to the production of live-weight beef on cattle farms followed a slight declining trend evident toward the end of the study period as illustrated in Figure 10.27.

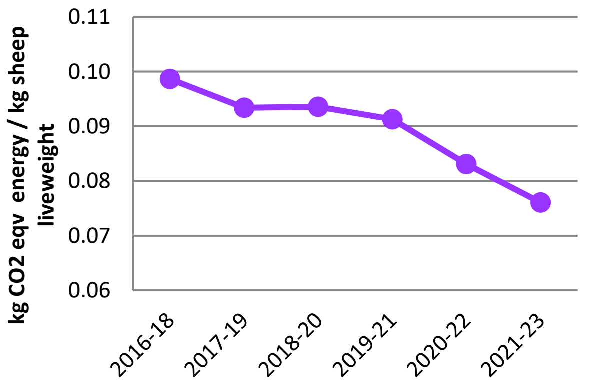
Figure 10.27: Energy use related GHG emissions per kg live-weight beef produced: 2018-2023 Cattle Farms



Note: (IPCC approach) 3 year rolling average

Energy related GHG emissions from the production of live-weight sheep tended to follow a declining trends over the course of the study period as illustrated in Figure 10.28.

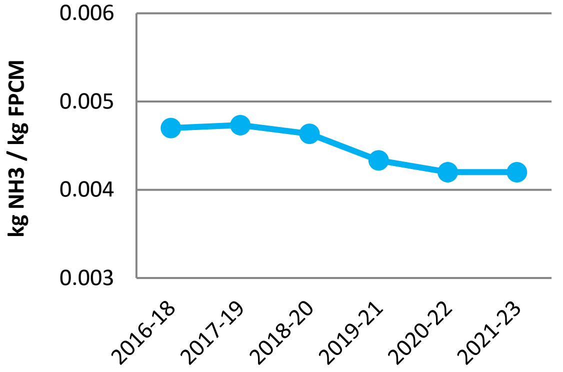
Figure 10.28: Energy use related GHG emissions per kg live-weight sheep produced: 2018-2023 Sheep Farms



Note: (IPCC approach) 3 year rolling average

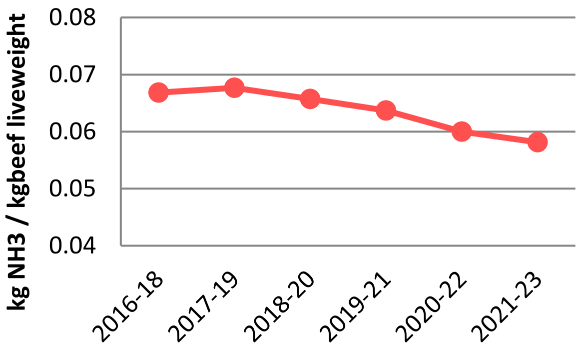
On a three year rolling average basis, the NH_3 emissions intensity of milk production tended to be decline towards the end of the study period as outlined in Figure 10.29.

Figure 10.29: Ammonia emissions per kg FPCM: 2018-20233 year rolling average Dairy Farms



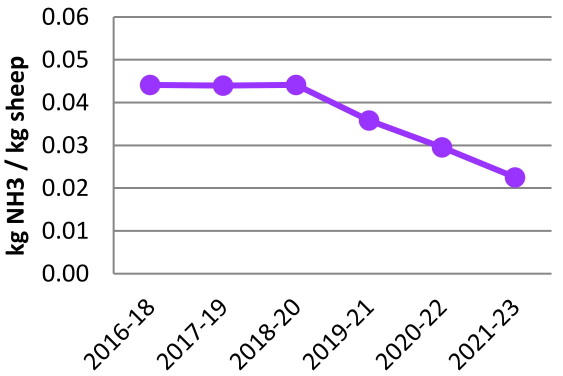
On a three-year rolling average basis, NH_3 emissions per kg of live-weight beef produced on cattle farms also declined towards the end of the study as shown in Figure 10.30.

Figure 10.30: Ammonia emissions per kg live-weight beef produced: 2018-2023 Cattle Farms



The NH_3 emissions per kg of live-weight sheep meat produced on sheep farms was seen to decline towards the end of the study period, as illustrated in Figure 10.31.

Figure 10.31: Ammonia emissions per kg live-weight sheep produced: 2018-2023Sheep Farms



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Appendix 1

Appendix 1 – Individual year results by farm system 2018-2023

Table A 1: Sustainability Indicator results for Dairying Farms 2018-2023

Indicator	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Economic Sustainability Metrics						
Economic return per hectare (gross output)	3,641	3,620	3,730	4,403	6,223	4,456
Profitability per hectare (gross margin)	1,730	1,802	1,920	2,459	3,666	2,209
Family farm income per hectare	1,059	1,122	1,246	1,594	2,451	750
Productivity of labour	48,986	52,449	57,813	78,615	120,603	33,329
Market orientation	89%	88%	90%	91%	94%	91%
Viability	73%	75%	80%	86%	93%	52%
Social Sustainability Metrics						
Household vulnerable	13%	12%	8%	6%	4%	22%
Isolation	7%	7%	6%	6%	6%	7%
High age profile	12%	15%	16%	15%	18%	19%
Hours worked on farm	2,398	2,380	2,422	2,544	2,553	2,537
Total hours worked	2,552	2,545	2,586	2,732	2,721	2,707
Agricultural education	77%	79%	83%	83%	84%	87%
Environmental Sustainability Metrics						
	tonnes CO_2 eqv per farm					
Total farm average Ag. GHG emissions	575.5	579.2	599.8	630.3	635.3	617.0
of which dairy	390.8	409.4	429.7	460.1	465.9	449.0
cattle	183.3	168.5	169.2	169.0	167.9	167.4
sheep	1.4	1.3	1.0	1.2	1.5	0.7
other	0.0	0.0	0.0	0.0	0.0	00
energy use	18.3	18.4	17.8	20.6	20.1	20.7
	tonnes CO2 eqv per ha					
Ag GHG Emissions	9.5	9.4	9.4	9.7	9.8	9.5
Energy GHG Emissions	0.33	0.32	0.30	0.35	0.33	0.34
kg CO2 eqv						
Ag. GHG Emissions per kg milk	0.90	0.89	0.87	0.84	0.84	0.88
Ag. GHG Emissions per kg FPCM	0.90	0.87	0.85	0.82	0.82	0.85
Ag. GHG Emissions per € output	3.1	2.8	2.9	2.5	1.8	2.24
Energy GHG Emissions per kg milk	0.046	0.044	0.038	0.036	0.035	0.036
Energy GHG Emissions per kg FPCM	0.044	0.043	0.038	0.035	0.033	0.035
Energy GHG Emissions per € output	0.109	0.098	0.095	0.094	0.060	0.081
GHG Emissions per kg FPCM (LCA)	1.05	1.01	1.00	0.99	1.00	0.99
	tonnes NH_3 per farm					
Total farm average NH_3 emissions	3.11	3.03	3.07	3.03	3.18	3.14
of which dairy	2.15	2.17	2.22	2.21	2.41	2.32
cattle	0.95	0.85	0.84	0.82	0.77	0.82
sheep	0.01	0.01	0.01	0.00	0.00	0.00
tillage	0.00	0.00	0.00	0.00	0.00	0.00

Indicator	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
Kg NH_3						
NH_3 emissions per hectare	51.6	49.2	48.2	46.7	49.5	48.8
NH_3 emissions per euro output	0.017	0.014	0.015	0.012	0.009	0.012
NH_3 emissions per kg milk	0.0050	0.0047	0.0045	0.0041	0.0044	0.0046
NH_3 emissions per kg FPCM	0.0049	0.0046	0.0044	0.0039	0.0042	0.0044
N Balance per hectare	195.7	176.6	174.7	163.9	160.5	147.2
P Balance per hectare	15.1	12.8	12.2	12.8	10.4	9.7
percentage						
N use efficiency	21.6	24.4	25.3	27.2	28.7	27.8
P use efficiency	48.9	55.0	55.9	54.4	58.7	60.5
Innovation Metrics						
Discussion Group Membership	42%	44%	44%	45%	46%	48%
Milk Recording	38%	46%	43%	52%	54%	57%
% of slurry spread using LESS	5%	32%	52%	68%	77%	81%
% of slurry applied during spring	50%	53%	52%	52%	61%	62%
% chemical N applied as Protected Urea	0%	3%	5%	11%	18%	27%
% of farms reseeding	26%	25%	32%	34%	37%	38%
% of farms liming	30%	36%	38%	46%	58%	50%

Table A 2: Sustainability Indicator results for Cattle Farms 2018-2023

Indicator	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,316	1,309	1,324	1,531	1,725	1,767
Profitability per hectare (gross margin)	486	495	511	654	754	1,011
Family Farm Income per hectare	321	310	333	407	372	348
Productivity of labour	13,510	13,831	14,255	16,939	17,052	16,747
Market orientation	62%	60%	62%	66%	68%	68%
Viability	18%	19%	18%	27%	27%	23%
Social Sustainability Metrics						
Household vulnerable	39%	41%	39%	34%	32%	32%
Isolation	24%	23%	23%	18%	17%	16%
High age profile	38%	39%	40%	40%	39%	40%
Hours worked	1,521	1,480	1,494	1,484	1,419	1,432
Total Hours Worked	2,215	2,161	2,173	2,226	2,199	2,247
Agricultural education	40%	40%	43%	46%	50%	54%
Environmental Sustainability Metrics						
	tonnes CO_2 eqv per farm					
Total farm average Ag. GHG emissions	161.6	149.8	147.4	157.8	152.3	156.6
of which dairy	0.0	0.0	0.0	0.0	0.0	0.0
cattle	155.8	144.2	141.5	152.5	147.0	151.6
sheep	5.6	5.4	5.7	4.8	4.9	4.7
other	0.2	0.2	0.2	0.5	0.4	0.4
energy use	6.1	5.9	5.6	6.1	5.7	6.0
	tonnes CO_2 eqv per ha					
Ag GHG Emissions	4.8	4.5	4.4	4.7	4.4	4.5
Energy GHG Emissions	0.2	0.2	0.2	0.2	0.2	0.2
	kg CO_2 eqv					
Ag. GHG Emissions per kg live-weight beef	12.6	11.7	11.7	12.1	10.6	10.8
Ag. GHG Emissions per € output	5.9	5.4	5.1	4.5	3.6	2.9
Energy GHG Emissions per kg live-weight beef	0.54	0.51	0.50	0.56	0.43	0.49
Energy GHG Emissions per € output	0.25	0.22	0.21	0.19	0.15	0.13
	tonnes NH_3 per farm					
Total farm average NH3 emissions	0.89	0.82	0.77	0.82	0.74	0.78
of which dairy	0.00	0.00	0.00	0.00	0.00	0.00
cattle	0.87	0.80	0.75	0.80	0.73	0.77
sheep	0.02	0.02	0.02	0.02	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	26.2	24.3	23.2	24.3	21.1	22.0
NH_3 emissions per Euro output	0.03	0.03	0.03	0.02	0.02	0.02
NH_3 emissions per kg live-weight beef	0.07	0.07	0.06	0.07	0.05	0.06
	kg per ha					
N Balance per hectare	67.8	57.8	58.9	66.9	46.3	46.6
P Balance per hectare	5.7	4.9	5.0	6.2	3.4	3.4

Indicator	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
			percentage			
N use efficiency	20.5	22.4	23.0	21.9	30.3	28.4
P use efficiency	60.3	66.6	67.9	62.8	81.0	77.0
			Per kg of N Surplus			
Innovation Metrics						
Discussion Group Membership	21%	19%	11%	16%	14%	14%
% of slurry spread using LESS	3%	12%	18%	24%	34%	38%
% of slurry applied during spring	43%	41%	44%	44%	52%	52%
% chemical N applied as Protected Urea	0%	1%	2%	2%	5%	6%
% of farms reseeding	9%	8%	9%	14%	11%	8%
% of farms liming	14%	11%	11%	21%	24%	25%

Table A 3: Sustainability Indicator results for Sheep Farms 2018-2023

Indicator	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,314	1,241	1,293	1,469	1,419	1,455
Profitability per hectare (gross margin)	396	409	489	619	615	766
Family Farm Income per hectare	275	321	401	442	341	251
Productivity of labour	12,363	14,256	17,652	18,623	15,386	13,011
Market orientation	59%	55%	61%	66%	63%	59%
Viability	20%	23%	25%	38%	27%	14%
Social Sustainability Metrics						
Household vulnerable	45%	41%	39%	27%	26%	38%
Isolation	13%	23%	26%	21%	21%	24%
High age profile	38%	40%	46%	37%	30%	39%
Hours worked on farm	1,579	1,555	1,524	1,537	1,466	1,560
Total hours worked	1,996	2,055	1,988	2,091	2,240	2,276
Agricultural education	50%	53%	52%	57%	58%	69%
Environmental Sustainability Metrics						
	tonnes CO_2 eqv per farm					
Total farm average Ag. GHG emissions	174.8	169.0	168.7	172.0	147.2	154.7
of which dairy	0.0	0.0	0.0	0.0	0.5	0.0
cattle	76.1	71.8	71.4	75.3	58.1	60.8
sheep	98.4	97.0	96.9	96.6	88.2	93.7
other	0.3	0.2	0.4	0.4	0.4	0.2
energy use	6.2	6.1	5.3	6.0	5.4	5.6
	tonnes CO_2 eqv per ha					
Ag GHG Emissions	4.6	4.3	4.2	4.3	3.6	3.9
Energy GHG Emissions	0.17	0.17	0.14	0.17	0.15	0.16
	kg CO_2 eqv					
Ag. GHG Emissions per kg live-weight sheep produced	13.0	12.0	12.5	12.3	11.2	12.4
Ag. GHG Emissions per € output	5.6	6.1	4.9	4.2	4.0	3.0
Energy Emissions per kg live-weight sheep produced	0.52	0.5	0.49	0.51	0.57	0.57
Energy GHG Emissions per € output	0.23	0.23	0.17	0.17	0.19	0.13
	tonnes NH_3 per farm					
Total farm average NH3 emissions	0.79	0.76	0.74	0.64	0.54	0.54
of which dairy	0.00	0.00	0.00	0.00	0.00	0.00
cattle	0.45	0.42	0.41	0.43	0.33	0.32
sheep	0.34	0.34	0.33	0.21	0.21	0.22
tillage	0.00	0.00	0.00	0.00	0.00	0.00
	kg NH_3					
NH_3 emissions per hectare	20.4	19.1	18.5	15.6	12.0	12.6
NH_3 emissions per Euro output	0.03	0.03	0.02	0.02	0.01	0.01
NH_3 emissions per kg live-weight sheep	0.05	0.04	0.05	0.02	0.02	0.02
	kg per ha					
N Balance per hectare	64.1	47.0	49.0	53.4	28.6	34.9
P Balance per hectare	7.0	5.9	5.8	7.1	3.1	3.6

Indicator	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
			percentage			
N use efficiency	24.2	29.4	29.3	25.7	39.0	30.9
P use efficiency	52.2	61.0	58.4	57.3	77.7	68.5
Innovation Metrics						
Discussion Group Membership	26%	25%	16%	19%	17%	19%
% of slurry applied during spring (where slurry is generated)	32%	42%	47%	56%	46%	43%
% chemical N applied as Protected Urea	0%	0%	2%	2%	2%	3%
% of farms reseeding	16%	7%	8%	13%	9%	13%
% of farms liming	17%	12%	16%	28%	21%	36%

Table A 4: Sustainability Indicator results for Tillage Farms 2018-2023

Indicator	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,855	1,976	1,693	2,217	2,810	2,171
Profitability per hectare (gross margin)	902	888	753	1,172	1,576	1,154
Family farm income per hectare	656	595	550	837	1,015	260
Productivity of labour	43,928	37,383	38,537	71,176	95,286	19,506
Market orientation	79%	75%	73%	79%	82%	75%
Viability	63%	62%	66%	76%	78%	34%
Social Sustainability Metrics						
Household vulnerable	17%	17%	17%	12%	12%	25%
Isolation	16%	17%	16%	18%	18%	17%
High age profile	33%	32%	37%	26%	24%	25%
Hours worked on farm	1,510	1,544	1,422	1,542	1,483	1,529
Total hours worked	2,081	2,218	2,062	2,225	2,211	2,345
Agricultural education	54%	64%	56%	63%	70%	71%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	147.6	146.0	149.0	152.6	141.9	145.8
of which dairy	0.0	0.0	0.0	0.0	0.0	0.0
cattle	110.6	102.6	109.1	102.3	79.9	83.7
sheep	12.3	15.2	18.1	14.7	20.2	23.6
other	24.7	28.2	21.8	35.6	41.8	38.5
energy use	14.4	14.1	13.0	16.3	15.2	16.1
			tonnes CO_2 eqv per ha			
Ag GHG Emissions	2.4	2.2	2.3	2.3	1.9	1.9
Energy GHG Emissions	0.22	0.23	0.19	0.22	0.21	0.21
			kg CO_2 eqv			
Ag. GHG Emissions per € output	1.67	1.68	1.81	1.33	0.86	0.93
Energy GHG Emissions per € output	0.15	0.16	0.14	0.12	0.09	0.11
			tonnes NH_3 per farm			
Total farm average NH3 emissions	0.75	0.74	0.68	0.88	0.76	0.87
of which dairy	0.00	0.00	0.00	0.00	0.00	0.00
cattle	0.58	0.52	0.54	0.50	0.38	0.42
sheep	0.04	0.05	0.06	0.03	0.04	0.04
tillage	0.13	0.17	0.08	0.35	0.35	0.41
			kg NH_3			
NH_3 emissions per hectare	10.8	10.0	10.1	11.9	9.4	10.7
NH_3 emissions per Euro output	0.01	0.01	0.01	0.01	0.01	0.01
			kg per ha			
N Balance per hectare	67.5	38.3	35.4	25.7	37.1	39.3
P Balance per hectare	7.9	3.9	6.1	2.9	1.3	2.1
			percentage			
N use efficiency	56.8	67.2	61.8	65.9	66.0	65.7
P use efficiency	69.3	86.7	72.9	88.7	94.7	93.8

Indicator	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
Innovation Metrics						
Discussion Group Membership	21%	28%	21%	26%	28%	22%
Break Crop	19%	19%	15%	11%	17%	22%
% of farms liming	27%	28%	20%	32%	29%	26%

Table A 5: Sustainability Indicator results for All Farms 2018-2023

Indicator	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
Economic Sustainability Metrics						
Economic return per hectare (gross output)	1,774	1,766	1,787	2,092	2,582	2,239
Profitability per hectare (gross margin)	727	746	783	1,014	1,328	1,195
Family Farm income per hectare	471	479	528	660	798	399
Productivity of labour	21,941	22,544	24,588	32,434	41,625	19,338
Market orientation	68%	65%	68%	71%	73%	71%
Viability	32%	33%	34%	43%	43%	27%
Social Sustainability Metrics						
Household vulnerable	34%	34%	32%	26%	24%	31%
Isolation	18%	19%	20%	16%	14%	16%
High age profile	33%	35%	36%	34%	32%	35%
Hours worked on farm	1,688	1,660	1,663	1,688	1,639	1,661
Total hours worked	2,230	2,218	2,209	2,295	2,302	2,343
Agricultural education	50%	51%	53%	56%	59%	64%
Environmental Sustainability Metrics						
			tonnes CO_2 eqv per farm			
Total farm average Ag. GHG emissions	237.0	230.2	233.5	245.6	239.4	239.9
energy use	8.9	8.8	8.4	9.5	9.0	9.4
			tonnes CO_2 eqv			
Ag GHG Emissions per hectare	5.4	5.2	5.1	5.3	5.1	5.1
Ag GHG Emissions per Euro output	5.0	4.8	4.4	3.9	3.1	2.7
Energy GHG Emissions per hectare	0.22	0.21	0.20	0.22	0.20	0.22
Energy Emissions per Euro output	0.21	0.20	0.18	0.16	0.13	0.12
			tonnes NH_3 per farm			
Total farm average NH3 emissions	1.26	1.21	1.18	1.20	1.16	1.18
			kg NH_3			
NH_3 emissions per hectare	28.7	26.9	26.0	26.0	23.9	24.5
NH_3 emissions per Euro output	0.03	0.02	0.02	0.02	0.01	0.01
			kg per ha			
N Balance per hectare	90.7	77.9	77.9	80.6	65.6	65.5
P Balance per hectare	7.8	6.5	6.5	7.3	4.6	4.5
			percentage			
N use efficiency	23.9	26.7	26.9	25.5	33.1	31.1
P use efficiency	57.3	64.7	64.3	61.8	76.9	73.6