



Ireland's 2030 Carbon Emissions Targets — An Economic Impact Assessment for the Agriculture Sector

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KPMG Tel: +353 1 410 2000
1 Stokes Place Fax: +353 1 412 2000
St Stephen's Green www.kpmg.ie
Dublin
D02 DE03

FAO: Irish Farmers Journal

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Ireland's 2030 carbon emissions targets – An Economic Impact Assessment for the Agriculture Sector

Dear Justin,

We are delighted to submit to you our report, **Ireland's 2030 carbon emissions targets – An Economic Impact Assessment for the Agriculture Sector**.

Agriculture is a crucial element of Ireland's economy but is also the largest contributor to greenhouse gas emissions. The Climate Action and Low Carbon Development (Amendment) Bill 2021 sets out Ireland's ambition to reach net zero across all sectors of the economy by 2050, with a reduction of 51% by 2030.

The pace and scale of decarbonisation required at a sector level is not yet known, but it is expected that agriculture will contribute to the national decarbonisation effort. As such, it is essential to understand the expected economic impacts and opportunities of agricultural decarbonisation in order to ensure a just transition to net zero in Ireland.

Drawing on best available data from Teagasc, the UK Committee on Climate Change, and consultation with sector experts, we have completed an impact assessment of these targets on the agricultural sector using four scenarios. The scenarios explore reductions in agricultural emissions of 13%, 18%, 30% and 50%. The key findings of the economic impact assessment are:

- The impact at farm level varies across the agricultural sectors: the viability of the beef, dairy and sheep sectors are the most at risk from livestock reductions, while the pig and poultry sectors are likely to be relatively less impacted. Farm-level viability becomes significantly challenged when livestock reductions reach 20% to 40%.
- Total economic output could fall by up to 21% across the sectors analysed. The negative impacts extend further when the knock-on impact of livestock reductions on abattoirs and dairy processors is considered.
- Overall livestock reductions could lead to a 21% decrease in total employment.

Please note that emissions from tillage cropping are not included in this assessment as there is a lack of detail on crop emission levels. Further, alterations to land use are not included in this analysis.

Sincerely,

Russell Smyth
Partner | KPMG Sustainable Futures

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About this report

High-level scope

Background & Context

Analyse the economic impact of various decarbonisation targets for the Irish agricultural sector.

Mitigation Scenarios & Costs

Consider scenarios for the range of mitigation actions required by agricultural sub-sectors to meet emissions targets and the costs to achieve these.

Economic Impacts

Examine the potential farm-level and economy-wide impacts of four scenarios for reducing agriculture's carbon emissions.

Key sources

Extensive stakeholder engagement with representatives of the agriculture sector in Ireland, in particular with:

- Environmental Protection Agency (EPA)
- Teagasc — Research projects e.g. Farm Zero C, MethAbate
- Irish Farmers Journal (IFJ)
- Michael Wallace, Professor of Agriculture and Food Economics, UCD
- Academic experts

Desktop research of third party papers and reports, including:

- Teagasc Marginal Abatement Cost Curve (2018)
- Forthcoming Teagasc research (2021)
- Scottish Rural College (SRUC): Non-CO₂ abatement in the UK agricultural sector by 2050
- The UK Climate Change Committee (CCC) Sixth Carbon Budget
- EPA National Inventory Report 2021
- EPA Climate Projections report 2020-2040

Bespoke modelling of the Irish agriculture industry and economy, using data on:

- Farm-level financial information
- Industry and sector employment
- Agriculture emissions intensity
- Processor and value chain output
- Land use surveys
- Teagasc National Farm Survey

About this report – Key Numbers



Farm-level impacts

- In Scenario 1, the benefits generated from the adoption of mitigation measures outweigh costs for the average dairy and beef farms: average profit increases by €5.1K and €0.2K respectively
- In Scenario 2, changes to dairy and beef farm-level income would be +€2.1K and -€0.3K respectively
- In Scenario 3, the measures and livestock reduction result in profit falling on average farms: by -€17.5K on an average dairy farm and by -€2.8K on an average beef farm
- In Scenario 4, profit falls by -€46.4K on the average dairy farm and by -€5.6K on the average beef farm



Economic Impacts

Economic Output

- Under Scenario 1, economic output would increase by ~€216.2 million when only considering agricultural abatement measures. Considering the total across all measures, economic output for primary agriculture would increase by ~€31.3 million
- Under Scenario 2, agricultural abatement measures increase economic output by ~€171 million. Considering the total across all measures, economic output for primary agriculture would decrease by ~€14 million
- For primary agriculture, economic output is reduced by ~€2.09bn (-14%) in Scenario 3 and ~€4.60bn (-30%) in Scenario 4
- In Scenario 3 the overall decline in output across primary agriculture and processing (beef and dairy) is ~€3.8bn (-20%)
- In Scenario 4 the overall decline in output across primary agriculture and processing (beef and dairy) is ~€8.9bn (-46%)



Economic Impacts

Employment

Impact on direct farm employment (Scenario 4):

- With a livestock reduction of 45% for dairy and a 47% reduction for beef in Scenario 4, there is a reduction in full time equivalent (FTE) employment of up to ~26,700 (-21%)

Impact on employment outside the farm gate (Scenario 4)

- The reduced output in Scenario 4 could reduce full time equivalent (FTE) employment in the farm supply chain and for processors (beef and dairy) by ~94,400 (-47%)

Contacts



Russell Smyth
Partner
Sustainable Futures



Orlaith Delargy
Associate Director
Sustainable Futures



Julie Stokes
Associate Director
Sustainable Futures



Requier Wait
Manager
Strategy



Fraser Clarke
Senior Associate
Strategy

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1.

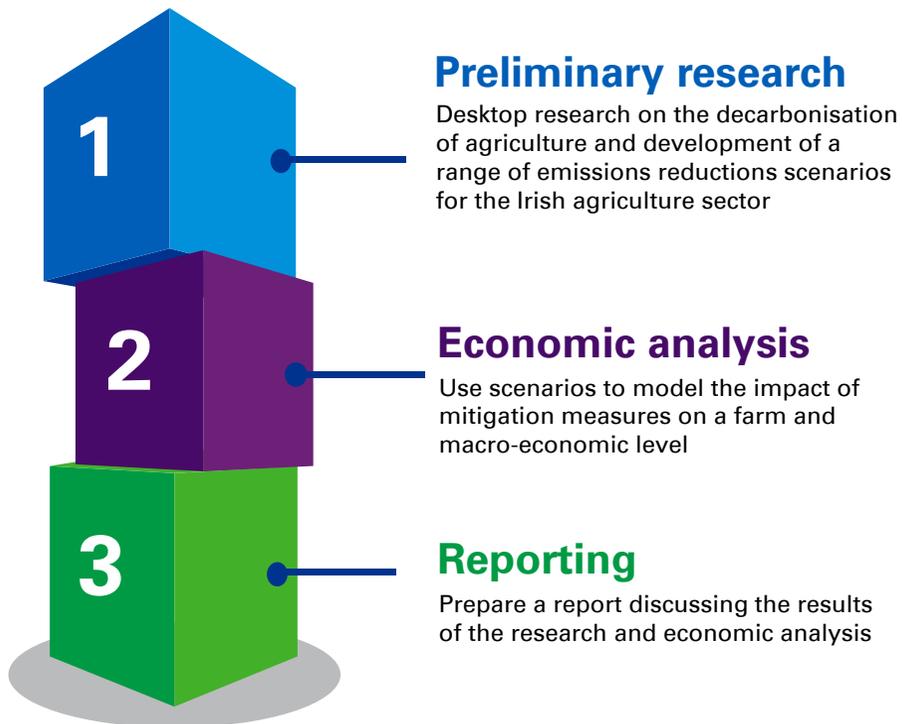
Executive summary



Executive summary

Background and context

- In early summer 2021, KPMG was commissioned by the Irish Farmers Journal to undertake an assessment of the agriculture sector's ability to decarbonise in line with a range of potential carbon budgets/scenarios.
- The purpose of this report was to analyse how these different decarbonisation scenarios would impact on rural communities and the wider economy.
- The project was conducted in three phases, as set out below.



- Develop the emissions profile of the Irish agriculture sector
- Conduct a review of relevant policies
- Prepare a longlist of mitigation actions
- Develop emissions reductions scenarios

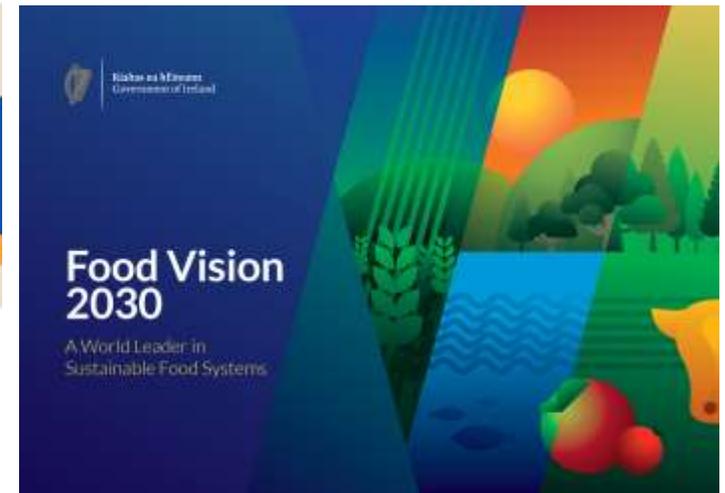
- Estimate the impact of scenarios on farm-level cost, income and profitability
- Estimate the economy-wide impact for each scenario
- Consider broader factors such as the EU Farm to Fork Strategy

- Prepare final report discussing outputs of model and potential pathways for the agriculture sector to decarbonise in line with the Climate Bill

Executive summary

Background and context

- Ireland's national emissions reduction target is to reach net zero across all sectors of the economy by 2050, with a reduction of 51% by 2030. This equates to an average annual reduction of over 7%.
- The agriculture sector accounts for the largest share of Ireland's carbon emissions and will be expected to play its part in the national effort to decarbonise. However, it is not expected that the sector will be required to reach net zero.
- The drive to reduce emissions from and improve environmental performance of Irish agriculture is underscored by recent policies and strategies such as the revised EU Common Agricultural Policy, the EU's Farm to Fork Strategy and nationally, the Food Vision 2030 strategy.

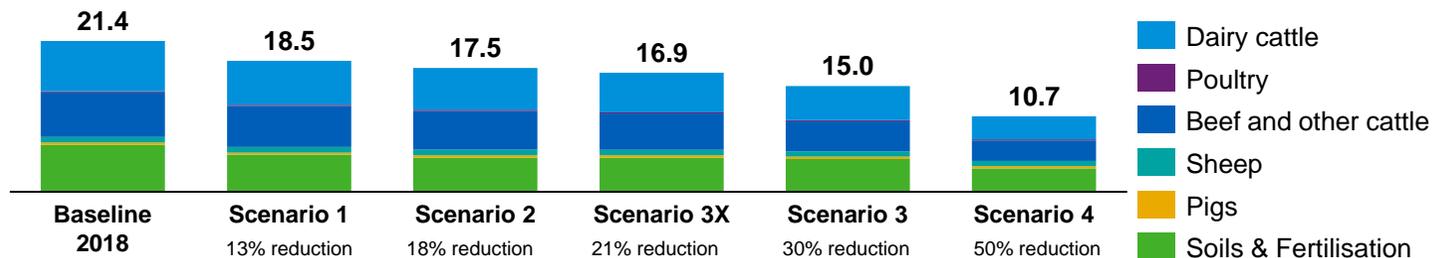


Executive summary

Approach to scenario analysis

- Four scenarios (S1, S2, S3 and S4) were developed to explore different emissions reduction pathways for the agriculture sector which will potentially be required under the Climate Bill. The scenarios increase in ambition, exploring emissions reductions of 13%, 18%, 30% and 50% across the agricultural sector compared with 2018 levels.
- As the report was published in October 2021, preliminary figures for the national and sectoral carbon budgets became known, with reports indicating that agriculture would be required to reduce its carbon emissions by between 21% and 30%. Thus, additional analysis of an emissions reduction target of 21% was conducted for completeness. This was named Scenario 3X and details can be found in the Appendix.
- The baseline figure of 21.4 MtCO₂e is taken from the recalculated figures for 2018 agricultural emissions, as provided in the EPA National Inventory Report 2021.
- All scenarios are compared against a baseline scenario: the Environmental Protection Agency's (EPA) 'With Existing Measures' (WEM) scenario*. The WEM scenario reflects a 'Business-as-Usual' approach, and assumes no additional policies or measures are implemented beyond those already in place by the end of 2019.

Carbon emissions by agricultural sector under each scenario (MtCO₂e)



See appendix for additional information on S3X

*Ireland's Greenhouse Gas Emissions Projections 2020-2040, EPA, 2021 <https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/irelands-greenhouse-gas-emissions-projections-2020-2040.php>

Executive summary

Scenario analysis results

- Mitigation measures were primarily drawn from the Teagasc Marginal Abatement Cost Curve (MACC) 2018 and forthcoming Teagasc research, used with permission from the author.
- These measures can be divided into Livestock measures and Soils & Fertilisation measures. The full application of Livestock and Soils & Fertilisation measures reaches a maximum 18% reduction across the agriculture sector. To achieve mitigation of 30% and 50%, Scenarios 3 and 4 apply a reduction in livestock numbers.
- The dairy and beef sectors together deliver the majority of the mitigation potential in Scenarios 1 and 2, with Dairy delivering over 34% of total mitigation in each Scenario, and Beef delivering over 15%. The Sheep, Pigs and Poultry sectors play a more minor role.

		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
		Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation	Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation	Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation	Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation
Agricultural Sector	Dairy	0.680	35%	0.993	34%	0.993	18%	0.993	10%
	Beef	0.295	15%	0.627	21%	0.627	11%	0.627	6%
	Sheep	0.006	0.3%	0.006	0.2%	0.006	0.1%	0.006	0.1%
	Pigs	0.056	3%	0.006	0.2%	0.006	0.1%	0.006	0.1%
	Poultry	0.002	0.1%	0.002	0.1%	0.002	0.04%	0.002	0.02%
Soils & Fertilisation		0.899	46%	1.316	45%	1.316	24%	1.316	13%
Reduction in Livestock Numbers		-	-	-	-	2.55	46%	6.84	70%
Total		1.938	100%	2.952	100%	5.50	100%	9.80	100%

Scenario 3 includes livestock reductions of 18% for dairy, 22% for beef and 5% for pigs, poultry and sheep.

Scenario 4 includes livestock reductions of 45% for dairy, 47% for beef and 6% for pigs, poultry and sheep.

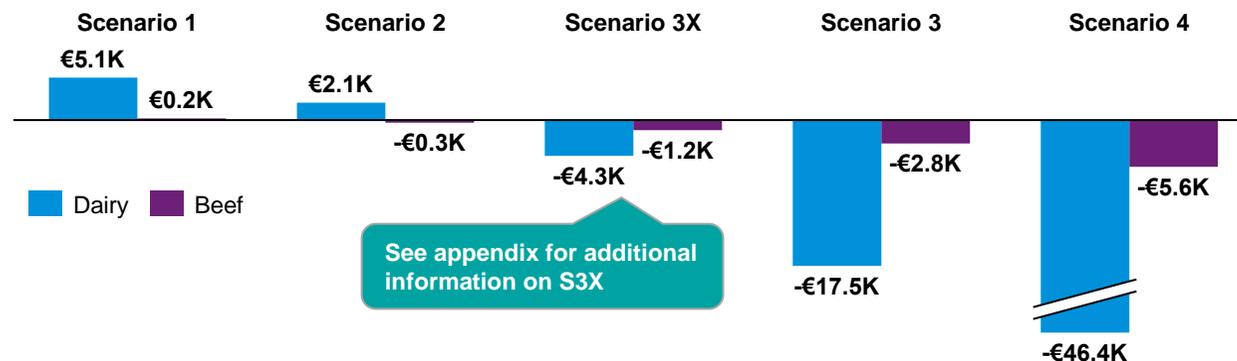
Executive summary

Farm-level impacts

Farm-level impacts

- In Scenario 1 (S1), the benefits generated from the adoption of mitigation measures outweigh costs for the average dairy and beef farms: average profit increases by €5.1K and €0.2K respectively.
- Scenario 2 (S2) includes the measures from Scenario 1 as well as covering slurry stores, lower average age of beef slaughter, and other additional mitigation measures resulting in an increase in costs/decrease in income for dairy and beef farmers. In S2, changes to dairy and beef farm-level income would be +€2.1K and -€0.3K respectively.
- Scenario 3X (S3X) includes the measures from S2 as well as livestock reductions of -5% in the dairy sector and -6% in the beef sector. Together, the measures and livestock reduction result in profit falling on average farms: by -€4.3K on an average dairy farm and by -€1.2K on an average beef farm. S3X is an additional scenario added which is included in the appendix.
- Scenario 3 (S3) includes the measures from S2 as well as livestock reductions of -18% in the dairy sector and -22% in the beef sector. Together, the measures and livestock reduction result in profit falling on average farms: by -€17.5K on an average dairy farm and by -€2.8K on an average beef farm.
- Scenario 4 (S4) includes the measures in S2 and livestock reductions of -45% for dairy and -47% for beef. Profit falls in this Scenario by -€46.4K on the average dairy farm and by -€5.6K on the average beef farm.

Impacts on average a dairy and beef farm's income/cost across Scenarios 1 to 4



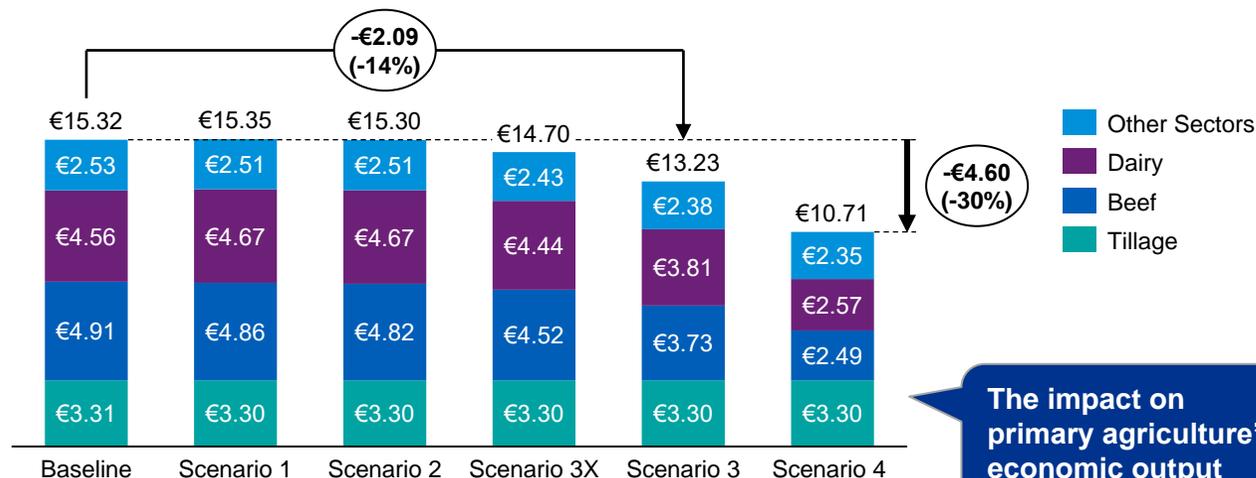
Executive summary

Economic Impacts

Primary agriculture's economic output – all abatement measures (Scenario 1-4)

- Considering the impact of agricultural, land-use and energy abatement measures, and livestock reductions, Scenarios 3 and 4 produce the largest reduction in economic output.
- The measures under Scenario 1 increase overall economic output slightly, whilst Scenario 2 leads to a slight decrease in output.
- Scenario 3 and 4 incorporate livestock reductions that cause an overall reduction in economic output.
- **For primary agriculture, economic output is reduced by ~€2.09bn (-14%) in Scenario 3 and ~€4.6bn (-30%) in Scenario 4.**

Direct, indirect and induced economic output, by 2030, €bn



The impact on primary agriculture's economic output

See appendix for additional information on S3X

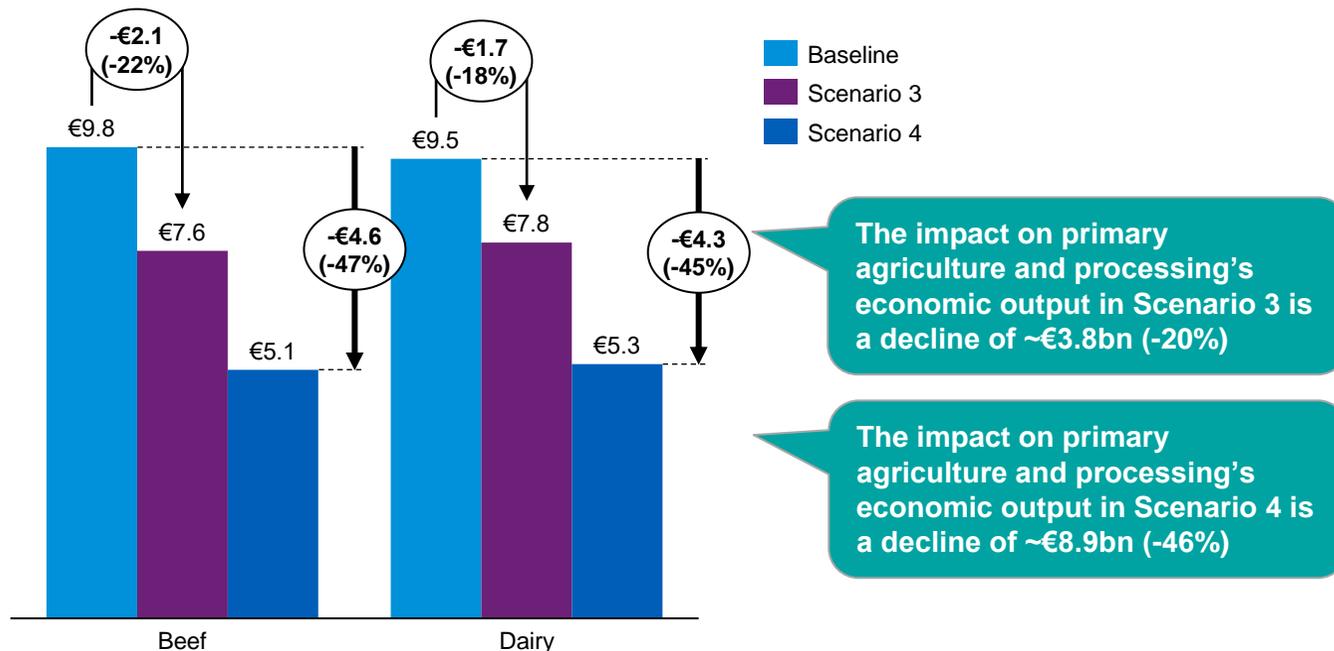
Executive summary

Economic Impacts

Primary agriculture and Processors' economic output (beef and dairy) – Scenario 3 & 4

- In Scenario 3, economic output for beef farms and processing falls by ~€2.1bn (-22%) and for dairy farms and processing the fall is ~€1.7bn (-18%).
 - **The overall decline in Scenario 3, across primary agriculture and processing, is ~€3.8bn (-20%)**
- In Scenario 4, economic output for beef farms and processing falls by ~€4.6bn (-47%) and for dairy farms and processing the fall is ~€4.3bn (-45%).
 - **The overall decline in Scenario 4, across primary agriculture and processing, is ~€8.9bn (-46%)**

Direct, indirect and induced economic output, by 2030, €bn



Executive summary

Economic Impacts

Employment - impact on direct farm employment (Scenario 3 & 4)

- With a livestock reduction of 18% for dairy and a 22% reduction for beef in Scenario 3, there is a reduction in full time equivalent (FTE) employment of ~7,400 (-6%) up to ~15,400 (-12%)
- With a livestock reduction of 45% for dairy and a 47% reduction for beef in Scenario 4, there is a reduction in full time equivalent (FTE) employment of ~26,700 (-21%)

Employment - impact on employment outside the farm gate (Scenario 3 & 4)

- The reduced output in Scenario 3 could reduce full time equivalent (FTE) employment in the farm supply chain and for processors (beef and dairy) by ~41,000 (-20%)
- The reduced output in Scenario 4 could reduce full time equivalent (FTE) employment in the farm supply chain and for processors (beef and dairy) by ~94,400 (-47%)

Employment – total impact (direct farm, farm supply chain and processing)

- Under Scenario 3, the total employment impact is in the range 48,400 to 56,400
- Under Scenario 4, the total employment impact is up to 121,100
- The range values are dictated by the manner in which the livestock reductions are implemented, for example whether reductions are applied to select farms or across the board

Executive summary

Further Economic Considerations

Farmer uptake and CAP support

- Based on our farm case studies, greater awareness of the economic and environmental benefits associated with mitigation measures is needed.
- Ireland's CAP Strategic Plan (2023-2027) proposes a number of interventions that can support agriculture in pursuing lower carbon emissions.
- Certain measures such as energy efficiency in dairy farming require an initial upfront capital investment. Whilst the savings produced by these measures can help to repay this investment over time, the initial capital outlay presents a significant initial cost to farmers.

EU Farm to Fork Strategy

- Organic farming: A large increase in the uptake of organic farming is required to meet the Farm to Fork target of 8% of total farmland being used for organic farming by 2030. Effective government support measures will be needed to support such a shift. The alignment and affiliation of certification bodies with Government will also be crucial.
- Reducing dependency on pesticides: Ireland's use of pesticides is relatively low compared to other EU countries. Should the implementation of this target account for domestic circumstances, the required reduction for Irish farmers could be lower.
- Reducing fertiliser use: From our Scenario analysis, the cost of using multi-species swards could be offset by the cost savings from using less fertiliser. This measure could help to reduce emissions without adding to costs.

Market prices

- Livestock reductions will have an impact on farmers' cost structure and incomes. As price takers, farmers will not be able to pass on the costs associated with these negative impacts to consumers through higher food prices.
- External factors such as global demand, population growth, changing consumer preferences and the impact of extreme weather on agricultural harvests will all influence global food prices.

2.

Background & Context



Background to this report

Ireland's national emissions reduction target is to reach net zero across all sectors of the economy by 2050, with a reduction of 51% by 2030 which equates to an average annual reduction of 7%.

The Climate Action and Low Carbon Development (Amendment) Bill 2021 ('Climate Bill') sets out Ireland's ambition to reach net zero by 2050. Carbon budgets will be set nationally and on a sector-by-sector basis to cap the level of allowable carbon emissions for the periods 2021-2025, 2026-2030 and 2031-2035. These carbon budgets are currently being determined, with the first expected to be published in Q3 2021.

The agriculture sector is expected to play its part in the national decarbonisation effort, although the scale and pace of decarbonisation and the actions required to achieve this are not yet known. Some details of agricultural mitigation measures are included in the Climate Action Plan 2019, although that Plan is associated with a less ambitious decarbonisation target than what is proposed under the Climate Bill. More stringent actions for agriculture are expected to be set out in the forthcoming Climate Action Plan 2021.

The purpose of this report is to analyse how a range of different decarbonisation scenarios would impact on rural communities and the wider economy.

The report is split into **two parts**:

Context Setting & Scenario Analysis

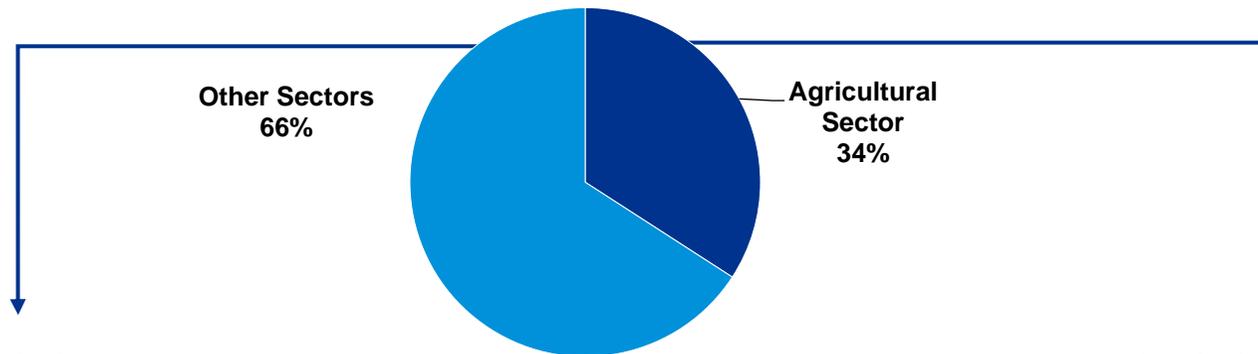
1. Policy context
2. Approach to scenario analysis
3. Scenario analysis results

Economic Impact Assessment

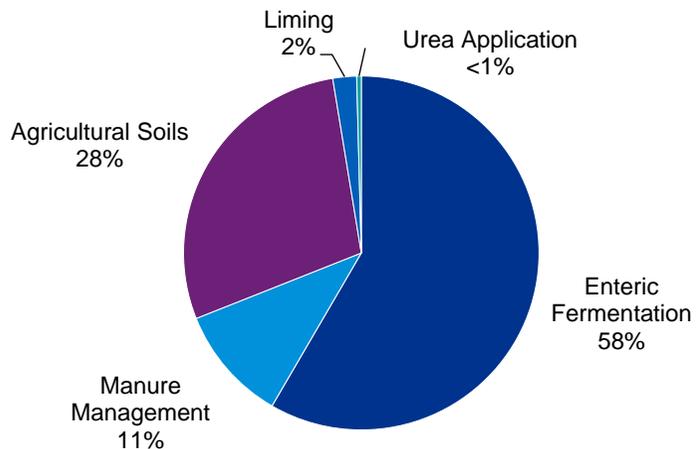
1. Farm-level financial impacts
2. Sector level financial impacts
3. Economic impacts
4. Employment impacts

Irish Agriculture - Emissions

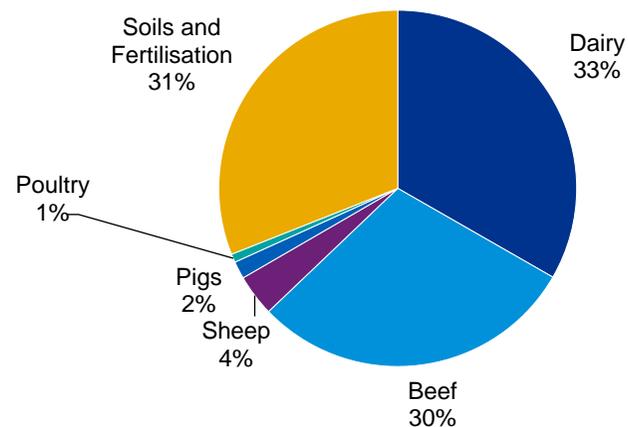
The agriculture sector accounts for the largest share of Ireland’s carbon emissions.*



Breakdown of emissions by source



Breakdown of emissions by sub-sector (excludes Tillage)**



Data source: Ireland National Inventory Report, EPA, 2021

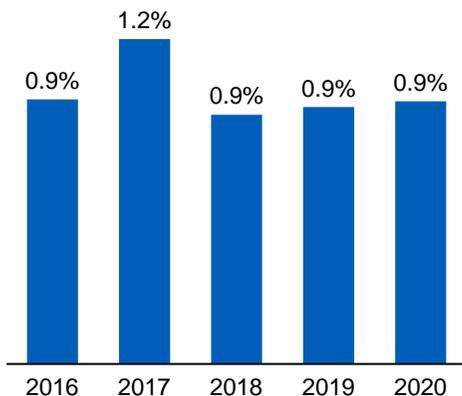
*Please note that in this report the terms ‘carbon emissions’ and ‘greenhouse gas (GHG) emissions’ are used interchangeably.
 *Emissions refer to 2018 recalculated emissions EPA 2021

**Note: Ireland’s National GHG emissions inventory provides emissions data for each livestock sector but does not report a breakdown of the tillage sector’s emissions.

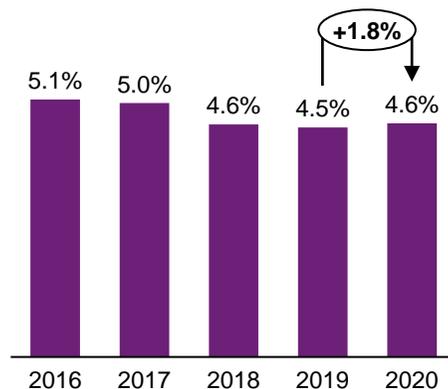
Irish Agriculture - Economics

Agriculture is one of Ireland's most important sectors, accounting for ~4.6% of total employment and 0.9% of total GDP in 2020.

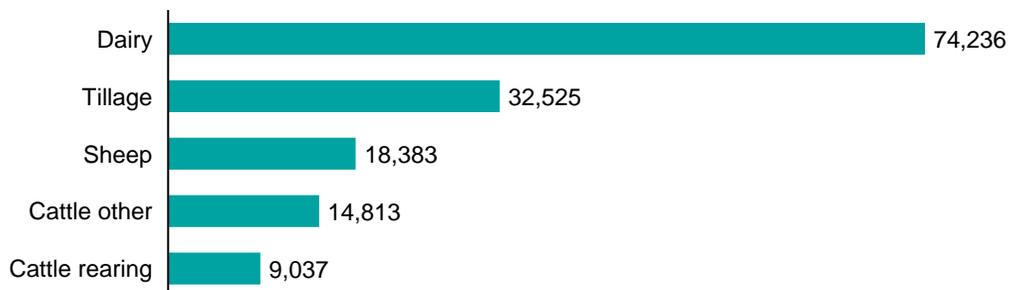
Agriculture as % of total GDP, 2016-2020



Agricultural employment as a % of total civil employment, 2016-2020



Average Family Farm Income, 2020, €



The agri-food sector accounted for 7.1% of total employment in 2019

Key takeaways

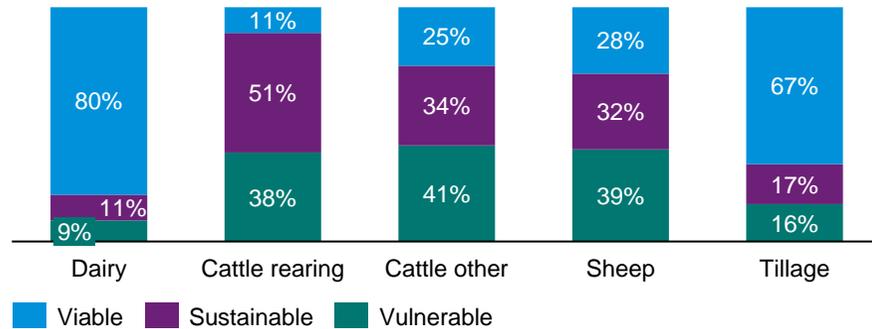
- The agri-food sector in Ireland created €14.4bn in Gross Value Added in 2019. The Primary Agriculture, Fisheries and Forestry account for over 22% of this (€3.3bn), showing an increase of 3.2% compared to 2018 levels
- The agri-food sector employed over 164,400 people or 7.1% of total employment in 2019. Over 51% of farm households had a source of off farm employment income in 2020
- The Primary Agriculture, Fisheries and Forestry sub-sector employs over 100,000 people or 4.6% of the total civil employment
- Average family farm income (FFI) for 2020 was €25,662, a 9% increase on 2019 figures
- There were over 137,000 farms in Ireland in 2016, with over 50% of them being located in the Border, Midland and Western region
- Agri-food exports reached €14.1 billion in 2020, a decrease of 3% from 2019. Ireland exports ~90% of the food produced in the country
- Across all farm systems, almost two-thirds of farms have no farm business related debt although this varies considerably by farm type. Six out of ten dairy farms had borrowings in 2020 compared to three out of ten on sheep, cattle and tillage farms

Source: DAFM (2020); Teagasc (2021); KPMG analysis. Note: Some figures are rounded.

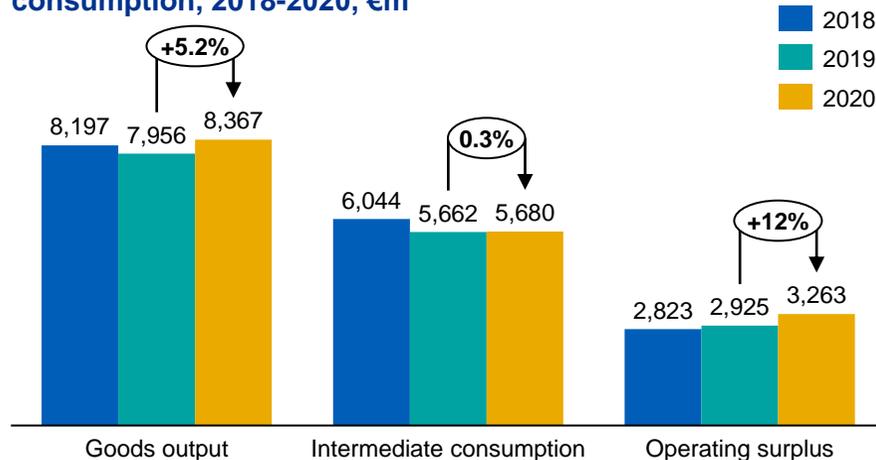
Irish Agriculture - Economics

65% of farms were classified as economically viable or sustainable in 2020.

Viability of farms by sector, 2020



Trends in operating surplus, goods output and intermediate consumption, 2018-2020, €m



Source: CSO (2020), Output, Input & Income in Agriculture Final Estimates; Teagasc (2020), National Farm Survey – Preliminary results 2020; KPMG analysis.

Key takeaways

- In 2020, 80% of Dairy farms were found to be viable (up from 74% in 2019). The proportion of Dairy farm households deemed to be sustainable, due to the presence of an off-farm income source within the household, declined by 3% year-on-year to 11%. Only 9% of Dairy farms were considered vulnerable.
- The proportion of viable Tillage farms stood at 67% in 2020, up 6% from the previous year. In turn, those in the sustainable category declined from 23% to 17%, with those found to be vulnerable down marginally to 16%, on average.
- The situation on Drystock farms remains more challenging, particularly on Cattle Rearing farms where only 11% were deemed viable in 2020, down from 13% in 2019
- 38% of Cattle rearing farms were classed as vulnerable in 2020, demonstrating a 5% decrease year-on-year, while 41% of Cattle Other farms were classed as vulnerable in 2020, a figure relatively unchanged year-on-year. The proportion of sheep farms deemed vulnerable in 2020 remained relatively stable at 39%
- 2020 saw an increase of 5.2% in the value of goods output at producer prices from €7,956 million in 2019 to €8,367 million in 2020
- Operating surplus in agriculture in 2020 showed an annual increase of €338m (+12%), up from €2,925m in 2019 to €3,263m

Decarbonising Agriculture - The Policy & Research Landscape

National and EU policy is evolving and will place greater demands on Ireland's agriculture sector to reduce its carbon emissions and improve its environmental performance.



The EU Farm to Fork Strategy aims to ensure the food chain has a neutral and/or positive environmental impact, preserving and restoring the natural systems it depends on. Targets are set to 2030 and aim to:

- Increase organic farmland to 25% of agricultural area;
- Reduce the use and risk of chemical pesticides by 50%; and
- Reduce nutrient losses by at least 50%, while ensuring no deterioration on soil fertility. This will reduce the use of fertilisers by at least 20% by 2030.



As Ireland prepares for the next Common Agricultural Policy (CAP), an important element of the draft National CAP Plan 2023-2027 is the eco-scheme under Pillar 1, which proposes payments for farmers that deliver actions that contribute to:

- Climate change mitigation, including reduction of carbon emissions from agricultural practices, as well as maintenance of existing carbon stores and enhancement of carbon sequestration;
- Climate change adaptation, including actions to improve resilience of food production systems, and animal and plant diversity for stronger resistance to diseases and climate change;
- Protection or improvement of water quality and reduction of pressure on water resources;
- Prevention of soil degradation, soil restoration, improvement of soil fertility and of nutrient management and soil biota;
- Protection of biodiversity, conservation or restoration of habitats or species, including maintenance and creation of landscape features or non-productive areas;
- Actions for a sustainable and reduced use of pesticides, particularly pesticides that present a risk for human health or environment;
- Actions to enhance animal welfare or address antimicrobial resistance.



At a national level, Food Vision 2030 commits to:

- Immediately implement the 'AgClimatise' Roadmap and update as required to ensure consistency with new national targets
- Produce detailed plans by Q2 2022 to manage the sustainable environmental footprint of the dairy and the beef sectors.
- A reduction in biogenic methane of at least 10% by 2030 (on 2018 level);
- A reduction in emissions associated with chemical fertiliser use to reduce by more than 50% by 2030.
- Contribute to R&D on emissions reductions technologies such as feed additives; grass biorefining; and lower emission breeding.

Decarbonising Agriculture - The Policy & Research Landscape

The most significant analysis into actions that the Irish agriculture sector can take to reduce its carbon emissions is the 2018 Teagasc Marginal Abatement Cost Curve (MACC) report: ‘An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030’

This report provides a range of costed actions or mitigation measures that have the potential to reducing carbon emissions within the agriculture sector. The measures are divided into Agricultural measures, Land use or Carbon sequestration measures and Energy measures. The measures analysed in the MACC have informed the Climate Action Plan 2019, AgClimatise and its successor Food Vision 2030.

The four scenarios explored in this report deal primarily with the Agricultural measures described in the MACC. These are on-farm measures that can apply to different farming sub-sectors: Dairy, Beef, Sheep, Pigs and Poultry*. Agricultural measures are further sub-divided into two categories:

1. **Livestock**
2. **Soils & Fertilisation**

Separately, this report explores the application of land use, carbon sequestration and energy-related measures. These measures are not included in the scenarios as the mitigation and sequestration potential from such measures would not be allocated to the agriculture sector in national GHG accounts. However, they would contribute to Ireland’s national effort to reach net zero by 2050.



Lanigan et al, An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030, Teagasc, 2018

Note: Ireland's National GHG emissions inventory provides emissions data for each livestock sector but does not report a breakdown of the tillage sector's emissions. We have included measures relevant to the tillage sector for information and narrative purposes, and provide economic analysis of the same, but do not discuss mitigation potential associated with the tillage sector alone.

Decarbonising Agriculture - The Policy & Research Landscape

Future developments could influence the way in which agricultural emissions are accounted for.

LULUCF

It is important to note that, under current national GHG accounting rules, emissions reductions associated with land use and energy measures are counted under the Energy sector and the Land Use, Land Use Change and Forestry (LULUCF) sector. This means that these measures will not count towards the agriculture sector's emissions reductions efforts.

However, under the recently published Fit for '55 package, the European Commission has proposed that from 2030 onwards agriculture and land use will be accounted for together under a new sector: Agriculture, Forestry and Other Land Uses (AFOLU)*. In this report, we provide details of the contribution that the agriculture sector can make to national decarbonisation by implementing these measures.

*GWP**

Methane has a much shorter atmospheric lifetime than CO₂ (around 12 years compared with centuries for CO₂), but it is a much more potent greenhouse gas when it comes to warming potential. The most common way to estimate the effect of methane on warming is global warming potential (GWP). This is a multiplier which can consider the impact of methane over different time periods. Currently all national calculations use Global Warming Potential 100, which considers impact over a 100-year timeframe (GWP100). The Intergovernmental Panel on Climate Change (IPCC) has indicated a GWP for methane between 84-87 when considering its impact over a 20-year timeframe (GWP20) and between 28-36 when considering its impact over a 100-year timeframe (GWP100). This means that one tonne of methane can be considered to be equivalent to 28 to 36 tonnes of CO₂ if looking at its impact over 100 years.

A new metric called GWP* is being considered by the scientific community to better account for the different behaviours of short- and long-lived GHGs. GWP* accounts for the current year's methane emissions and the trend for the most recent 20-year period. If the GWP* approach was adopted for national inventories in future, it would change the calculations for how each sector contributes to global warming. This is particularly relevant for agriculture, in which methane is the predominant greenhouse gas with emissions rising over the past decade.

Sources: International Energy Agency, Methane and climate change, Methane Tracker 2021, <https://www.iea.org/reports/methane-tracker-2021/methane-and-climate-change>

Siobhán Walsh, 'High confidence' in methane metric could be good for national herd, 09 August 2021, <https://www.farmersjournal.ie/high-confidence-in-methane-metric-could-be-good-for-national-herd-640100>

Decarbonising Agriculture - The Policy & Research Landscape

The stabilisation of livestock numbers and carbon leakage are key considerations in the reduction of Irish agricultural emissions.

- Livestock emissions, particularly emissions from dairy and beef systems, account for the majority of agricultural emissions in Ireland. AgClimatise states that “in total, approximately 80% of the agricultural GHG inventory is related directly to the number of animals and the management of the manure they produce.”
- Efficiency and technology measures as described in the MACC can reduce absolute emissions if production is held constant. The MACC emphasises the need to avoid “rebound effects” from efficiency measures – in other words, where efficiency gains lead to production increases such that absolute emissions increase.
- Carbon leakage refers to a displacement rather than a reduction in GHG emissions, typically from one country or region to another country or region with less stringent climate rules, or more carbon-intensive production practices.
- While a reduction in livestock numbers could reduce national-level emissions, there is the potential for carbon leakage if global demand for meat and dairy products does not also reduce. A recent OECD and FAO forecast points to greater global demand for such products towards 2030.
- It is sometimes argued therefore, that reducing agricultural production in Ireland could lead to a net increase in global emissions, if this production is replaced by a shift to regions with more intensive agricultural systems, and create indirect climate impacts from the emissions associated with land use change.
- However the Climate Change Advisory Council found that although leakage is likely to occur, “there is insufficient evidence to provide a definitive answer to whether a reduction in agricultural production in Ireland will lead to a net increase in global greenhouse gas emissions. The balance of probability suggests that mitigation measures implemented with the support of subsidies, together with an extended range of mitigation options, would not increase global emissions.”
- The European Commission has adopted the Carbon Border Adjustment Mechanism (CBAM) to tackle the risk of carbon leakage resulting from EU climate policies such as those set out in the Green Deal. This measure could affect agriculture as fertilisers are included in the first phase of the CBAM.



Sources: Emmet-Booth, Dekker, O'Brien, Climate Change Mitigation and the Irish Agriculture and Land Use Sector, Climate Change Advisory Council 2019
[OECD-FAO Agricultural Outlook 2021–2030](#), Food and Agriculture Organization of the United Nations, 2021

3.

Scenario
analysis:
Approach
and results



We have developed and analysed four scenarios, reflecting four different decarbonisation pathways for the agriculture sector which will potentially be required under the Climate Bill.

The scenarios increase in ambition, exploring emissions reductions of 13%, 18%, 30% and 50% across the agricultural sector compared with 2018 levels. Each scenario was developed through an iterative process in close collaboration with experts, as per the following steps below. Alongside each of the four scenarios, a baseline scenario has also been included for comparison purposes. This baseline scenario and each of the four scenarios are explored in more depth on the following slides.

1. Desk based research, including:

EPA National Inventory Report 2021

EPA Climate Projections report 2020-2040

Teagasc Marginal Abatement Cost Curve, 2018

Forthcoming Teagasc research, used with permission from the author

UK Climate Change Committee Sixth Carbon Budget

Scottish Rural College report 'Non-CO₂ abatement in the UK agricultural sector by 2050'

2. Multiple information gathering sessions held with a number of experts in both industry and academia, including:

IFJ sector leads

Teagasc sector and carbon emissions experts

Research project leads (e.g. MethAbate, Farm Zero C)

EPA emissions experts

Michael Wallace, Professor of Agriculture and Food Economics, UCD

3. Development of an extensive list of mitigation measures and proposed allocation to agricultural sectors

4. Feedback on long list via agricultural sector workbooks

5. Shortlisting of mitigation measures

6. Development of 4 scenarios

Baseline scenario

The baseline scenario adopts the Environmental Protection Agency’s (EPA) projections of carbon emissions for the agriculture sector under its ‘With Existing Measures’ (WEM) scenario.

The WEM scenario reflects a ‘Business-as-Usual’ approach, and assumes no additional policies or measures are implemented beyond those already in place by the end of 2019. Under this scenario, agricultural carbon emissions are projected to increase by approximately 3% between 2018 and 2030 (from **21.35 MtCO₂e** to **21.94 MtCO₂e**). The table below presents some of the changes underlying this increase in carbon emissions, including changes to livestock numbers, nitrogen fertiliser use and changes to cropland area. The baseline scenario is used to compare the impact of each of the four scenarios.

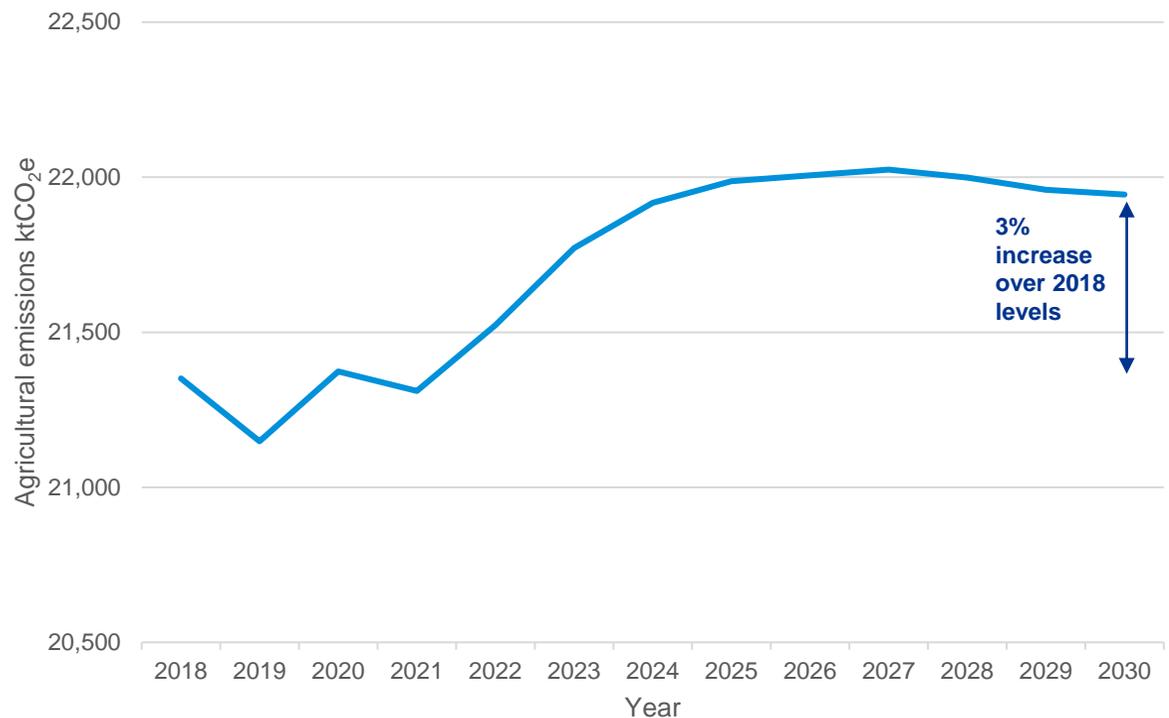


Table: Changes to agriculture carbon emissions sources under the WEM scenario

Emissions source	% change between 2018 and 2030
Dairy cattle	13%
Non-dairy cattle	-3%
Sheep	8%
Pig	-2%
Poultry	30%
Nitrogen input from application of synthetic fertilisers	5%
Area of cultivated organic soils	-10%

Scenario development

Each scenario has been developed to reflect the potential levels of decarbonisation of the agriculture sector required under the Climate Bill. We have analysed four decarbonisation pathways to 2030, compared to a 2018 baseline year: 13%, 18%, 30% and 50%.*

Mitigation measures to reduce carbon emissions described in the Teagasc’s Marginal Abatement Cost Curve (MACC) 2018 have been adopted in each of the four scenarios. Scenario 1 applies these measures only, while Scenarios 2, 3 and 4 apply increased ambition to the Teagasc measures as well as additional, novel measures.**

To reach the ambitious decarbonisation pathways in Scenario 3 and 4, a reduction in livestock numbers is also included. The table below presents each scenario, the data sources used and the level of decarbonisation required.

Scenario	Description	Data sources	% level of decarbonisation by 2030
Scenario 1	Full application of mitigation measures in Teagasc MACC	Teagasc MACC 2018	13%
Scenario 2	Application of MACC with increased uptake on some measures and additional mitigation measures	Teagasc MACC 2018, forthcoming Teagasc research, Scottish Rural College (SRUC)	18%
Scenario 3	Scenario 2 with reduction in livestock numbers	Teagasc MACC 2018, forthcoming Teagasc research, Scottish Rural College (SRUC)	30%
Scenario 4	Scenario 3 with increased reduction in livestock numbers	Teagasc MACC, Emerging/unpublished Teagasc research, Scottish Rural College (SRUC)	50%

See appendix for additional information on Scenario 3X (21% decarbonisation)

*Note that each of the decarbonisation pathways include the reduction in agriculture sector carbon emissions that has occurred between 2018 and 2019 (0.87 MtCO₂e), as reported by the EPA. For the purpose of this analysis, carbon emissions in 2020 and 2021 are assumed to be unchanged from 2019 and remain constant. The reduction in carbon emissions from mitigation measures are included in our analysis from 2022, when they are assumed to be implemented.

Additional analysis of an emissions reduction target of 21% was conducted for completeness. This was named Scenario 3X and details can be found in Appendix *

Scenario development

A suite of mitigation measures has been collated and allocated across each of the scenarios using the data sources described previously.

The table below presents each of the mitigation measures included in our analysis, the relevant agriculture category, their mitigation potential (i.e. potential to reduce carbon emissions) and the scenario in which each mitigation measure has been applied.

Agriculture category	Mitigation measure	Mitigation potential in 2030 (MtCO ₂ e)	Scenario 1	Scenario 2	Scenario3	Scenario 4
Livestock*	3NOP**	0.453	x	✓	✓	✓
	Improved dairy economic breeding index (EBI)	0.430	✓	✓	✓	✓
	Improved animal health (Dairy & Beef)	0.303	✓	✓	✓	✓
	Low-emission slurry spreading	0.203	✓	✓	✓	✓
	Slurry chemical amendments	0.101	✓	✓	✓	✓
	Lower age of slaughter	0.098	x	✓	✓	✓
	Adding lipids/fatty acids to dairy diets	0.083	✓	✓	✓	✓
	Extended grazing	0.066	✓	✓	✓	✓
	Improved beef liveweight gain	0.061	✓	✓	✓	✓
	Anaerobic Digestion of Slurry and Grass	0.056	✓	✓	✓	✓
	Reduced crude protein in pig diets	0.051	✓	x	x	x
	Reduced crude protein in pigs & bovines	0.046	x	✓	✓	✓
	Improved beef maternal traits	0.025	✓	✓	✓	✓
	Increased use of sexed semen	0.024	✓	✓	✓	✓
	Cover slurry stores	0.003	x	✓	✓	✓
Soils & Fertilisation	Switching N fertiliser from CAN to protected urea	0.521	✓	x	x	x
	Fertiliser type	0.472	x	✓	✓	✓
	Nitrogen use efficiency	0.287	✓	✓	✓	✓
	Compound Fertiliser	0.206	x	✓	✓	✓
	Draining wet mineral soils	0.197	✓	✓	✓	✓
	Multi-species swards	0.069	x	✓	✓	✓
	Inclusion of clover in pasture swards	0.069	✓	x	x	x
	Reduced N ₂ O from organic soils	0.067	x	✓	✓	✓
Nitrification Inhibitors	0.019	x	✓	✓	✓	

*'Livestock' refers to the following sectors: Dairy, Beef, Sheep, Pigs and Poultry

**3NOP is a methane-inhibiting feed additive for cows. Please see Slide 103 for further detail of this measure.

Allocation of mitigation measures

Some mitigation measures apply to multiple livestock categories. In these cases, the mitigation potential of each measure has been allocated across livestock categories.

Mitigation measures have been split based on the contribution of each livestock category to total agricultural emissions. The tables below show both the 2018 split of carbon emissions as well as the methodology we have applied to calculate the weighted proportions for each livestock category.

Agriculture category	Total carbon emissions in 2018 (MtCO ₂ e)	% of total carbon emissions in 2018
Dairy	7.11	48%
Beef	6.31	43%
Sheep	0.81	5%
Pigs	0.34	2%
Poultry	0.16	1%
Total livestock	14.73	100%
Livestock	14.73	69%
Soils and Fertilisation	6.63	31%
Total	21.35	100%

Agriculture category	Total carbon emissions in 2018 (MtCO ₂ e)	% of total carbon emissions in 2018
Dairy	6.04	41%
Dairy-Beef Calf	2.15	15%
Beef Suckler Calf	5.23	36%

Allocation of mitigation measures to livestock categories	Total weighted proportions	Dairy	Beef	Sheep	Pigs	Poultry
Dairy, Beef	91%	53%	47%	-	-	-
Dairy, Beef, Sheep	97%	50%	44%	6%	-	-
Dairy, Beef, Pigs	93%	52%	46%	-	2%	-
Dairy, Beef, Poultry	92%	52%	46%	-	-	1%
Dairy, Beef, Pigs, Poultry	95%	51%	45%	-	2%	1%
Dairy, Beef, Sheep, Pigs, Poultry	100%	48%	43%	5%	2%	1%
Beef; Pigs	45%	-	95%	-	5%	-
Pigs, Poultry	3%	-	-	-	67%	33%
Dairy, Pigs, Poultry	52%	93%	-	-	4%	2%

Example:
If a mitigation measure applies to both Dairy and Beef, we divide the Dairy sector's contribution to overall agricultural emissions (48%) by the total contribution of Dairy and Beef to overall agricultural emissions (91%). This gives 53%, which becomes the Dairy sector's allocation for the measure.

For example, the 'Improved animal health' measure applies to Dairy and Beef and delivers 0.147 MtCO₂e of mitigation. Dairy would take 53% of this figure while Beef would take 47%.

Note: Ireland's National GHG emissions inventory reports on each livestock sector emissions but does not report a breakdown of the tillage sector's emissions. We have included measures relevant to the tillage sector for information and narrative purposes on Slide 37 but will not be able to provide a decarbonisation trajectory for the tillage sector on its own.

Scenario analysis results

Results: Baseline Scenario v Scenarios 1, 2, 3 & 4

The table below presents results of each of the four scenarios developed.

Carbon emissions in 2018 and 2030 for Scenario 1, Scenario 2, Scenario 3 and Scenario 4 are presented alongside the Baseline Scenario. The mitigation potential in 2030 and the % change in carbon emissions against 2018 levels and against the 2030 baseline scenario are also shown.

Further detail on the mitigation measures informing each of the scenarios is provided later in the report.

Scenario	Carbon emissions in 2018 (MtCO ₂ e)	Carbon emissions in 2019 (MtCO ₂ e)	Mitigation potential in 2030 (MtCO ₂ e)	Carbon emissions in 2030 (MtCO ₂ e)	Change in carbon emissions between 2018 & 2030 (MtCO ₂ e)	% difference against 2018 baseline	% difference against WEM Scenario 2030 baseline
Baseline Scenario	21.35	20.48	-	21.94	-0.59*	-3%	n/a
Scenario 1	21.35	20.48	1.94	18.54	2.81	13%	18%
Scenario 2	21.35	20.48	2.95	17.53	3.82	18%	20%
Scenario 3	21.35	20.48	5.50**	14.98	6.37	30%	32%
Scenario 4	21.35	20.48	9.80***	10.68	10.67	50%	51%

Although 2018 is the baseline year for this analysis, we note that the EPA reported a 0.87 MtCO₂e reduction in agriculture sector carbon emissions between 2018 and 2019. This reduction is therefore included in the analysis.

*Note that '-' indicates an increase in carbon emissions / negative mitigation potential

**2.95 MtCO₂e arising from efficiency measures + 2.55 MtCO₂e from a reduction in livestock numbers

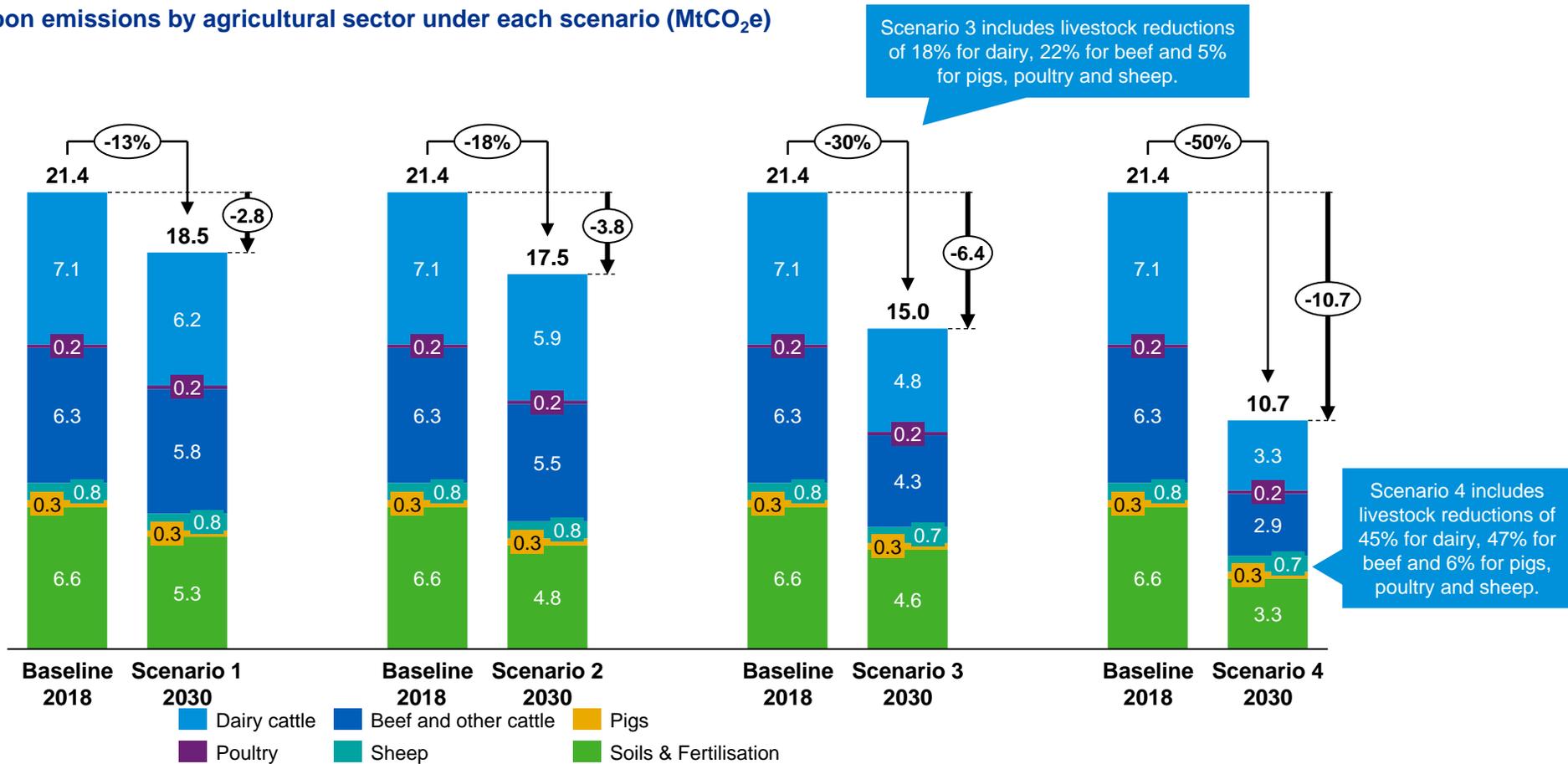
***2.95 MtCO₂e arising from efficiency measures + 6.84 MtCO₂e from a reduction in livestock numbers

Scenario analysis results

Results: Baseline Scenario v Scenarios 1, 2, 3 & 4

The graph below presents results of each of the four scenarios developed, broken down by agriculture category (Dairy, Beef, Sheep, Pigs, Poultry and Soils & Fertilisation).

Carbon emissions by agricultural sector under each scenario (MtCO₂e)



Additional analysis of an emissions reduction target of 21% was conducted for completeness. This was named Scenario 3X and details can be found in Appendix ***

Notes: Scenario 1 and 2 assume there are no changes to livestock numbers. No land-use or energy abatement measures are included.

Source: Teagasc, EPA, KPMG analysis

Scenario analysis results

Results: Breakdown of mitigation potential by agriculture sector

The potential reduction in carbon emissions delivered by each agriculture sector is presented in the table below.

For both Scenario 1 and 2, the dairy, beef and soils and fertilisation agriculture sectors deliver the majority of measures to reduce carbon emissions. In both Scenario 3 and 4, a reduction in livestock numbers is required to reach the ambitious targets of 30% and 50% reduction in carbon emissions by 2030, respectively – the contribution of the required cut in livestock numbers to a reduction in carbon emissions dwarfs what can be delivered through efficiency and technological measures.

		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
		Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation	Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation	Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation	Mitigation potential (MtCO ₂ e)	% contribution to overall mitigation
Agricultural Sector	Dairy	0.680	35%	0.993	34%	0.993	18%	0.993	10%
	Beef	0.295	15%	0.627	21%	0.627	11%	0.627	6%
	Sheep	0.006	0.3%	0.006	0.2%	0.006	0.1%	0.006	0.1%
	Pigs	0.056	3%	0.006	0.2%	0.006	0.1%	0.006	0.1%
	Poultry	0.002	0.1%	0.002	0.1%	0.002	0.04%	0.002	0.02%
	Soils & Fertilisation	0.899	46%	1.316	45%	1.316	24%	1.316	13%
Reduction in Livestock Numbers		-	-	-	-	2.55	46%	6.84	70%
Total		1.938	100%	2.952	100%	5.50	100%	9.80	100%

Source: Teagasc, EPA, KPMG analysis

Scenario development

The full application of measures from the Teagasc research (MACC and forthcoming research) deliver a maximum of 18% reduction in emissions across the agriculture sector with livestock reductions applied thereafter.

Further mitigation may be possible with uplifted/increased application of the Teagasc measures, and through innovation and emerging technologies. These measures were raised in engagement with sector experts and analysis of the Scottish Rural College (SRUC) research.

Although these uplifted/additional measures are not included in the four scenarios, a summary of the potential options is provided overleaf for completeness. It is estimated that if measures were uplifted, a 20% reduction in measures would be possible, and therefore a smaller livestock reduction would be required to reach more ambitious decarbonisation targets.

It should be noted however that the mitigation potential described overleaf is based on best available research, and has not been fully costed and tested for interactions in the same way as the Teagasc measures have. Thus, there is a greater level of uncertainty associated with the uplifted measures.



Scenario development

Measures that could potentially be uplifted to achieve greater mitigation are marked in purple. These measures are not included in the four Scenarios but are included here for completeness.

Mitigation measure	Mitigation potential without uplift (MtCO ₂ e)	Mitigation potential with uplift (MtCO ₂ e)	Justification for uplift
3NOP	0.453	0.453	No change
Improved dairy economic breeding index (EBI)	0.430	0.430	No change
Improved animal health (Dairy, Beef)	0.147	0.303	The Teagasc MACC only considers a 20% improvement on baseline health for Dairy & Beef. There may be room for further improvement in baseline health. To uplift the measure, the SRUC measure 'Better health planning for cattle' has been included, which gives a higher mitigation potential.
Low-emission slurry spreading	0.117	0.211	The Teagasc MACC assumes a 50% limit on uptake of slurry spreading. Based on expert feedback and the Climate Action Plan, this measure could potentially be uplifted to 90% uptake. A direct increase in mitigation potential was assumed.
Slurry chemical amendments	0.027	0.101	The Teagasc MACC assumes a 20% uptake across dairy and pigs. Measure could be uplifted by applying to the beef sector and assumed a 50% uptake among dairy, beef and pigs. Information was provided by GlasPort Bio and informed by their large-scale studies.*
Lower age of slaughter	0.098	0.098	No change
Adding lipids/fatty acids to dairy diets	0.083	0.083	No change
Extended grazing	0.066	0.066	No change. Expert feedback indicated there was little room for improvement on this measure.
Improved beef liveweight gain	0.061	0.061	No change
Anaerobic Digestion of Slurry and Grass	0.056	0.056	No change
Reduced crude protein in pigs & bovines	0.046	0.046	No change
Improved animal health (Sheep)	n/a	0.043	The 'Improved animal health' measure in the Teagasc MACC only covers the Dairy & Beef sectors. The measure could be uplifted by adding the mitigation potential from improved health in other sectors. The SRUC measure 'Improved health for sheep' is added here.
Improved beef maternal traits	0.025	0.025	No change
Increased use of sexed semen	0.024	0.024	No change
Cover slurry stores	0.003	0.003	No change. The forthcoming Teagasc research does not provide information on what level of uptake this mitigation potential represents. It could already reflect uptake on 100% of farms. Elsewhere, the Teagasc ammonia MACC assumes a 100% adoption rate for covering slurry stores.
Total mitigation potential from Livestock measures	1.635	2.003	

*GlasPort Bio is an Irish biotechnology company that has developed an additive to i) reduce methane and ammonia emissions from treated slurry during storage (ii) improve slurry nutrient content following treatment to allow for greater use of treated slurry/displacement of mineral fertiliser (iii) increase biogas potential from treated slurry to increase potential of slurry as a feedstock in Anaerobic Digestion and (iv) reduce slurry malodours during treatment.

Agriculture's contribution to national decarbonisation efforts

Beyond the agricultural measures described on slide 27, the agriculture sector can deliver on a series of carbon sequestration and energy-related measures, outlined the Teagasc MACC and other Teagasc research.

The Carbon sequestration and Energy measures have not been included in the four scenarios as they would not be allocated to the agriculture sector in national GHG accounting. However, the measures are explored separately as they show how the agricultural sector could meaningfully contribute to Ireland's national decarbonisation target, potentially delivering as much as 5.8 MtCO₂e – see Table below. The economic impact of these measures has been analysed where cost information is available.

Carbon sequestration mitigation measures

MACC 2018

- Improved grassland management
- Water table manipulation of peaty agricultural grassland soils
- Inclusion of cover crops in tillage
- Straw incorporation in tillage
- Forestry*

Additional measures from forthcoming Teagasc research**

- Multi-species swards***
- Digestate from Anaerobic Digestion/biogas
- Pig slurry on arable
- Lime CO₂ Emissions Factor reduction
- Enhanced weathering****
- Agroforestry*
- Hedgerows

*Please find discussion of Forestry and Agroforestry overleaf.

**Analysis of the economic impact has been conducted for the measures in the MACC but not for the forthcoming Teagasc research as no cost information is available for these measures.

***The multi-species sward measure applies to 50,000 ha of derogation farms. It is assumed that there is no interaction with other measures relating to fertiliser.

****Enhanced weathering is a process where the formation of carbonate minerals in soils is promoted artificially to produce a measurable permanent sink for atmospheric CO₂. The addition of basalt rock dust to soils can reduce pH, condition soils and enhance CO₂ sequestration (Beerling et al. 2018).

Energy-related mitigation measures

MACC 2018

- Increased farm energy efficiency
- Increased use of wood biomass for energy generation
- Increased use of short rotation coppice and miscanthus biomass for heat production
- Increased use of short rotation coppice for electricity production
- Biogas production by anaerobic digestion of slurry and grass
- Biomethane from biogas
- Oilseed rape for biodiesel
- Sugar beet for bioethanol

Mitigation measure	Measures in Teagasc MACC (MtCO ₂ e)	Measures in Teagasc forthcoming research (MtCO ₂ e)
Sequestration potential from carbon sequestration measures	2.97	4.05
Mitigation potential from energy-related measures	1.76	1.76
Total	4.73	5.81

Agriculture's contribution to national afforestation efforts

The extent to which agriculture will contribute to national afforestation efforts is unclear.

In the table below we provide options to include or exclude the sequestration potential from forestry and agroforestry under agriculture's contribution to national decarbonisation.

Forestry

The Teagasc MACC estimates that afforestation at a static rate of 7,000 ha per year will deliver 2.1 MtCO₂e of carbon sequestration of the period 2021 to 2030. The rate is held static "due to considerable barriers to uptake within the farming community". However, the extent to which this afforestation effort would be carried out by the agriculture sector / farmers versus a national afforestation programme is not clear. It should also be noted that afforestation has not yet reached the level of 7,000 ha per year, reaching just 3,500 ha in 2020 and 2,700 ha for the first half of 2021. The new national afforestation target is 8,000 ha per year, but Minister Pippa Hackett gave evidence to the Joint Oireachtas Committee on Agriculture, Food and the Marine on 4th August 2021, stating the target will not be reached this year. Thus, the 2.1 MtCO₂e from Forestry referenced in the MACC is likely to be significantly overestimated.

Agroforestry

Agroforestry refers to the growing of trees combined with animal or crop agriculture. Forthcoming Teagasc research estimates that this measure has the potential to deliver 0.026MT CO₂e per annum by 2030. The research states that: "given that agroforestry is classified as forestry and requires a re-classification of land and mandatory re-planting, it is unlikely that more than 5,000 ha would be established prior to the end of the decade."

Mitigation measure	Teagasc MACC No Forestry (MtCO ₂ e)	Teagasc forthcoming research No Forestry (MtCO ₂ e)	Teagasc MACC With Forestry (MtCO ₂ e)	Teagasc forthcoming research With Forestry (MtCO ₂ e)
Sequestration potential from carbon sequestration measures	0.87	1.09	2.97	4.05
Mitigation potential from energy-related measures	1.76	1.76	1.76	1.76
Total	2.63	2.88	4.73	5.81

Contribution of the tillage sector to national decarbonisation efforts

The tillage sector can contribute to national decarbonisation efforts through carbon sequestration and energy efficiency measures.

Ireland's National GHG emissions inventory provides emissions data for each livestock sector but does not report a breakdown of the tillage sector's emissions. As such, measures relevant to the tillage sector are discussed here and included in the economic analysis, but mitigation measures for the tillage sector are not assessed.

Currently there are circa 5,000 full-time tillage farmers producing the majority of output, with 10,000 farms involved in tillage at some level. Tillage farming has the lowest greenhouse gas emissions of any production system in Irish agriculture, with the average mixed tillage farm emitting 1.18 tCO₂e/ha.

Given that tillage has a lower carbon footprint than other sectors, AgClimatise recommends that the area under cultivation is retained or increased: "Currently, there are approximately 300,000 hectares of tillage crops (cereals, legumes and potatoes) produced annually and this area must be retained, despite increasing land competition from the dairy sector."

Tillage measures in the Teagasc MACC

The measures in the Teagasc MACC that refer to tillage are either Carbon sequestration or Energy measures. As such, they would not count towards the decarbonisation of the agriculture sector, but they could contribute to national decarbonisation efforts. For example, the inclusion of cover crops and straw incorporation in tillage can sequester carbon. Straw incorporation can increase Soil Organic Carbon while the use of cover crops (e.g. mustard) can reduce the loss of carbon and leached nitrogen (which in reduces indirect N₂O emissions).

The 'Increased farm energy efficiency' measure in the Teagasc MACC refers to energy efficiency in the dairy sector only, although carbon savings could be made in the tillage sector, too. Some tillage farmers have high electricity needs to run fridges for crop storage and fuel is required for grain drying. These electricity/fuel requirements could be replaced by renewable energy sources such as willow, miscanthus or straw. Three measures in the MACC refer to this: Increased use of wood biomass for energy generation; Increased use of short rotation coppice and miscanthus biomass for heat production; and Increased use of short rotation coppice for electricity production. The tillage sector could also contribute to the production of renewable fuels by growing oilseed rape for biodiesel and sugar beet for bioethanol.

Sources: AgClimatise - A Roadmap towards Climate Neutrality, Department of Agriculture, Food and the Marine, 2020, <https://www.gov.ie/en/publication/07fbc-ag-climatise-a-roadmap-towards-climate-neutrality/>
2027 Sectoral Road Map: Tillage, Teagasc, 2020, <https://www.teagasc.ie/media/website/publications/2020/2027-Sectoral-Road-Map---Tillage.pdf>

4.

Scenario 1 -
Further
detail



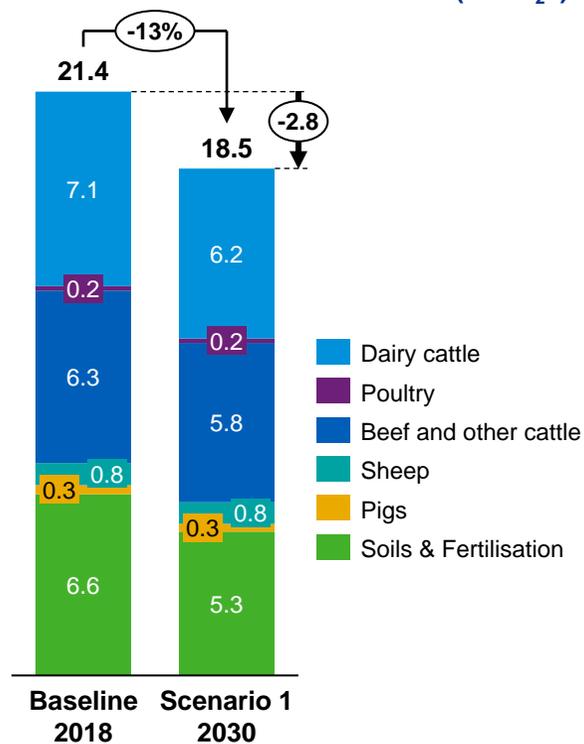
Scenario analysis results

Scenario 1 - Overview

An overview of Scenario 1 is provided below.

Scenario 1 reaches a reduction in carbon emissions of 1.938 MtCO₂e by 2030 (13% reduction compared to 2018 levels). Reductions are achieved by applying the mitigation measures outlined in the Teagasc MACC (see table on the next slide). No livestock reduction is applied in this Scenario. Livestock measures account for 54% of total mitigation in this Scenario, while Soils & Fertilisation measures account for the remaining 46%. Dairy and Beef deliver the majority of mitigation potential (35% and 15%, respectively), with small contributions from Pigs, Sheep and Poultry.

Total carbon emissions per agricultural sector under Baseline and Scenario 1 (MtCO₂e)



The dairy-beef split includes mitigation potential from both the dairy and beef sectors. This is due to a number of the mitigation measures for dairy-beef calves occurring from the dairy cow which the beef sector have no control over.

Agriculture category	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Dairy	0.680	35%
Beef	0.295	15%
Pigs	0.056	3%
Sheep	0.006	0.3%
Poultry	0.002	0.1%
Soils & Fertilisation	0.899	46%
Total	1.938	100%

Agriculture category	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Dairy	0.577	30%
Dairy-Beef Calf	0.153	8%
Suckler Beef	0.244	13%

Notes: Scenario 1 and 2 assume there are no changes to livestock numbers, No land-use and energy abatement measures are included
Source: Teagasc, EPA, KPMG analysis

Scenario analysis results

Scenario 1 – Mitigation measures

An overview of the agricultural mitigation measures in Scenario 1 is provided below.

Agriculture category	Mitigation measure	Allocation	2030 mitigation potential (MtCO _{2e})	% of total mitigation potential
Livestock	Improved dairy economic breeding index (EBI)	Dairy	0.430	22%
	Improved animal health	Dairy, Beef, Sheep, Pigs, Poultry	0.147	8%
	Low-emission slurry spreading	Dairy, Beef, Sheep, Pigs, Poultry	0.117	6%
	Extended grazing	Dairy, Beef 20/80	0.066	3%
	Improved beef liveweight gain	Beef	0.061	3%
	Anaerobic Digestion of Slurry and Grass	Dairy, Beef, Pigs, Poultry	0.056	3%
	Reduced crude protein in pig diets	Pigs	0.051	3%
	Adding lipids/fatty acids to dairy diets	Dairy	0.035	2%
	Slurry chemical amendments	Dairy, Beef, Sheep, Pigs, Poultry	0.027	1%
	Improved beef maternal traits	Beef	0.025	1%
	Increased use of sexed semen	Dairy, Beef	0.024	1%
	Total Livestock			1.039
Soils & Fertilisation	Switching N fertiliser formulation from CAN to protected urea	Soils & Fertilisation	0.521	27%
	Draining wet mineral soils	Soils & Fertilisation	0.197	10%
	Nitrogen (N) use efficiency	Soils & Fertilisation	0.112	6%
	Inclusion of clover in pasture swards	Soils & Fertilisation	0.069	4%
	Total Soils & Fertilisation			0.899
Total			1.938	100%

5.

Scenario 2 -
Further
detail



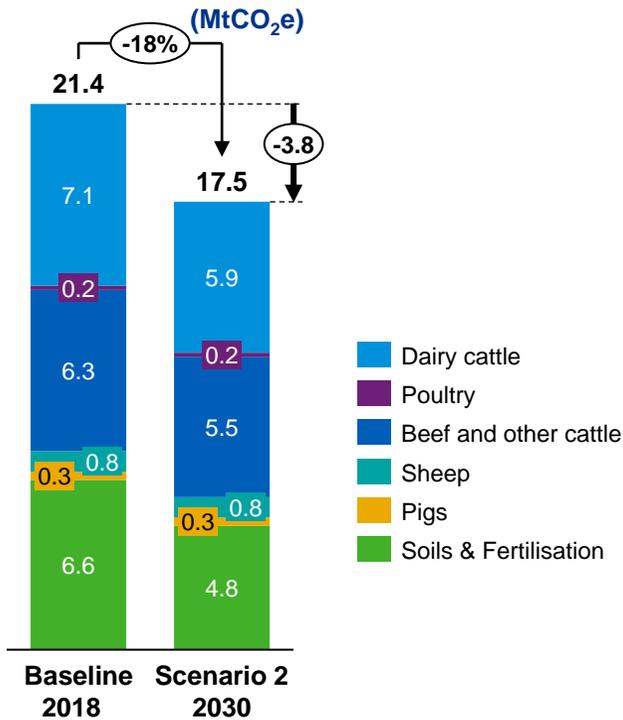
Scenario analysis results

Scenario 2 - Overview

An overview of Scenario 2 is provided below.

This scenario reaches a reduction in carbon emissions of 2.952 MtCO₂e in 2030 (18% reduction compared to 2018 levels). Reductions are achieved by applying the mitigation measures outlined in the Teagasc MACC, with some uplifted and additional measures from forthcoming Teagasc research (see table on the next slide). No livestock reduction is applied in this Scenario. Livestock measures account for 55% of total mitigation in this Scenario, while Soils & Fertilisation measures account for the remaining 45%. Dairy and Beef deliver the majority of mitigation potential from Livestock (34% and 21%, respectively), with small contributions from Pigs, Sheep and Poultry.

Total carbon emissions per agricultural sector under Baseline and Scenario 2



The dairy-beef split includes mitigation potential from both the dairy and beef sectors. This is due to a number of the mitigation measures for dairy-beef calves occurring from the dairy cow which the beef sector have no control over.

Agriculture category	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Dairy	0.993	34%
Beef	0.627	21%
Pigs	0.006	0.2%
Sheep	0.006	0.2%
Poultry	0.002	0.1%
Soils & Fertilisation	1.316	45%
Total	2.952	100%

Agriculture category	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Dairy	0.843	29%
Dairy-Beef Calf	0.257	9%
Suckler Beef	0.521	17%

Scenario analysis results

Scenario 2 - Mitigation measures

An overview of the agricultural mitigation measures in Scenario 2 is provided below. Measures which have been added or amended compared with Scenario 1 are highlighted in green.

Agriculture category	Mitigation measure	Allocation	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Livestock	3NOP*	Dairy, Beef	0.453	15%
	Improved dairy economic breeding index (EBI)	Dairy	0.430	15%
	Improved animal health	Dairy, Beef	0.147	5%
	Low-emission slurry spreading	Dairy, Beef, Sheep, Pigs, Poultry	0.117	4%
	Lower age of slaughter	Beef	0.098	3%
	Adding lipids/fatty acids to dairy diets	Dairy	0.083	3%
	Extended grazing	Dairy, Beef 20/80	0.066	2%
	Improved beef liveweight gain	Beef	0.061	2%
	Anaerobic Digestion of Slurry and Grass	Dairy, Beef, Pigs, Poultry	0.056	2%
	Crude protein in pigs & bovines	Beef, Pigs	0.046	2%
	Slurry chemical amendments	Dairy, Beef, Sheep, Pigs, Poultry	0.027	1%
	Improved beef maternal traits	Beef	0.025	1%
	Increased use of sexed semen	Dairy, Beef	0.024	1%
	Cover slurry stores	Dairy, Beef, Pigs	0.003	0%
Total Livestock			1.635	55%
Soils & Fertilisation	Switching N fertiliser formulation from CAN to protected urea	Soils & Fertilisation	0.472	16%
	Nitrogen (N) use efficiency	Soils & Fertilisation	0.287	10%
	Draining wet mineral soils	Soils & Fertilisation	0.197	7%
	Nitrification inhibitors	Soils & Fertilisation	0.019	1%
	Compound fertiliser	Soils & Fertilisation	0.206	7%
	Reduced N ₂ O from organic soils	Soils & Fertilisation	0.067	2%
	Multi-species swards	Soils & Fertilisation	0.069	2%
Total Soils & Fertilisation			1.316	45%
Total			2.952	100%

*3NOP is a methane-inhibiting feed additive for cows. Please see Slide 103 for further detail of this measure.

6.

Scenario 3 -
Further
detail



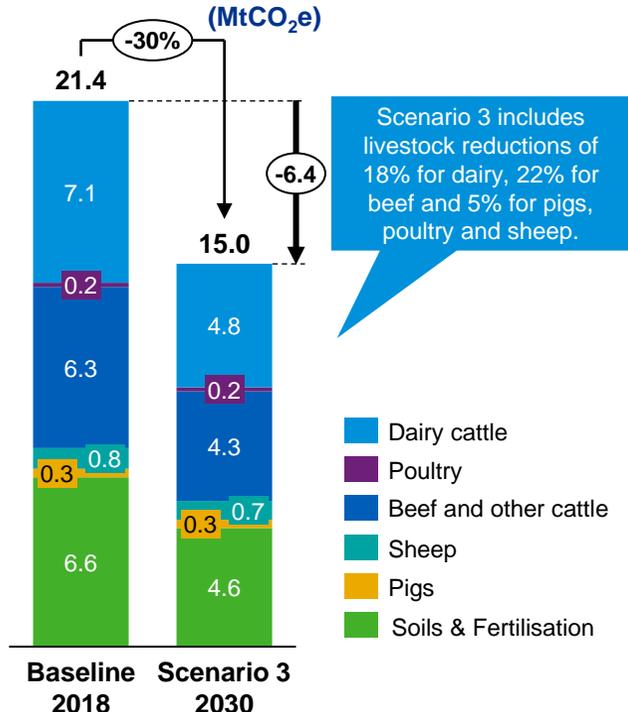
Scenario analysis results

Scenario 3 - Overview

An overview of Scenario 3 is provided below.

This scenario reaches a 30% reduction compared to 2018 levels, with 18% (2.95 MtCO₂e) coming from the application of the measures explored in Scenario 2, and the remainder coming from a livestock reduction of 18% for dairy, 22% for beef and 5% for pigs, poultry and sheep. The methodology for applying this reduction in livestock numbers is described on the slides which follow.

Total carbon emissions per agricultural sector under Baseline and Scenario 3 (MtCO₂e)



It is assumed that beef suckler will take a greater share of the beef livestock reduction compared to dairy-beef

Agriculture category	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Dairy	0.993	34%
Beef	0.627	21%
Pigs	0.006	0.2%
Sheep	0.006	0.2%
Poultry	0.002	0.1%
Soils & Fertilisation	1.316	45%
Total	2.952	100%

Agriculture category	% reduction in livestock numbers
Dairy	18%
Dairy-Beef	17%
Beef Suckler	25%
Sheep	5%
Pigs	5%
Poultry	5%

Scenario 3 – Mitigation measures

An overview of the agricultural mitigation measures in Scenario 3 is provided below. There is no change versus Scenario 2.

Agriculture category	Mitigation measure	Allocation	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Livestock	3NOP*	Dairy, Beef	0.453	15%
	Improved dairy economic breeding index (EBI)	Dairy	0.430	15%
	Improved animal health	Dairy, Beef	0.147	5%
	Low-emission slurry spreading	Dairy, Beef, Sheep, Pigs, Poultry	0.117	4%
	Lower age of slaughter	Beef	0.098	3%
	Adding lipids/fatty acids to dairy diets	Dairy	0.083	3%
	Extended grazing	Dairy, Beef 20/80	0.066	2%
	Improved beef liveweight gain	Beef	0.061	2%
	Anaerobic Digestion of Slurry and Grass	Dairy, Beef, Pigs, Poultry	0.056	2%
	Crude protein in pigs & bovines	Beef, Pigs	0.046	2%
	Slurry chemical amendments	Dairy, Beef, Sheep, Pigs, Poultry	0.027	1%
	Improved beef maternal traits	Beef	0.025	1%
	Increased use of sexed semen	Dairy, Beef	0.024	1%
	Cover slurry stores	Dairy, Beef, Pigs	0.003	0%
Total Livestock			1.635	55%
Soils & Fertilisation	Fertiliser type	Soils & Fertilisation	0.472	16%
	Nitrogen (N) use efficiency	Soils & Fertilisation	0.287	10%
	Draining wet mineral soils	Soils & Fertilisation	0.197	7%
	Nitrification Inhibitors	Soils & Fertilisation	0.019	1%
	Compound Fertiliser	Soils & Fertilisation	0.206	7%
	Reduced N ₂ O from organic soils	Soils & Fertilisation	0.067	2%
	Multi-species swards	Soils & Fertilisation	0.069	2%
Total Soils & Fertilisation			1.316	45%
Total			2.952	100%

*3NOP is a methane-inhibiting feed additive for cows. Please see Slide 103 for further detail of this measure.

Scenario analysis results

Scenario 3 - Livestock Reduction

Livestock reductions are required under Scenario 3 to reach a 30% reduction in agriculture carbon emissions by 2030.

In order to reach a 30% reduction in carbon emissions, the agriculture sector must further reduce its carbon emissions to reach approximately 14.95 MtCO₂e by 2030. To reach this, a reduction in livestock numbers is required. The table below sets out the data and methodology adopted to understand the extent to which a reduction in livestock numbers needs to be relied upon to each its 2030 target.

Agriculture category	No. of animals in 2018	ktCO ₂ e/head under Scenario 3	Emissions in 2018 (ktCO ₂ e)	% carbon emissions reduction applied to 2018 levels	Emissions under Scenario 3 including reduction in livestock numbers (ktCO ₂ e)	No. of animals in 2030 under Scenario 3	% reduction in livestock numbers
Dairy	2,126,421	0.0028	7,111	32%	4,836	1,738,789	18%
Beef	5,116,034	0.0011	6,306	32%	4,288	3,990,550	22%
Sheep	5,142,969	0.0002	807	8%	752	4,885,888	5%
Pigs	1,597,050	0.0002	338	6%	318	1,515,870	5%
Poultry	17,538,138	0.0000092	163	6%	154	16,700,426	5%
Soils & Fertilisation	-	-	6,626	30%	4,605	-	-
Total	-	-	21,351	-	~14,952	-	-

Note 1. The number of livestock remains constant under Scenario 3 from 2018 to 2030.

Note 2. The reduction in livestock numbers is informed by each sector's contribution to overall agricultural emissions. As cattle make up 91% of emissions, the dairy and beef sectors undergo the most extensive cut in numbers. Through mitigation measures alone, dairy can achieve mitigation of 993 ktCO₂e while beef only can achieve mitigation of 627 ktCO₂e. As such, dairy has the lower livestock reduction compared to beef.

Note 3: The Soils & Fertilisation category is assumed to be largely impacted by the dairy and beef sectors, therefore emissions in this category are reduced proportionately to these sectors.

7.

Scenario 4 -
Further
detail



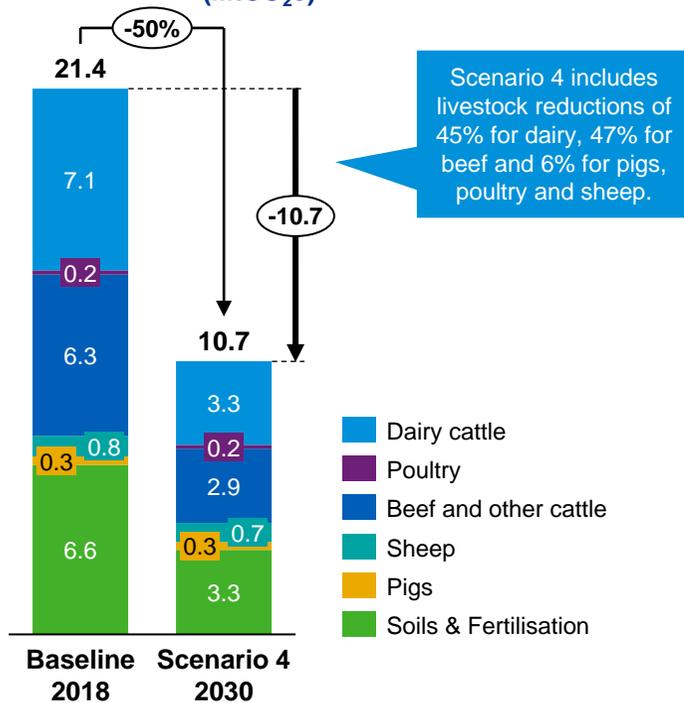
Scenario analysis results

Scenario 4 - Overview

An overview of Scenario 4 is provided below.

This scenario reaches a 50% reduction compared to 2018 levels, with 18% (2.95 MtCO₂e) coming from the application of the measures explored in Scenario 2, and the remainder coming from a livestock reduction of 45% for dairy, 47% for beef and 6% for pigs, poultry and sheep. The methodology for applying this reduction in livestock numbers is described on the slides which follow.

Total carbon emissions per agricultural sector under Baseline and Scenario 4 (MtCO₂e)



It is assumed that beef suckler will take a greater share of the beef reduction livestock compared to dairy-beef

Agriculture category	2030 mitigation potential (MtCO ₂ e)	% of total mitigation potential
Dairy	0.993	35%
Beef	0.627	21%
Pigs	0.006	0.2%
Sheep	0.006	0.2%
Poultry	0.002	0.1%
Soils & Fertilisation	1.316	45%
Total	2.952	100%

Agriculture category	% reduction in livestock numbers
Dairy	45%
Dairy-Beef	37%
Suckler Beef	52%
Sheep	6%
Pigs	6%
Poultry	6%

Scenario 4 - Mitigation measures

An overview of the agricultural mitigation measures in Scenario 4 is provided below. There is no change versus Scenario 3.

Agriculture category	Mitigation measure	Allocation	2030 mitigation potential (MtCO ₂ e)
Livestock	3NOP*	Dairy, Beef	0.453
	Improved dairy economic breeding index (EBI)	Dairy	0.430
	Improved animal health	Dairy, Beef	0.147
	Low-emission slurry spreading	Dairy, Beef, Sheep, Pigs, Poultry	0.117
	Lower age of slaughter	Beef	0.098
	Adding lipids/fatty acids to dairy diets	Dairy	0.083
	Extended grazing	Dairy, Beef 20/80	0.066
	Improved beef liveweight gain	Beef	0.061
	Anaerobic Digestion of Slurry and Grass	Dairy, Beef, Pigs, Poultry	0.056
	Crude protein in pigs & bovines	Beef, Pigs	0.046
	Slurry chemical amendments	Dairy, Beef, Sheep, Pigs, Poultry	0.027
	Improved beef maternal traits	Beef	0.025
	Increased use of sexed semen	Dairy, Beef	0.024
	Cover slurry stores	Dairy, Beef, Pigs	0.003
	Total Livestock		
Soils & Fertilisation	Fertiliser type	Soils & Fertilisation	0.472
	Nitrogen (N) use efficiency	Soils & Fertilisation	0.287
	Draining wet mineral soils	Soils & Fertilisation	0.197
	Nitrification Inhibitors	Soils & Fertilisation	0.019
	Compound Fertiliser	Soils & Fertilisation	0.206
	Reduced N ₂ O from organic soils	Soils & Fertilisation	0.067
	Multi-species swards	Soils & Fertilisation	0.069
Total Soils & Fertilisation			1.316
Total			2.952

*3NOP is a methane-inhibiting feed additive for cows. Please see Slide 103 for further detail of this measure.

Scenario analysis results

Scenario 4 - Livestock Reduction

Livestock reductions are required under Scenario 4 to reach a 50% reduction in agriculture carbon emissions by 2030.

In order to reach a 50% reduction in carbon emissions, the agriculture sector would need to further reduce its carbon emissions to reach approximately 10.68 MtCO_{2e} by 2030. To reach this, a reduction in livestock numbers is required. The table below sets out the data and methodology adopted to understand the extent to which a reduction in livestock numbers needs to be relied upon to each its 2030 target.

Agriculture category	No. of animals in 2018	ktCO _{2e} /head under Scenario 3	Emissions in 2018 (ktCO _{2e})	% carbon emissions reduction applied to 2018 levels	Emissions under Scenario 4 including reduction in livestock numbers (ktCO _{2e})	No. of animals in 2030 under Scenario 4	% reduction in livestock numbers
Dairy	2,126,421	0.0028	7,111	54%	3,271	1,176,240	45%
Beef	5,116,034	0.0011	6,306	54%	2,901	2,699,489	47%
Sheep	5,142,969	0.0002	807	8%	745	4,832,268	6%
Pigs	1,597,050	0.0002	338	7%	315	1,501,357	6%
Poultry	17,538,138	0.0000092	163	7%	152	16,487,229	6%
Soils & Fertilisation	-	-	6,626	50%	3,303	-	-
Total	-	-	21,351	-	~10,680	-	-

Note 1. The number of livestock remains constant under Scenario 3 from 2018 to 2030.

Note 2. The reduction in livestock numbers is informed by each sector's contribution to overall agricultural emissions. As cattle make up 91% of emissions, the dairy and beef sectors undergo the most extensive cut in numbers. Through mitigation measures alone, dairy can achieve mitigation of 993 ktCO_{2e} while beef only can achieve mitigation of 627 ktCO_{2e}. As such, dairy has the lower livestock reduction compared to beef.

Note 3: The Soils & Fertilisation category is assumed to be largely impacted by the dairy and beef sectors, therefore emissions in this category are reduced proportionately to these sectors.

8.

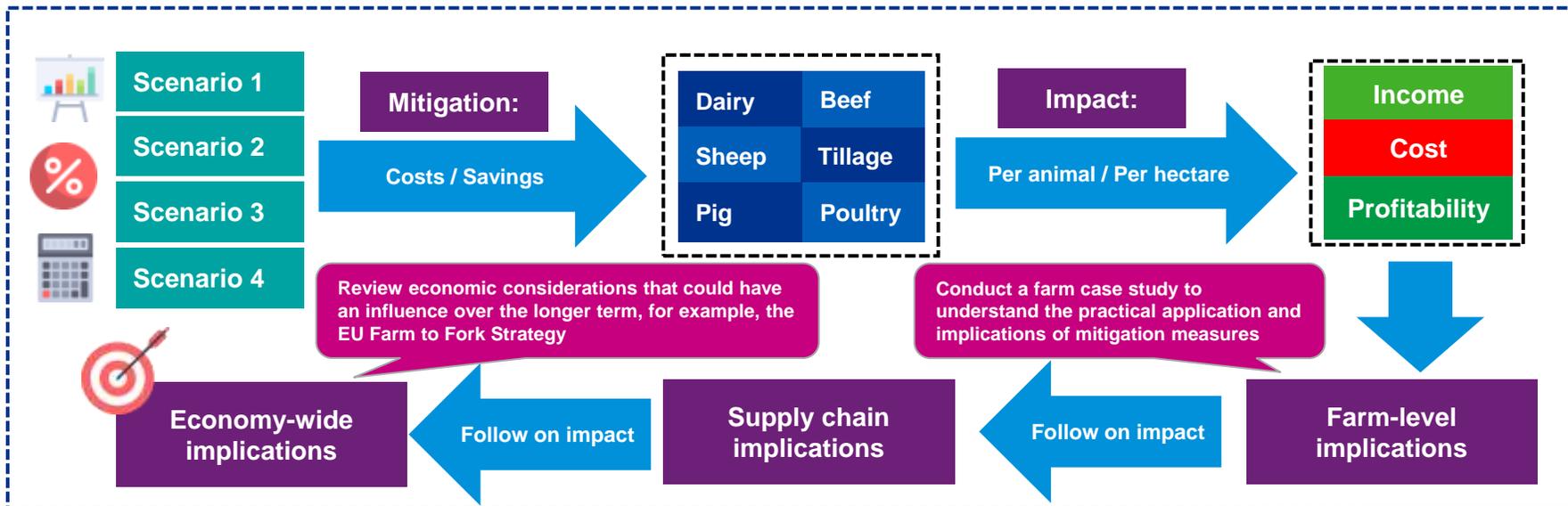
Approach to economic analysis



The economic analysis considers the farm-level and economy-wide impacts across Scenarios.

- The economic analysis considers the actions the agriculture sector can take to contribute to Ireland’s 2030 emissions reduction target, and the impact these actions (**Scenarios 1, 2, 3 and 4**) could have on rural communities and the wider economy
- Mitigation actions can increase costs, save costs and increase output/income
- These impacts are considered on the farm-level and the wider economy
- In addition to the standard mitigation measures, Scenario 3 and 4 considers the impact of reducing livestock numbers across the dairy, beef, sheep, pig and poultry sectors. Reducing livestock numbers creates more significant negative impacts across the value chain

The economic analysis process



9.

Farm level impacts



Overview: Farm-level Introduction (1/2)

Introduction: Farm-level economic analysis



Average Dairy Farm Size

- 59 Hectare
- 80 Dairy Cows
- 161 total cattle



Average Beef Farm Size

- 32 Hectare
- 23 Cows
- 55 total cattle



Scenario 1 & 2

- Application of MACC and additional mitigation measures



Scenario 3

- Application of MACC and additional mitigation measures
- Livestock reduction



Scenario 4

- Application of MACC and additional mitigation measures
- Greater livestock reduction

Note: Under current national GHG accounting rules, emissions reductions associated with land use and energy measures will not count towards the agriculture sector's emissions reduction efforts

Source: Teagasc National Farm Survey (2019).

Note: The Sheep, Pig and Poultry sectors are not included in the farm-level economic analysis as the Teagasc MACC does not analyse a significant number of measures for these sectors.

Key takeaways

- The income, costs, farm sizes and herd sizes for an average dairy and beef farm, based on the Teagasc national farm survey, were used for the farm-level economic analysis*
- Each measure has been defined as being either a net benefit or cost and are grouped together and displayed in the following categories:
 - Reduction in income
 - Increase in cost
 - Increase in income
 - Reduction in cost
- A number of the measures result in cost savings (Reduction in cost) which in turn is likely to increase a farm's profit
- Each scenario in the farm-level economic analysis includes the full application of the mitigation measures in the Teagasc MACC. Note that carbon reductions from land-use and energy abatement measures cannot be claimed by the agriculture sector. However, farmers still bear the costs/benefits from these measures and therefore they have been included in the farm-level analysis to display the total impacts to an average dairy/beef farm under each scenario
- The reduction in livestock in scenario 3 and 4 reduces both income and input costs. These changes have been shown separately to fully show the impacts from the livestock reductions

Overview: Farm-level Introduction (2/2)

Introduction: Farm-level economic analysis

Mitigation Measures

- The total net cost/benefit for each mitigation measure has been taken from the Teagasc MACC, including other sources, and divided by the expected uptake to give a net cost/benefit per a animal, hectare or farm
- The costs per animal, hectare or farm are then applied to the average dairy/beef farm size from the Teagasc national farm survey. Mitigation cost/benefits that relate directly to animals decrease with the livestock reductions

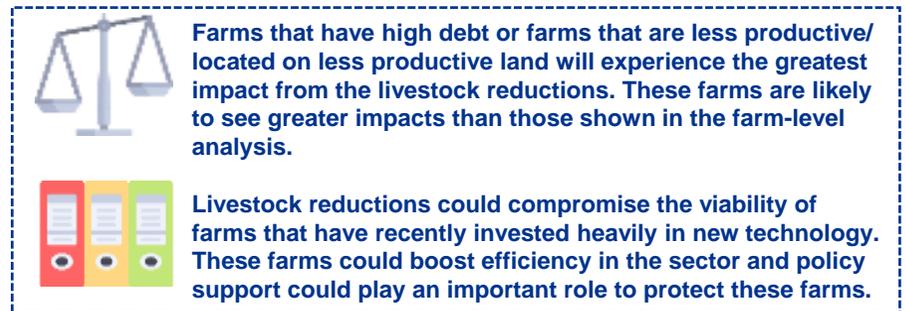
Farm Income

- The reduction in livestock is assumed to cause a similar decrease in income
- Subsidies have been held constant for this analysis
- Any other source of income such as machinery hire revenue is also held constant

Farm Costs

- The breakdown of the different cost for an average dairy/beef farm from the Teagasc national farm survey was used for this analysis
- Costs were individually reviewed to see how they would decrease with herd numbers, as several fixed cost such as machinery costs, interest on loans, other fixed costs, and labour costs are more inelastic and less likely to decrease with livestock reductions. This will result in inefficiencies with livestock reductions
- Other potential increases in cost, such as increases in energy costs and labour are not account for in this analysis

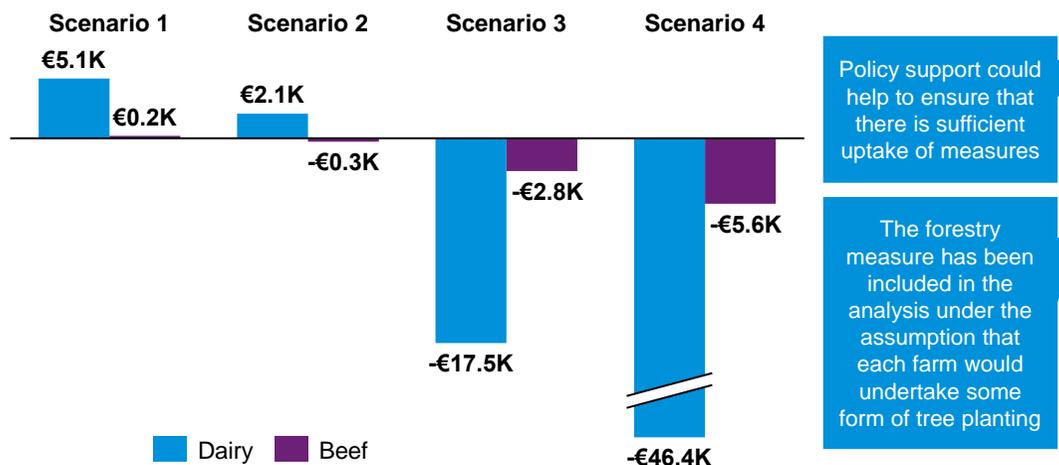
Key activities and approach across Farm-level



Overview: Farm-level impacts on dairy & beef sectors across all scenarios

The impact on an average dairy and beef farm varies across scenario 1 to 4.

Impacts on dairy and beef farms' profit across scenario 1 to 4



Key takeaways

- In Scenario 1 (S1), the benefits generated from the adoption of mitigation measures outweigh the costs for the average dairy and beef farm: average profit increases by €5.1K and €0.2K respectively
- However, a number of mitigation measures that are costly generate relatively fewer benefits on the farm-level. Incentives/supports may be needed to increase adoption of these measures (e.g. Forestry and water table manipulation of peaty grassland soils)
- Scenario 2 (S2) includes the measures from Scenario 1, as well as cover slurry stores, lower average age of beef slaughter, and other additional mitigation measures resulting in an increase in costs/decrease in income for dairy and beef farmers. In S2, changes to dairy and beef farm-level income would be +€2.1K and -€0.3K respectively
- Scenario 3 (S3) includes the measures from S2 as well as livestock reductions of -18% in the dairy sector and -22% in the beef sector. Together, the measures and livestock reduction result in profit falling on average farms: by -€17.5K on an average dairy farm and by -€2.8K on an average beef farm
- Scenario 4 (S4) includes the measures in S3 and livestock reductions of -45% for dairy and -47% for beef. Profit falls in this Scenario, by -€46.4K on the average dairy farm and by -€5.6K on the average beef farm.

See appendix for additional information on S3X (21% reduction in emissions)

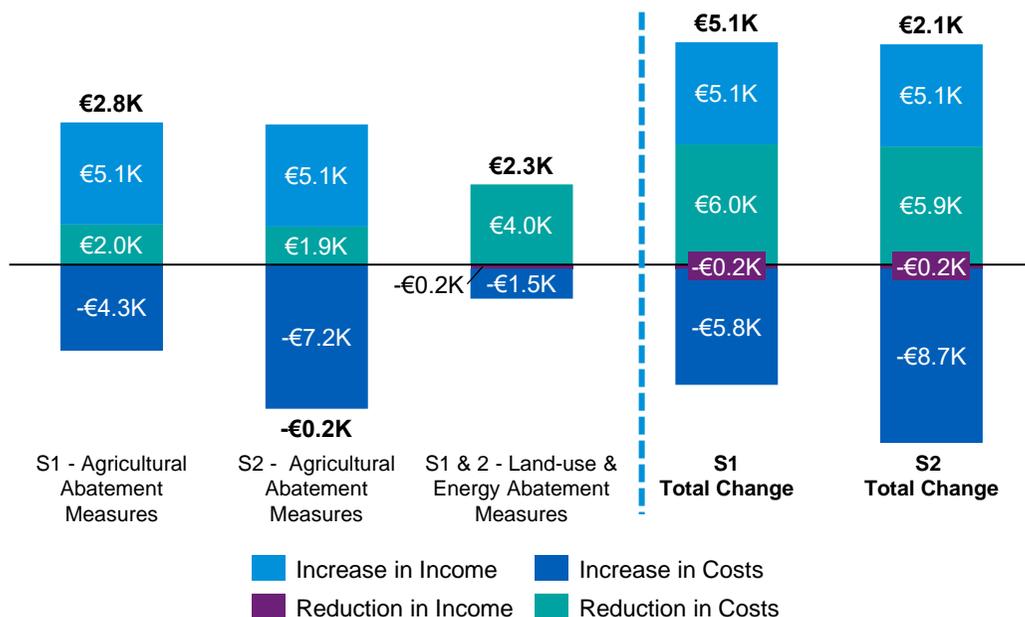
Scenario	Description	Reduction in Emissions
Scenario 1	Full application of mitigation measures in Teagasc MACC	13%
Scenario 2	Application of MACC with increased uptake on some measures and additional mitigation measures	18%
Scenario 3	Scenario 2 measures with livestock reduction (-18% dairy, -22% beef)	30%
Scenario 4	Scenario 3 measures with livestock reduction (-45% dairy, -47% beef)	50%

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: A value axis break was used to shrink the display of dairy in Scenario 4, to enhance readability for the smaller segments.



An average dairy farm will see an increase in profit through the implementation of the measures under Scenario 1 and 2.

Impacts to a dairy farm's income/cost under Scenario 1 & 2



Key takeaways

- The abatement measure causing the main increase in output/income for dairy farmers is the improvement of the dairy economic breeding index (EBI). This is **estimated to increase the annual output by €50 - €70 per dairy cow, by 2030** for farms that have a low EBI
- Through the implementation of all measures in **S1, the average dairy farm will see an increase in annual profit of €5,100 by 2030**. €2,800 of this is from agriculture-only abatement measures. This increase in profit is mainly achieved through better practises and better livestock genetics
- Through the implementation of all measures in **S2 the average dairy farm will see an increase in annual profit of €2,100 by 2030**. Covering slurry stores explains the main difference in increased costs between S1 and S2
- Cost reductions primarily arise through increased energy and nitrogen use efficiency:
 - Farm energy efficiency measures include plate coolers (to pre-cool milk), variable speed drives on vacuum pumps, solar photovoltaics (PV) and heat recovery systems – these result in annual savings of €2,500 (after the capital cost has been recovered)
 - Better nitrogen use efficiency will reduce costs. This measure is estimated to save €20 - €30 per ha for farms that currently have inefficient nitrogen use
- There is no change for the land-use and energy abatement measures between Scenario 1 – 4 for the dairy sector

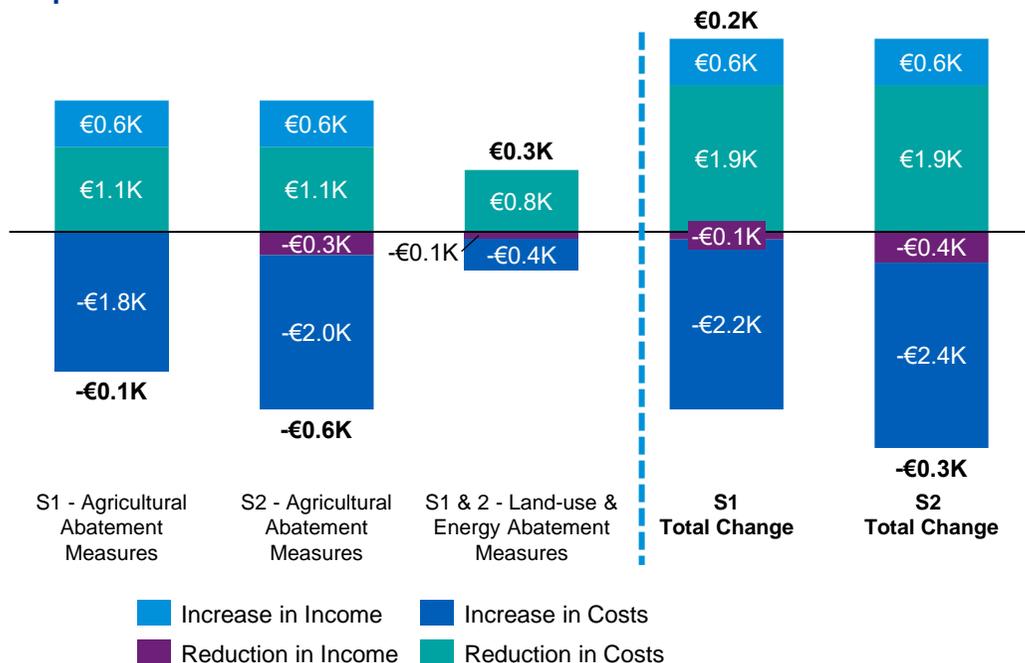
Scenario 1 & 2 include the full application of the mitigation measures in Teagasc MACC. Carbon reductions from land-use and energy abatement measures cannot be claimed by the agriculture sector. However, farmers still bear the costs/benefits from these measures and this has been included in the analysis.

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: Assumed no change in current livestock numbers, price of milk and farm costs other than those stated in the abatement measures.



In Scenario 1, the average beef farm will see little change to their bottom line.

Impact to a beef farm's income/cost under Scenario 1 & 2



Key takeaways

- The average beef farm will see very **little change in profit through the implication of all measures in S1**. This is due to the increase in costs counterbalanced by increases in income and reductions in costs
- Better nitrogen use efficiency is the main driver of lower costs, by reducing the amount of nitrogen required. The measure is estimated to save €30 - €50 per ha for farms that currently use nitrogen inefficiently
- Draining wet mineral soils and water table manipulation of peaty agricultural grassland soils will be the most costly measures for the beef sector. These cost abatement measures will apply only to a subset of all beef farms. Incentives and/or subsidies may be required to encourage farmers to undertake these measures
- Improved beef maternal traits and improved beef liveweight gain are the main driver of increased output/income
- **Under S2 an average beef farm will see a decrease in profit of ~ €300**
- S2 includes a reduction in average slaughter age as an additional abatement measure, compared to S1. This is estimated to result in a decrease of annual profit of €100-€200 for the average beef farm. However when considering the improved beef liveweight gain measure (included in S1), the cost from the reduction in slaughter age is off set by the benefit from the beef liveweight gain.

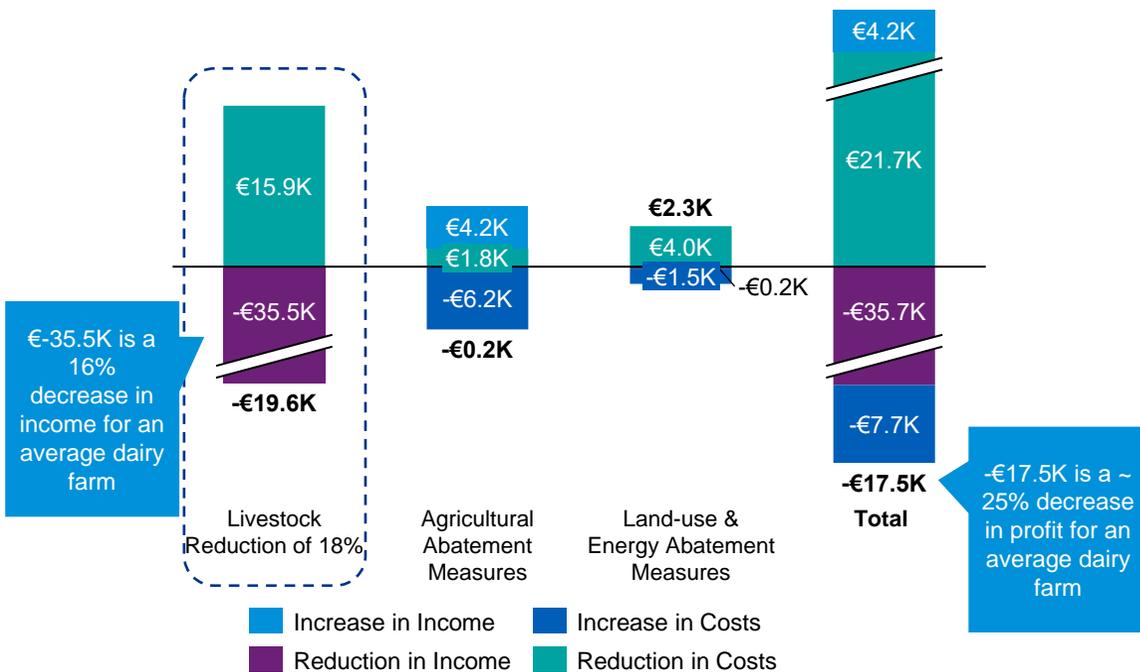
Scenario 1 & 2 include the full application of the mitigation measures in Teagasc MACC. Carbon reductions from land-use and energy abatement measures cannot be claimed by the agriculture sector. However, farmers still bear the costs/benefits from these measures and this has been included in the analysis.

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: Assumed no change in current livestock numbers, meat prices and farm costs other than those stated in the abatement measures.



A 18% livestock reduction and mitigation measures will see a reduction in profit of ~€17.5K per a dairy farm.

Impacts to beef farm's income/cost under Scenario 3



€-35.5K is a 16% decrease in income for an average dairy farm

-€17.5K is a ~25% decrease in profit for an average dairy farm

Scenario 3 is the full application of the MACC with increased uptake on some measures, additional mitigation measures, as well as a reduction in dairy livestock of 18%.

Key takeaways

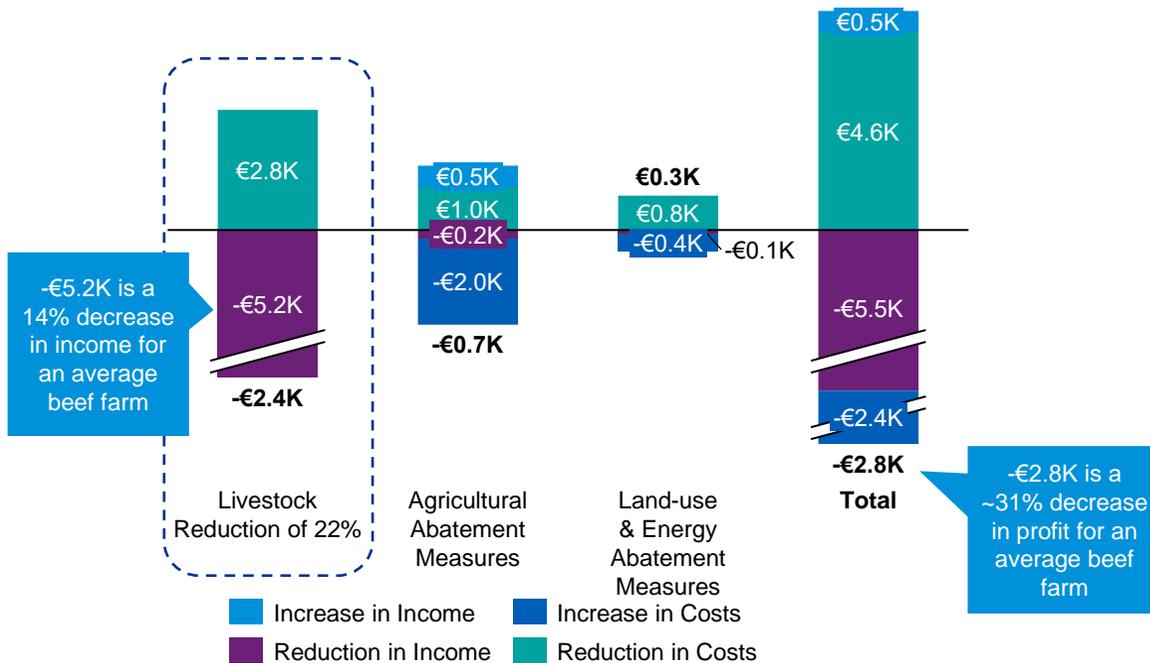
- Under Scenario 3, the dairy sector sees a livestock reduction of 18%. This significantly decreases income, by ~€35.5K (-16%) for an average dairy farm. This is offset by the reduction in costs of ~€15.9K, mainly for feed and concentrates
- However, several fixed cost; such as machinery costs, other fixed/overhead costs, and labour costs are more inelastic and less likely to decrease with the livestock reductions. As the livestock reduction increases, these fixed cost will reduce the farm's optimum efficiency and limit economies of scale
- The benefit/cost from the agricultural abatement measures, compared to Scenario 2, fall with the livestock reduction, as there are fewer cattle that animal-related measures can be applied to
- Overall, the implementation of Scenario 3 measures and the livestock reduction of 18%, would **result in a decrease in profit of ~€17.5K (-25%) for the average dairy farm**
- We have assumed that subsidies and income from other sources for the farm stay constant with the livestock reduction

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: The percentage decrease in income and income include allowance for subsidies and other farm income sources. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.



A 22% livestock reduction and mitigation measures will see a reduction in profit of ~€2.8K per beef farm.

Impacts to a beef farm's income/cost under Scenario 3



-€5.2K is a 14% decrease in income for an average beef farm

-€2.8K is a ~31% decrease in profit for an average beef farm

Key takeaways

- Under Scenario 3, **beef livestock falls by 22% relative to the baseline. The livestock reduction results in a decrease of income of ~€5.2K (-14%)** for an average beef farm. This is offset by the reduction in costs of ~€2.8K from a reduction in feed and concentrates, and other costs
- However, a number of fixed cost such as machinery costs, other fixed/overhead costs, and labour costs are more inelastic and less likely to decrease with the livestock reductions. As the livestock reduction increases, these fixed cost will reduce the farm's optimum efficiency and limit economies of scale
- The benefit/cost from the agricultural abatement measures, compared to Scenario 2, fall with the livestock reduction, as there are fewer cattle that animal-related measures can be applied to
- Overall, the implementation of Scenario 3 measures and the livestock reduction of 22% would **result in a decrease in profit of €2.8K (-31%) for the average beef farm**
- We have assumed that subsidies and income from other sources for the farm stay constant with the livestock reduction

Scenario 3 is the full application of the MACC with increased uptake on some measures, additional mitigation measures, as well as a reduction in beef livestock of 22%.

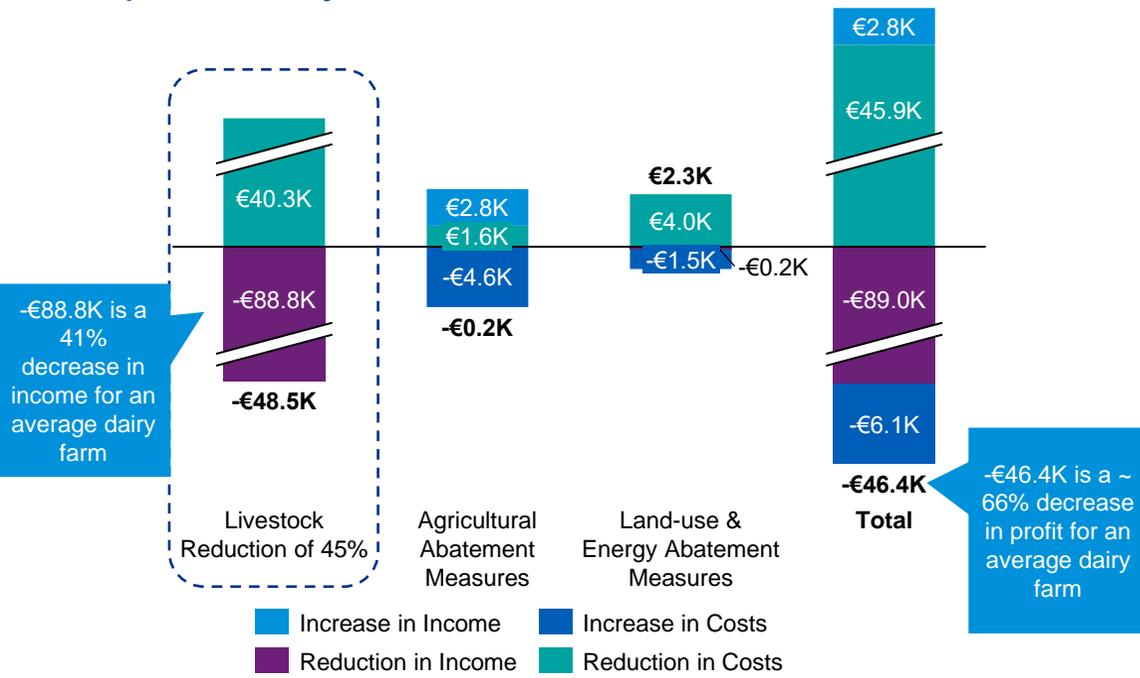
Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: The percentage decrease in income and income include allowance for subsidies and other farm income sources. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.

Scenario 4 - Dairy



A livestock reduction of 45% and mitigation measures will see a reduction in profit of €46.4K to the average dairy farm.

Impacts to a dairy farm's income/cost under Scenario 4



-€88.8K is a 41% decrease in income for an average dairy farm

-€46.4K is a ~66% decrease in profit for an average dairy farm

Key takeaways

- Under Scenario 4, the dairy sector sees a livestock reduction of 45%. This has a significant impact on income, leading to a fall of ~€89K (-41%) for an average dairy farm. This is offset by the reduction in costs of ~€40K (feed and concentrates)
- However, several fixed cost such as machinery costs, other fixed/overhead costs, and labour costs are more inelastic and less likely to decrease with the livestock reductions. As the livestock reduction increases, these fixed costs will reduce the farm's optimum efficiency and create diseconomies of scale
- Overall the implementation of Scenario 4 measures and the livestock reduction of 45% would result in a decrease in profit of €46.4K (-66%) on an average dairy farm
- With such a large decrease in livestock, it is likely that the smaller and/or less profitable dairy farms will no longer be profitable and, ultimately, consolidate with other farms. If this was to happen, costs could fall by less, where economies of scales are achieved through consolidation. Consolidation has not been taken into account for the farm-level analysis

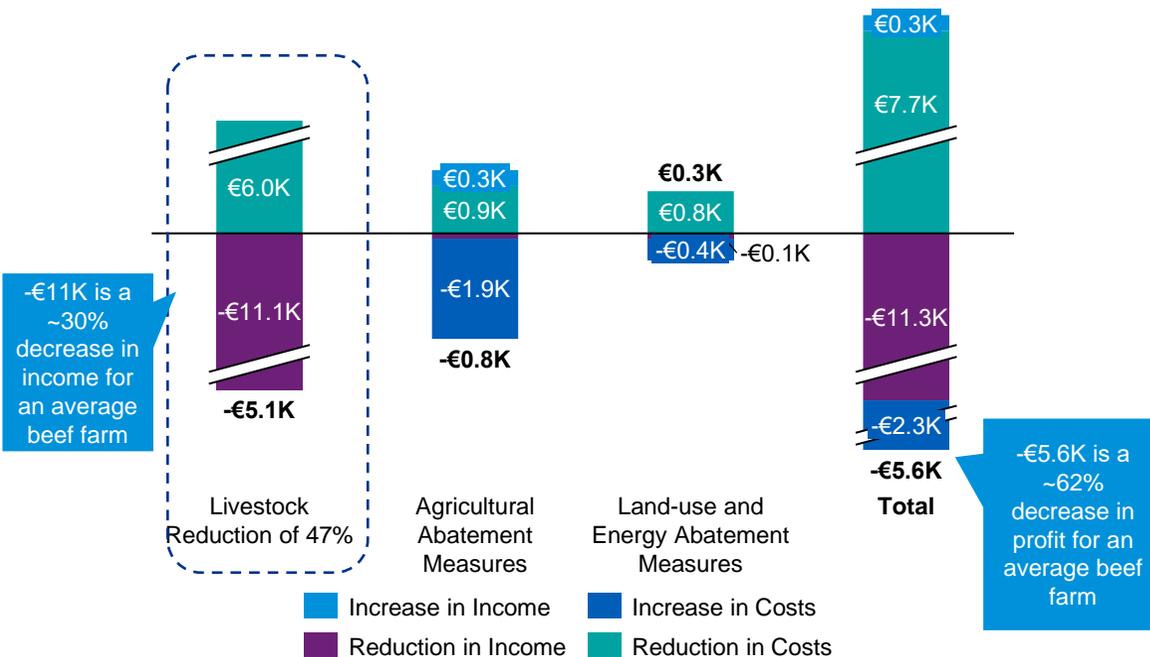
Scenario 4 is the full application of the MACC with increased uptake on some measures, additional mitigation measures, as well as a reduction in the dairy livestock of 45%.

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: The percentage decrease in income and income include allowance for subsidies and other farm income sources. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.



A livestock reduction of 47% and mitigation measures will see a reduction in profit of €5.6K to the average beef farm.

Impacts to a beef farm's income/cost under Scenario 4



-€11K is a ~30% decrease in income for an average beef farm

-€5.6K is a ~62% decrease in profit for an average beef farm

Scenario 4 is the full application of the MACC with increased uptake on some measures, additional mitigation measures, as well as a reduction in the beef livestock of 47%.

Key takeaways

- Under Scenario 4, the beef sector sees a livestock reduction of 47%. This results in a decrease in income of ~€11K (-30%) for the average beef farm. This is offset by the reduction in costs ~€6K from such inputs as feed and concentrates
- However, several fixed cost such as machinery costs, other fixed/overhead costs, and labour costs are more inelastic and less likely to decrease with the livestock reductions. As the livestock reduction increases, these fixed costs will reduce the farm's optimum efficiency and create diseconomies of scale
- Overall the implementation of Scenario 4 measures and the livestock reduction of 47% would result in a decrease in profit of €5.6K (-62%) on an average beef farm
- As more than 67% of beef farms are relatively small (<30ha), livestock reductions will impact the profitability of these farms the most, and they will most likely consolidate with larger farms. Consolidation has not been taken into account for the farm-level analysis

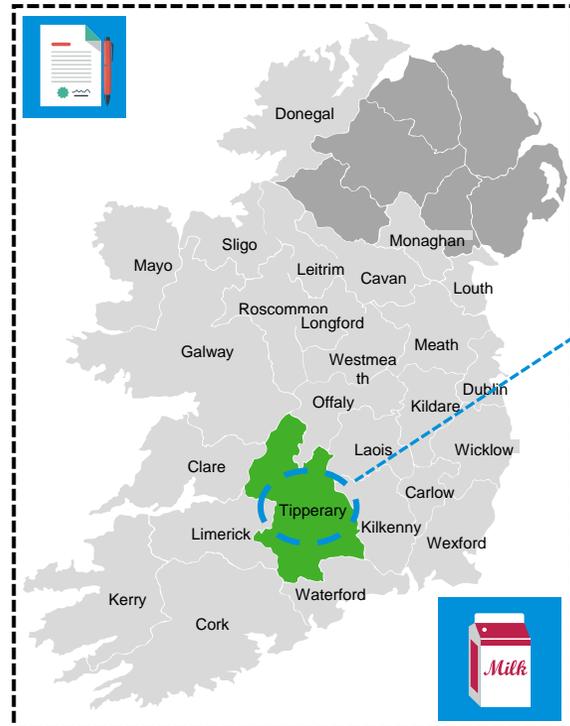
Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: The percentage decrease in income and income include allowance for subsidies and other farm income sources. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.

Farm case study: Lessons from a dairy farm



Mitigation measures with well understood economic benefits are more widely adopted.

Location of case study



Dairy farm case study



- Herd size: Average of 140
- Land area: 75 ha
- Location: Co. Tipperary

Investing in key measures, including:

- Improved animal health
- Improved dairy economic breeding index (EBI)
- Improved grassland management
- Inclusion of clover in pasture swards
- Increased farm energy efficiency
- Low-emission slurry spreading
- Nitrogen (N) use efficiency
- Switching N fertiliser formulation from CAN to protected urea
- Higher sugar content grasses

Key takeaways

We interviewed a dairy farmer about the carbon mitigation measures currently being applied on the case study farm and farmers' general uptake of the measures considered in our Scenarios.

- Measures for which the economic benefits are well understood, for example, vaccinating for improved animal health, tend to have a wider adoption amongst farmers
- The measures currently applied on the case study farm fall into this category
- Measures for which the economic benefits are generally less understood or less well known, tend to have limited adoption amongst farmers. For example:
 - Adding lipids/fatty acids to dairy diets
 - Anaerobic Digestion of Slurry and Grass
- Other measures are more applicable to specific regions:
 - Draining wet mineral soils: This measure has some applications on heavy soils, particularly in the West of Ireland
- Some measures have less clear economic benefits and would need government support to encourage uptake:
 - Water table manipulation of peaty agricultural grassland soils: It will be difficult to convince farmers to undertake, government support would be needed

Energy efficiency measures require an initial upfront capital investment. Supports mechanisms could be helpful in supporting farmers to invest in these mitigation measures

Greater awareness of the economic and environmental benefits associated with mitigation measures is needed to encourage farmer uptake

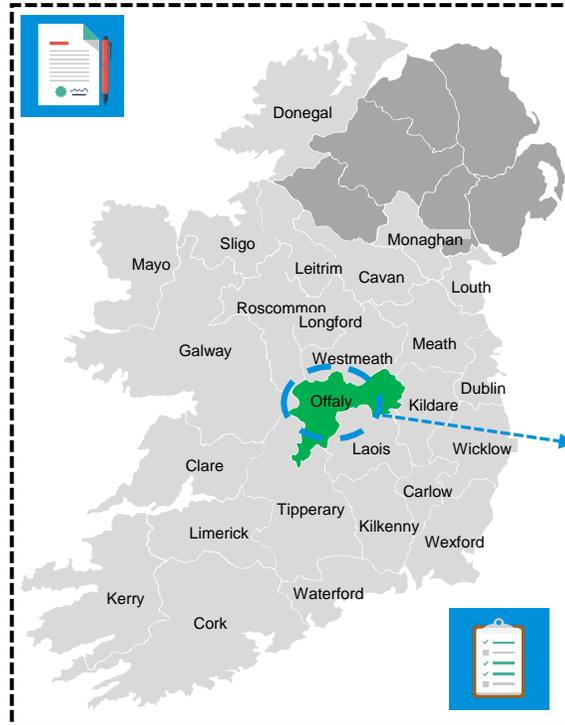
Source: Dairy farmer interview, KPMG analysis.

Farm case study: Lessons from a beef and sheep farm



Mitigation measures with well understood economic benefits are more widely adopted.

Location of case study



Beef and sheep case study



- Beef herd size: Average of 235
- Sheep flock size: Average of 240
- Land area: 73 ha
- Location: Co. Offaly

Investing in key measures, including:

- Extended grazing
- Improved animal health
- Improved beef liveweight gain
- Improved beef maternal traits
- Low-emission slurry spreading
- Also applies the age of slaughter measure (reduction in the age at which animals are slaughtered)

Key takeaways

We interviewed a beef and sheep farmer about the carbon mitigation measures currently being applied on the case study farm and farmers' general uptake of the measures considered in our Scenarios.

- Measures for which the economic benefits are well understood, for example, improved beef liveweight gain, tend to have a wider adoption amongst farmers
- The measures currently applied on the case study farm fall into this category
- Slurry chemical amendments is a measure not currently applied on the farm. The economic benefits are viewed as encouraging for adoption by farmers, the case study farmer would consider adopting this measure
- Some measures are viewed to not have sufficient economic benefits to encourage adoption by farmers. These measures would need government support. For example:
 - Anaerobic Digestion of Slurry and Grass
 - Cover slurry stores

The economic benefits of these measures are generally well understood. Farmers would be willing to adopt these measures.

Source: Beef/sheep farmer interview, KPMG analysis.

10.

Economic impacts - Overview



Understanding the significance of rural areas and communities

Rural economies make a vital contribution to Ireland's overall economic output.

Ireland's agriculture sector remains a key component of the Irish modern economy. It accounts for ~1 per cent (0.9%) of GDP and over 4.5% of total employment, providing over 100,000 jobs. Agri-food exports reached a high of €14.1 billion in 2020, an increase of 60% since 2010. Ireland exports ~90% of the food produced in the country.

Average family farm income (FFI) for 2020 was €25,662, a 9% increase on 2019 figures. There is a large gap between the average income levels in dairy and drystock (Beef and Sheep), with average dairy farm income twice as high as average drystock farm income. Proportionally, hours worked are highest on dairy farms, while the labour input on drystock farms tends to be lower.

The average farm size in the 2020 Teagasc National Farm Survey (NFS) was 42.8 hectares, with average income per hectare of €600. Approximately 42 percent of dairy farms are 50 to 100 hectares in size, with a further 32 percent in the 30 to 50 hectare bracket. 28 per cent of farms are greater than 100 hectares in size.

Given agriculture's significant contribution to the Irish's economy and society, it is vital that governments, local communities, and the voluntary and community sector collaborate towards achieving carbon reduction targets whilst supporting the sustainability of agriculture.

Sources: DAFM (2020), IFJ (2019).

Key statistics

€4bn

Gross Value Added in Primary
Agriculture, Fisheries and Forestry in
2019 (1% of total GVA)

>137,000

Farms in Ireland in 2016, with over 50%
located in the Border, Midland and
Western region

~65%

Farms have no farm business
related debt in 2020 (varies by
farm type)

€14.1bn

value of total agri-food exports in
2020

€25,662

Average annual income per farm,
2020

>100,000

People employed in the agri-food
sector in Ireland in 2020 (4.5% of
total employment)

Overview: Economic impact analysis

Economic impact assessments consider the injection of income as a result of economic activity from a specific industry sector.

Definitions and viewpoint

Economic impact assessments consider the injection of income as a result of a specific event, policy choice or economic activity from a specific industry.

The agriculture sector buys inputs that are produced in different sectors within the economy. The purchase of agricultural inputs creates a flow of expenditure and a multiplier impact within the economy.

The geographic/spatial viewpoint assumed in an economic impact analysis will influence the extent of leakage of expenditure. For example, on a county or city level, more value chain inputs will be sourced from “outside” the focus area, resulting in leakage of expenditure out of the focus area. Similarly, on a national level, imported components will create a leakage of expenditure that lowers the overall economic impact.

Considering the national scale of the agriculture sector, our analysis has been primarily based on a national viewpoint, estimating the economic impacts on a national level.

Scenario analysis and economic impact

An increase in demand for agricultural output requires producers (the sector) to increase their purchases of goods and services from their suppliers to produce the product in question. In turn, suppliers of agricultural inputs increase their purchases of the goods and services they need to produce the products they supply to the agricultural sector.

This creates additional rounds of expenditure in the value chain, also referred to as the multiplier impact, that leads to increased output and employment. Similarly, a decline in demand and a reduction expenditure will create a reduction in output and employment.

Scenario analysis and economic impact (continued)

The overall impact can be categorised in terms of the following components:

1. **Direct:** impacts directly accruing from expenditure by farmers in the sector (e.g. purchase of farming inputs)
2. **Indirect:** impacts generated by expenditure by firms within the sector’s supply chain
3. **Induced:** impacts generated by the spend of individuals and firms outside the sector as a result of increased incomes (e.g. additional household expenditure as a result of increased incomes)

Scenario 1 and 2 considers carbon mitigation measures that could increase or decrease costs. In terms of economic impact, an increase in costs represents an increase in expenditure and economic impact, while a decrease in expenditure lowers the sector’s economic impact.

Scenario 3 and 4 incorporate reductions in livestock numbers. This will have an impact on variable and fixed costs, where lower output and expenditure will translate into less expenditure flowing to the supply chain, lowering the sectors economic impact.

Measuring economic impact

- **Primary agriculture - economic output:** we consider the impact on gross output for each of the four scenarios
- **Primary agriculture and processing – economic output for beef and dairy:** we consider the impact on gross output for Scenario 3 and 4
- **Primary agriculture employment – beef and dairy:** we consider the impact for on-farm employment for Scenario 3 and 4
- **Employment outside the farm gate – beef and dairy:** we consider the impact for the beef and dairy farm supply chain, as well as primary beef and dairy processors

11.

Economic
impacts -
Economic
output

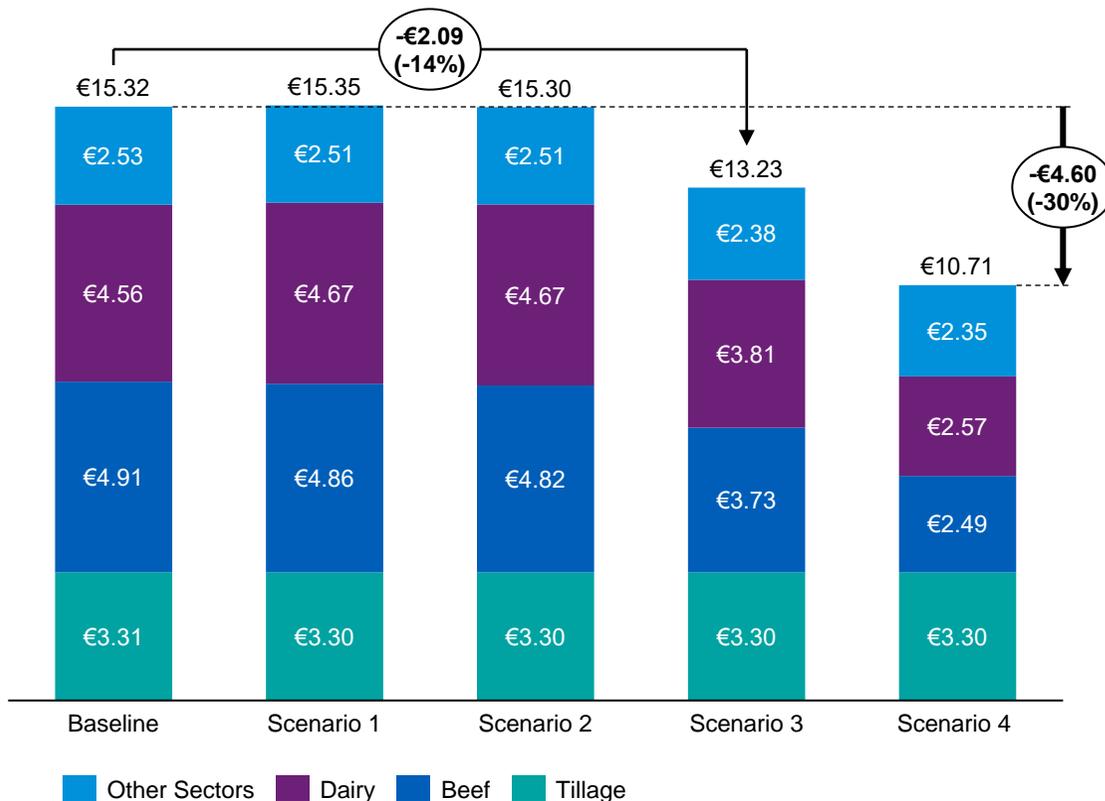


Economic impacts

Primary agriculture's economic output - all abatement measures (S1-4)

Scenario 4 would create the largest reduction in primary agriculture's economic output, a decline of ~€4.60bn (-30%).

Direct, indirect and induced economic output, by 2030, €bn



Key takeaways

- Considering the impact of agricultural, land-use and energy abatement measures, and livestock reductions, Scenario 3 and 4 produce the largest reduction in economic output
- Note that the carbon reductions achieved via the land-use and energy abatement measures are not attributed to agriculture in the national GHG inventory. However, these measures produce benefits and/or costs for the primary agriculture sector
- The measures under Scenario 1 increase overall economic output slightly, whilst Scenario 2 leads to a slight decrease in output
- Scenario 3 and 4 incorporate livestock reductions that cause an overall reduction in economic output.
- For primary agriculture, economic output is reduced by ~€2.09bn (-14%) in Scenario 3 and ~€4.60bn (-30%) in Scenario 4:**
 - The herd reductions are accompanied by a loss of income and a reduction in spending flowing to the beef and dairy supply chain. The forward impact on meat and dairy processors is not included here

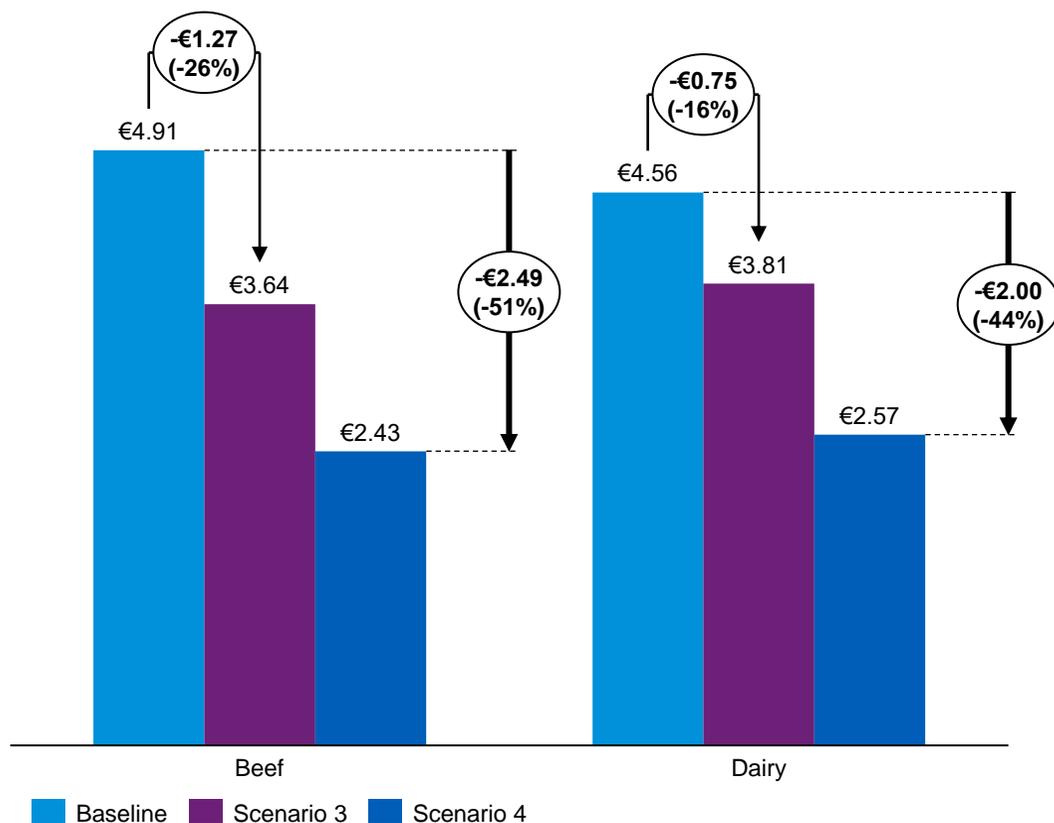
Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis. Note: figures include capital formation, livestock breeding, and wider supply chain activities (suppliers of agricultural inputs), may differ slightly from other sources. Meat and dairy processing is not included.

Economic impacts

Primary agriculture's (beef and dairy) economic output - Scenario 3 & 4

Scenario 4 results in a significant decrease in the economic output for beef (-51%) and dairy (-44%).

Direct, indirect and induced economic output, by 2030, €bn



Key takeaways

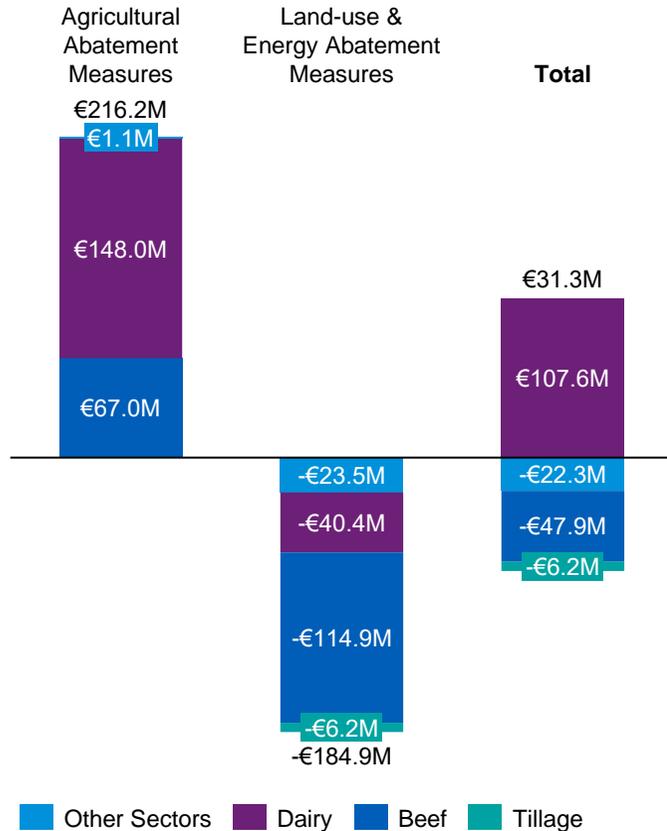
- Scenario 3 incorporates a livestock reduction of 22% for the beef sector. **This decrease in beef livestock leads to a reduction in income and expenditure on inputs, resulting in a ~€1.27bn (-26%) decrease in economic output**
- Scenario 3 also incorporates an 18% livestock reduction for the dairy sector. **This decrease in dairy livestock results in a ~€0.75bn (-16%) decrease in economic output**
- Scenario 4 incorporates a livestock reduction of 47% for the beef sector. **This decrease in beef livestock leads to a reduction in income and expenditure on inputs, resulting in a ~€2.49bn (-51%) decrease in economic output**
- Scenario 4 also incorporates a 45% livestock reduction for the dairy sector. **This decrease in dairy livestock results in a ~€2.00bn (-44%) decrease in economic output**
- These impacts are based on a reduction in farm income and spending flowing to the beef and dairy supply chain. The forward impact on meat and dairy processors is not included here

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis. Note: figures include capital formation, livestock breeding, and wider supply chain activities (suppliers of agricultural inputs), may differ slightly from other sources. Beef and dairy processing is not included.

Primary agriculture's economic output - Scenario 1

Under Scenario 1, total economic output is increased by ~€31.3 million.

Direct, indirect and induced economic output, by 2030, €m



Key takeaways

- Under Scenario 1, economic output would increase by ~€216.2 million when only considering agricultural abatement measures. The mitigation measures result in an increase in production from improved genetics and farm production
- When only considering land-use and energy abatement measures, these measures reduce production and expenditure flowing to the supply chain, lowering output by ~€184.9 million:
 - The forestry measures which accounts for the conversion of farm land, result in a reduction in output for all sectors, with the greatest impact on beef
- Considering the total across all measures, economic output would increase by ~€31.3 million

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis.

Primary agriculture's economic output - Scenario 2

Under Scenario 2, total economic output is decreased by ~€14 million.

Direct, indirect and induced economic output, by 2030, €m



Key takeaways

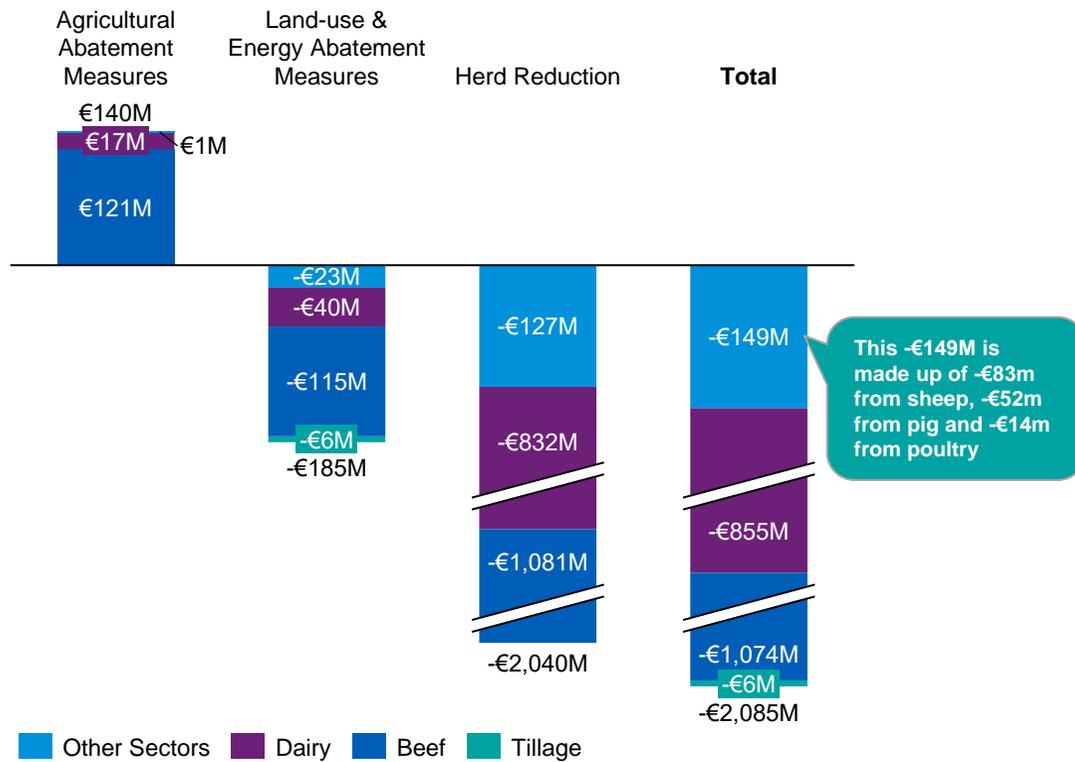
- Scenario 2 includes the application of the MACC measures in Scenario 1, with an increased uptake of some agricultural measures and additional mitigation measures
- Agricultural abatement measures increases output for beef and other sectors. Overall, economic output increases by ~€11 million**
 - The decrease for beef from S1 is driven by a reduction in the slaughter age measure being included. The cost of reducing the slaughter age is offset by the benefits received from the improved beef liveweight gain measure
 - Land-use and energy abatement measures would decrease economic output by ~€185 million. This is mainly driven by forestry measures that reduce income in dairy, beef and other sectors
- The total economic output would decrease by ~€14 million when considering the agricultural, land-use and energy abatement measures**

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis.

Primary agriculture's economic output - Scenario 3

Under Scenario 3, economic output is decreased by ~€2,085 million.

Direct, indirect and induced economic output, by 2030, €m



Key takeaways

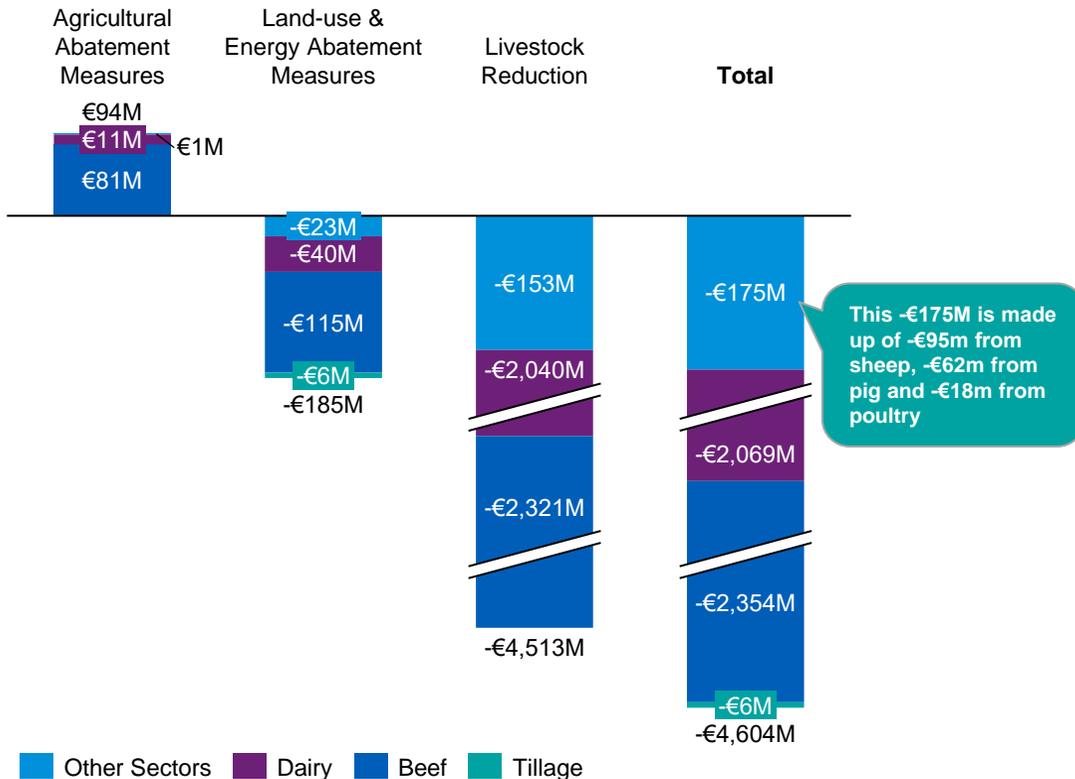
- Scenario 3 includes all measures in Scenario 2 with livestock reductions of 18% for dairy, 22% for beef and 5% for pigs, poultry and sheep.
- The above livestock reductions results in a ~€2.04bn decrease in economic output for the agriculture sector. This decrease is made up of the following:
 - The beef sector contributes the greatest share of this decrease, with a decrease of ~€1,081 million
 - The dairy sector also sees a large decrease in economic output as a result of the livestock reduction, with a decrease of ~€832 million
 - The other sectors have a decrease of ~€149 million (~€127 million of this is from a livestock reduction of 5% to sheep, pigs and poultry)
- The overall decrease in economic output for Scenario 3 is €2.09bn**

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis.

Primary agriculture's economic output - Scenario 4

Under Scenario 4, economic output is decreased by ~€4.6bn.

Direct, indirect and induced economic output, by 2030, €m



Key takeaways

- Scenario 4 includes the same measures as in Scenario 3 but with higher levels of livestock reductions: 45% for dairy, 47% for beef and 6% for pigs, poultry and sheep
- The above livestock reductions results in a ~€4.5bn decrease in economic output for the agriculture sector. This decrease is made up of the following:
 - The beef sector contributes the greatest share of this decrease, with a decrease of ~€2.3bn
 - The dairy sector also sees a significant decrease in economic output as a result of the livestock reduction, with a decrease of ~€2bn
 - The other sectors have a decrease of ~€175 million (~€153 million of this is from a livestock reduction of 6% to sheep, pigs and poultry)
- The overall decrease in economic output for Scenario 4 is ~€4.6bn**

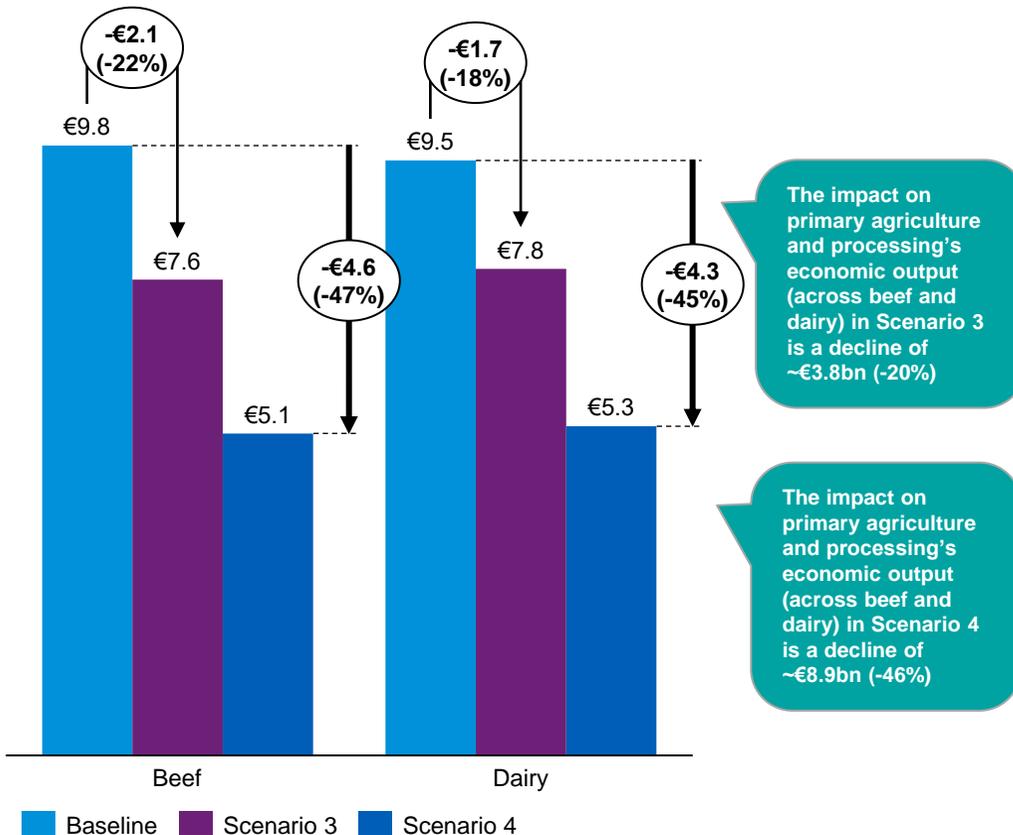
Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis. Note: A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.

Economic impacts

Primary agriculture & processors' economic output (beef and dairy)

Scenario 4 results in a ~€8.9bn (-46%) decrease in economic output across primary agriculture and processors.

Direct, indirect and induced economic output, by 2030, €bn



Key takeaways

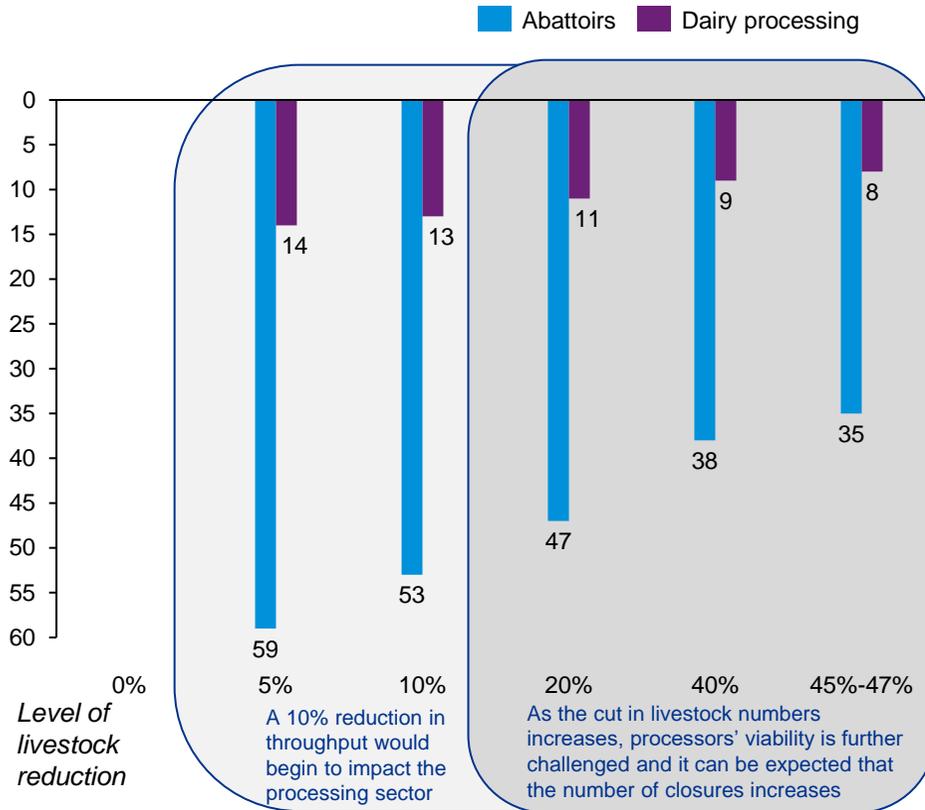
- In addition to primary agriculture, the livestock reductions considered in Scenario 3 and 4 have an impact on beef and dairy processors. The low margin processing sector will feel an immediate impact from any livestock reductions
- Most Irish beef processors are currently working under capacity. Many only work four days a week, with a weekly slaughter of 36,000. Any downward shift in supply could lead to some smaller factories closing, with an impact on competition within the beef sector
- Reducing dairy livestock would immediately have an impact on the efficiency of dairy processing plants. A 10% reduction would not necessarily equate to a 10% cut in production, however, larger livestock reductions such as a 40% cut, would drastically impact processors' viability and could lead to plant closures
- **In Scenario 3, economic output for beef farms and processing falls by ~€2.1bn (-22%) and for dairy farms and processing the fall is ~€1.7bn (-18%).**
 - The overall decline in Scenario 3 is ~€3.8bn (-20%)
- **In Scenario 4, economic output for beef farms and processing falls by ~€4.6bn (-47%) and for dairy farms and processing the fall is ~€4.3bn (-45%).**
 - The overall decline in Scenario 4 is ~€8.9bn (-46%)

Source: CSO (2021), KPMG analysis. Note: figures include beef and dairy processing, may differ slightly from other sources.

Economic impact - downstream processing sector (Scenario 3 & 4)

The low margin processing sector will feel an immediate impact from any livestock reductions.

Number of processing facilities based on livestock reductions



Key takeaways

- The graph on the left provides an **illustrative example** of the potential impact of livestock reductions on key processors in the value chain. Ireland currently has approximately 33 beef abattoirs, 10 sheep abattoirs, 9 pork abattoirs, 7 poultry processors and 14 milk processors. The red meat processing sector employs ~11,700 people and dairy processing ~ 7,500 people
- It is likely that smaller abattoirs may be impacted first and would have to close due to lower levels of input. Larger abattoirs may be in a slightly better position to either withstand input changes or to adapt their processing accordingly
- The associated reduction in milk production has a key impact on dairy processors. For abattoirs, reductions in beef/sheep numbers could drive the biggest disruptions to the supply chain, while pork and poultry production is affected to a lesser extent.
- Most Irish beef processors are currently working under capacity. Many only works four days a week, with a weekly slaughter of 36,000. Any downward shift in supply could lead to some smaller factories closing, with an impact on competition within the beef sector. Similarly, for sheep abattoirs, a 5-10% reduction in the sheep flock will already start to challenge viability
- Reducing dairy livestock would immediately have an impact the efficiency of dairy processing plants. A 10% reduction would not necessarily equate to a 10% reduction in production, however, larger livestock reductions such as a 40% cut, would drastically impact processors' viability and could lead to plant closures
- In the Scenario on the left, a 10% reduction in throughput would already challenge the viability of smaller processors and the threat would grow with higher livestock reductions. The closure of processors would negatively impact regional economies through job losses and lower output

Source: Industry interviews, DAFM (2021), Eurostat (2021), IBISWorld (2021), KPMG analysis. Note: Potential cattle imports for slaughter are not considered in this example.

12.

Economic
impacts -
Employment

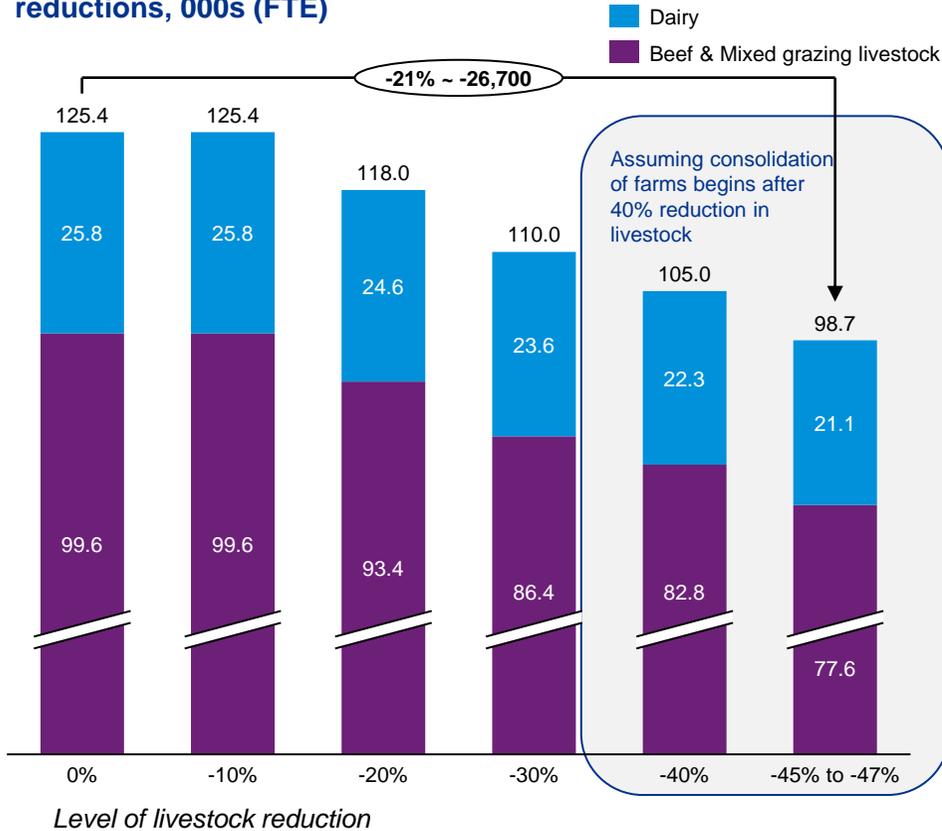


Economic impacts

Employment - impact on direct farm employment (Scenario 3 & 4)

A 45% reduction in dairy and 47% in beef livestock numbers, could result in a decrease in dairy and beef farm employment of ~26,700.

Direct farm employment by sector across a range of livestock reductions, 000s (FTE)



Key takeaways

- The graph on the left illustrates the impact on employment for a range of livestock reductions
- **In Scenario 3, with a livestock reduction of 18% for dairy and a 22% reduction for beef, there is a reduction in full time equivalent (FTE) employment of ~7,400 (-6%) up to ~15,400 (-12%)**
- **With a livestock reduction of 45% for dairy and a 47% reduction for beef in Scenario 4, there is a reduction in full time equivalent (FTE) employment of ~26,700 (-21%)**
- Currently specialist beef production and mixed grazing livestock farms makes up the greatest share of Ireland's farm employment. Employing over 99,600 FTE employees across 90,000 farms. 67% of these farms are less than 30ha and assumed to have a secondary source of income
- Dairy comprises the second largest share of farm employment with over 25,800 full time equivalent employees. The majority of those are employed by large farms that are greater than 30ha. The dairy sector on average directly employs 1.6 FTE per farm
- The specialist beef production and mixed grazing livestock farms consists mainly of small farms, with on average each farm employing 1.1 FTE (including the owner). Many of these smaller farms may be likely to consolidate once the level of livestock reductions exceed 30 - 40%
- The reduction in other livestock numbers, at 5% to 6%, is assumed to not materially impact farm employment. It is assumed that farmers still receive the same subsidy amount with the reduction of livestock. **Job losses would be greater if the subsidies decreased with livestock reductions**

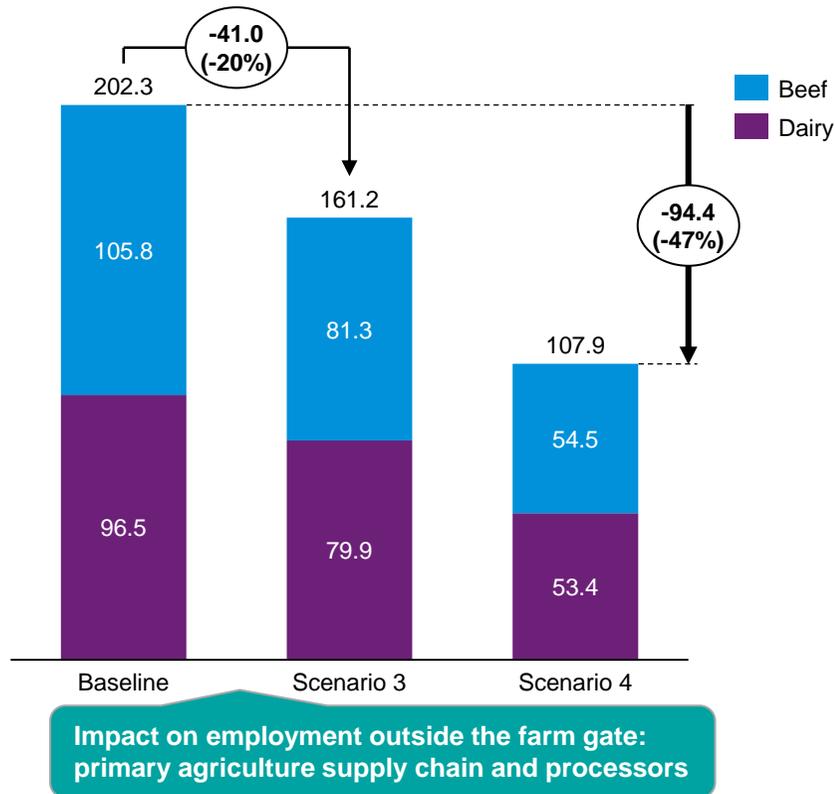
Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis. Note: Sheep, Pig and Poultry livestock reduction of 5% - 6% Scenario 3 & 4 – employment for these sectors is held constant. Owners are included in the employment data. Some figure are rounded. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.

Economic impacts

Employment - impact on employment outside the farm gate (Scenario 3 & 4)

A 45% reduction in dairy and 47% reduction in beef livestock numbers could result in a ~47% decrease in related beef and dairy related employment outside the farm gate.

Processors and primary agriculture supply chain employment by sector in Scenario 3 & 4 (with livestock reductions), 000s (FTE)



Key takeaways

- The graph on the left provides an **illustrative example** of the potential employment impact of livestock reductions on the beef and dairy farm supply chain, as well as primary beef and dairy processors
- In addition to direct farm employment, the decrease in output associated with livestock reductions could result in a loss of employment in the wider (upstream) supply chain that supplies inputs to the agricultural sector and for (downstream) dairy and beef processors
- The decreased spending on inputs associated with the decrease in output for beef and dairy farms produce a loss in income for numerous businesses, this will ultimately have a negative impact on employment in the wider supply chain and rural communities
- It is likely that smaller meat/dairy processors may be impacted first and would have to close due to lower throughput levels. Larger processors may be in a slightly better position to either withstand input changes or to adapt their processing accordingly
- The reduced output in Scenario 4 could **reduce full time equivalent (FTE) employment in the farm supply chain and for processors by ~94,400 (-47%)**

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis

13.

Further economic considerations



Farmer uptake and CAP support

Policy support for farmer education could support wider uptake of mitigation measures.

Selected support proposed in Ireland’s CAP Strategic Plan (CSP):
2023-2027

Proposed intervention	Purpose
Agri-Environment Climate Measure (AECM)	Deliver a range of environmental, climate and biodiversity benefits by supporting farmers to undertake appropriate actions. The nature of the actions will be determined by the needs of the land and environs
Agri-environment Climate Training	Provide training to farmers who partake in the National Agri-Environment Climate Measure
Organic Farming Scheme	Support to farmers wishing to convert from conventional farming systems to organic farming systems,
Eco-scheme	Provide additional direct income support to farmers for undertaking actions beneficial to the climate and the wider environment
Dairy Beef Welfare Scheme	Support to farmers who undertake actions to improve the viability of male dairy calves in locally based production systems
Suckler Carbon Efficiency Programme	Support to beef farmers to improve the environmental sustainability of the national beef livestock

Key takeaways

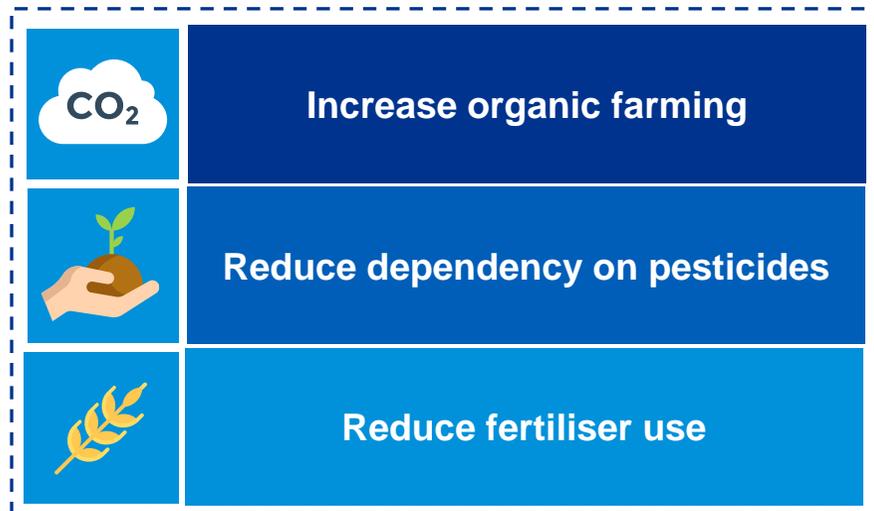
- Based on our farm case studies, greater awareness of the economic and environmental benefits associated with mitigation measures is needed
- Creating awareness of these benefits through farmer training could help to change behaviour and increase the uptake of mitigation measures
- Policy support for training to create awareness and change farming practices could facilitate the wider uptake of mitigation measures
- To this end, Ireland’s CAP Strategic Plan (2023-2027) proposes a number of interventions that can support agriculture in pursuing lower carbon emissions
- In addition, certain measures such as energy efficiency in dairy farming requires an initial upfront capital investment. Whilst the savings produced by these measures can help to repay this investment over time, the initial capital outlay presents a significant initial cost to farmers
- Supports mechanisms, such as the Capital Investment Initiative (CII), could be helpful in supporting farmers to invest in mitigation measures that require a large upfront capital investment

Source: DAFM (2021), KPMG analysis.

EU Farm to Fork Strategy (1/2)

The EU Farm to Fork Strategy will influence the longer-term agricultural emissions landscape.

Selected elements of the Farm to Fork Strategy



The Farm to Fork Strategy and the EU's Biodiversity Strategy (BDS) for 2030 represent key strategies for the Green Deal. The BDS aims to stop biodiversity loss. Components of the BDS will have an impact on farming practices. These include lowering the use and risk of chemical pesticides by 50%, lowering the use of fertiliser by 20%, placing at least 10% of agricultural area under high-diversity landscape features, and increasing organic farming to at least 25%

Key takeaways

- The EU Commission's Farm to Fork Strategy aims to move towards food systems that decrease the impacts on the environment and climate
- **Organic farming:**
 - The Strategy sets a target of 25% organic farming across the EU by 2030. ~2.7% of Ireland's Utilised Agricultural Area (UAA) is currently organically farmed
 - Ireland's current Programme for Government target for UAA under organic production is 7.5%. Effective government support measures could help to reach this target. The alignment and affiliation of certification bodies with Government will also be crucial
- **Reducing dependency on pesticides:**
 - The Strategy aims to reduce pesticide use by 50% by 2030. However, Ireland uses a relatively low amount of pesticides compared to other EU countries. Should the implementation of this target account for domestic circumstances, the required reduction for Irish farmers could be lower
- **Reducing fertiliser use:**
 - The Strategy aims to reduce fertiliser use by 20% by 2030. From our Scenario analysis, the cost of using multi-species swards could be offset by the cost savings from using less fertiliser. This measure could help to reduce emissions without adding to costs
 - Increased production of leguminous crops could further help to decrease Nitrogen use

Source: European Commission, Eurostat, IFJ.

EU Farm to Fork Strategy (2/2)

The EU Farm to Fork Strategy will influence the longer-term agricultural emissions landscape.

Yield % differences between organic and conventional crops by agro-ecological region estimated from FADN data.

Product	Ireland
Cereals	-45.4
Vegetables	-76.4
Wheat	-55.9
Fruits	-63.6
Non-fruit permanent crops	3.8

Source: Adapted from European Commission (2021)

Key takeaways

- The European Commission modelled the potential effects of selected Farm to Fork and Biodiversity strategies for the agricultural sector in the EU, using the CAPRI (Common Agricultural Policy Regionalised Impact analysis) modelling system
- Considering the potential impacts, without changing the common agricultural policy (CAP), they find that:
 - The main impact from the different targets in the area for cereals stems from landscape elements, which cause a -9% decrease in area. However, the overall effect is counteracted by an increase in cereal areas to compensate for lower yields that arise from shifts to organic and lower pesticide use production methods
 - The supply of vegetables and permanent crops is estimated to decrease by 12%, mainly due to the organic yield gap
 - Reducing livestock, to decrease manure output and to improve nitrogen balance, could decrease meat supply by 14% and raw milk supply by 10%

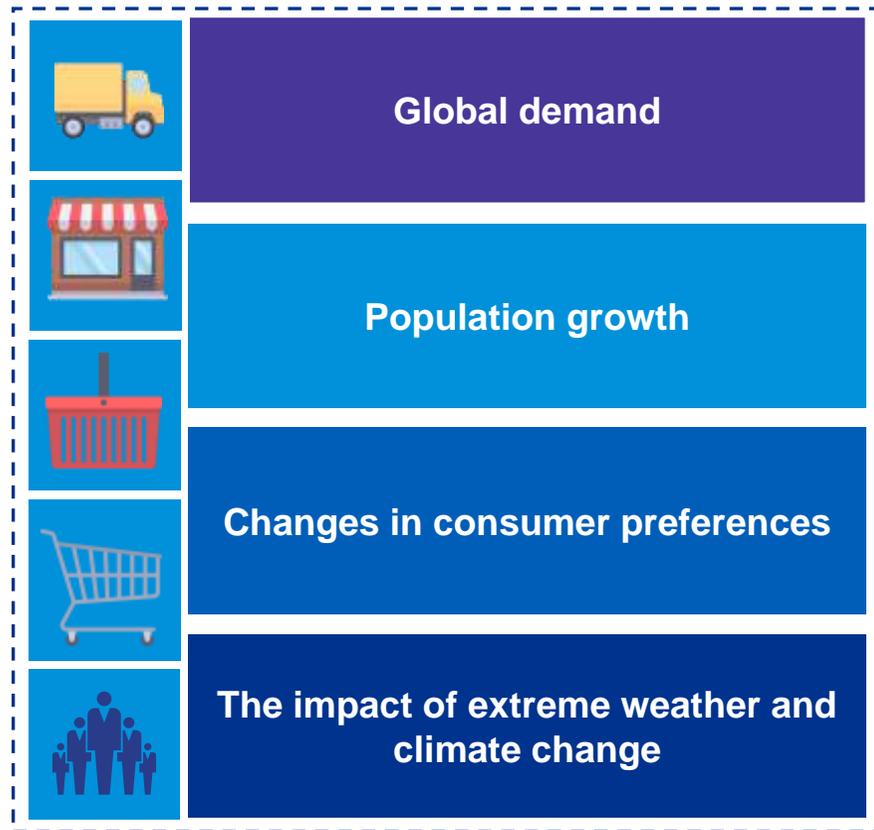
There are significant differences in yield between conventional and organic farming practices. A shift towards organic farming could have an impact on overall yields.

Source: European Commission (2021), Modelling environmental and climate ambition in the agricultural sector with the CAPRI model.

Market Prices and Demand

Global market dynamics will determine consumer food prices. Cost pressure from reducing livestock numbers cannot be passed on to consumers and will impact viability.

Factors Impacting Global Market Prices



Key takeaways

- Livestock reductions will have an impact on farmers' cost structure and incomes. As price takers, farmers will not be able to pass on the costs associated with these negative impacts to consumers through higher food prices
- External factors such as global demand, population growth, changing consumer preferences and the impact of extreme weather on agricultural harvests will all influence global food prices
- The World Bank forecasts that the world nominal price for beef will see an annual decrease of between -1.1% to -1.3% between 2021 to 2030. With rising input costs, the profit margin for beef farmers could likely decrease
- Globally, dairy products are expected to see an annual growth in demand of just under 2%. This increase in demand is partly driven by rising per capita consumption of fresh dairy products in developing countries
- Demand for agricultural commodities is expected to grow at 1.2% p.a. over the coming decade. Population growth is the main driver of this increase
- Should policies regarding the minimum age for the export of livestock be introduced, this would have significant impacts on the veal market and Ireland's export of calves. Approximately 140,000 one month old calves are exported each year. If these exports were no longer allowed, these calves would need to be incorporated into the dairy/beef herd and this would result in increased emissions

Source: World Bank, OECD, KPMG analysis.

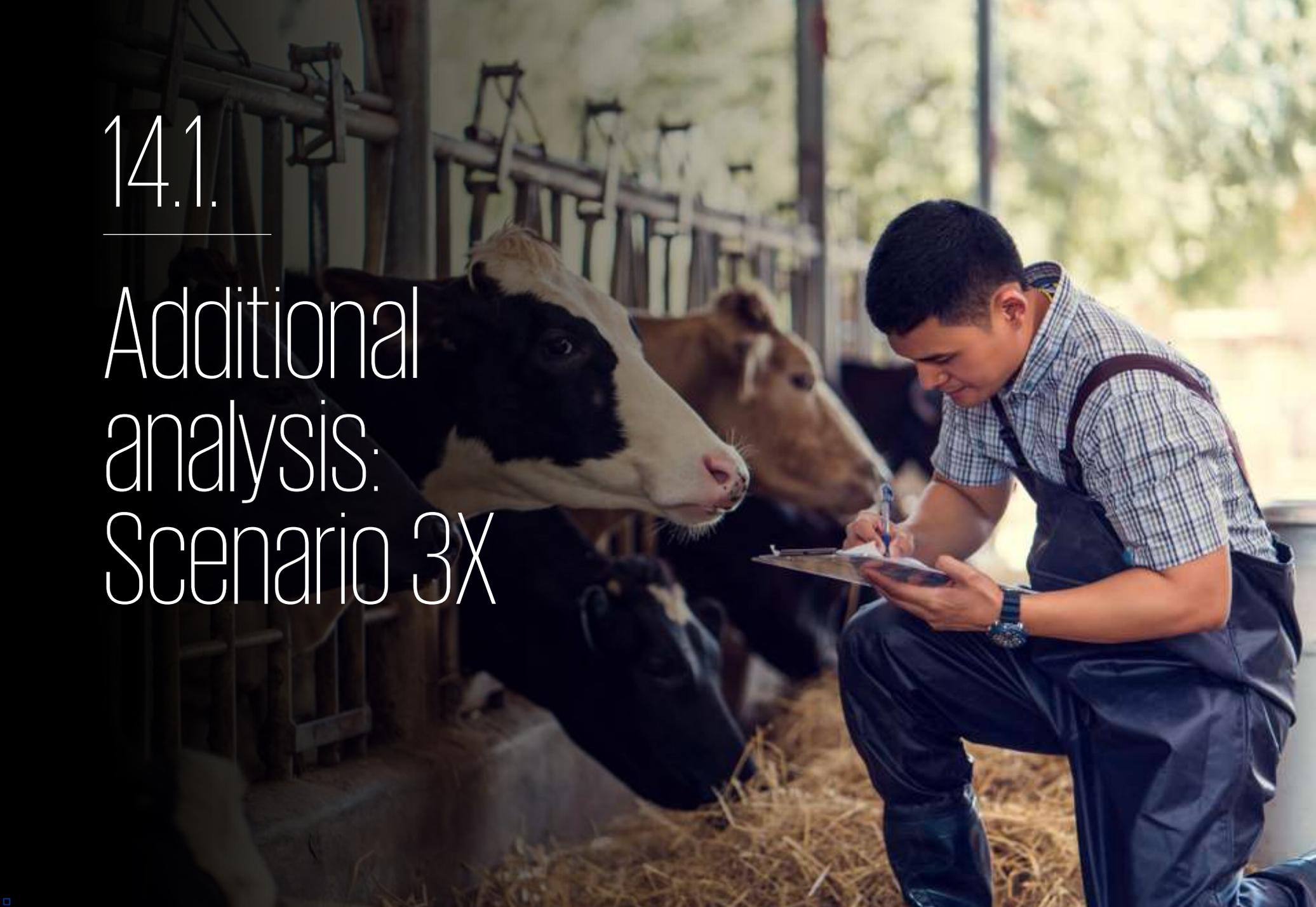
14.

Appendices



14.1.

Additional
analysis:
Scenario 3X



Scenario 3X considers the impact of another emissions reduction target for the agriculture sector, which may be required under the impending carbon budgets.

The Climate Action and Low Carbon Development (Amendment) Bill 2021 ('Climate Bill') sets out Ireland's ambition to reach net zero by 2050. Carbon budgets will be set nationally and on a sector-by-sector basis to cap the level of allowable carbon emissions for the periods 2021-2025, 2026-2030 and 2031-2035.

When this report was commissioned, the carbon budgets had not yet been determined on either an economy-wide or sectoral basis. At the time of publishing the report (October 2021), the Government was in the process of signing off economy wide and sectoral budgets, putting a limit on what each sector can emit during the carbon budget periods. Initial reports have indicated that agriculture will be required to reduce its carbon emissions by between 21% and 30% by 2030 compared to 2018 levels.

To date, our report has assessed the impact of four scenarios, each exploring different emissions reduction pathways for the agriculture sector (13%, 18%, 30% and 50% emissions reductions compared with 2018 levels).

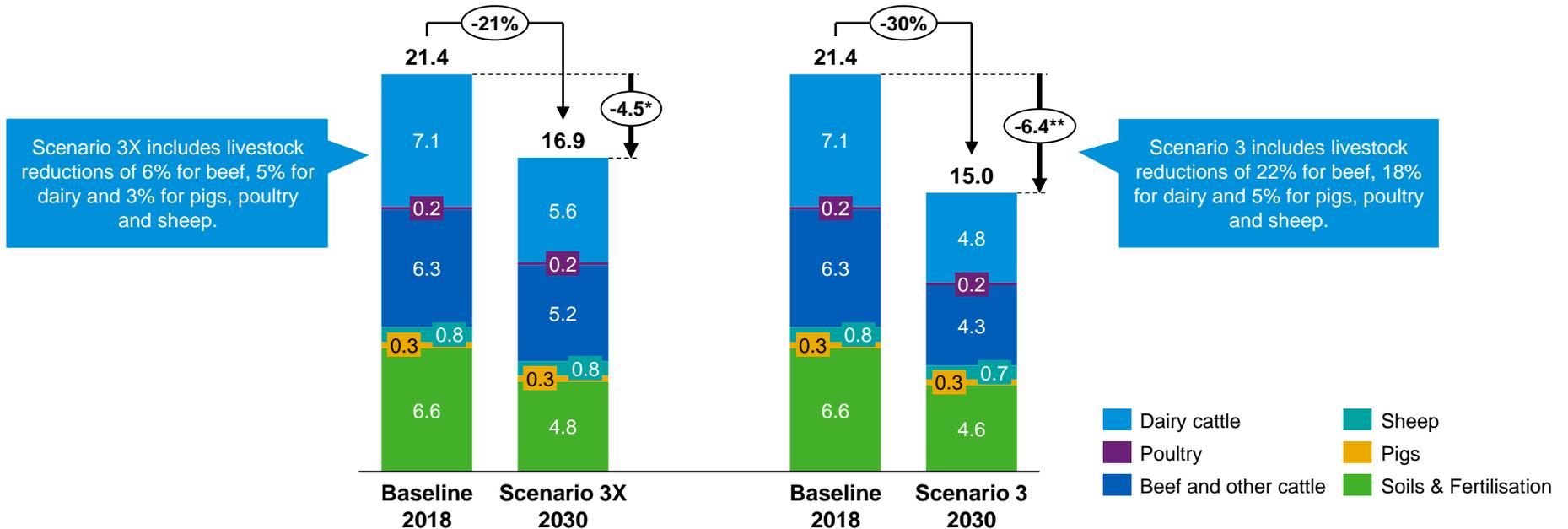
To explore the potential target for a 21% reduction in agriculture sector carbon emissions between 2018 and 2030, an additional analysis (Scenario 3X) has been undertaken. For the purpose of our analysis, this reduction is assumed to be linear. However, in reality, the carbon budgets will likely require early action (the bulk of emissions reductions in the short-term) or late action (smaller emissions reductions in the short-term, leaving most action to the latter half of the decade, resulting in more emissions over the carbon budget period). Early indications are that actions will be backloaded.

Scenario 3 (30% reduction) and **Scenario 3X** will be presented together to show the impact of the likely emissions reductions required under the impending carbon budgets for the agriculture sector.

About this Scenario

The graph below presents results of Scenario 3X and Scenario 3, broken down by agriculture category (Dairy, Beef, Sheep, Pigs, Poultry and Soils & Fertilisation).

Carbon emissions by agricultural sector under Scenario 3X and Scenario 3 (MtCO₂e)



*2.95 MtCO₂e arising from efficiency measures + 0.635 MtCO₂e from a reduction in livestock numbers

**2.95 MtCO₂e arising from efficiency measures + 2.55 MtCO₂e from a reduction in livestock numbers

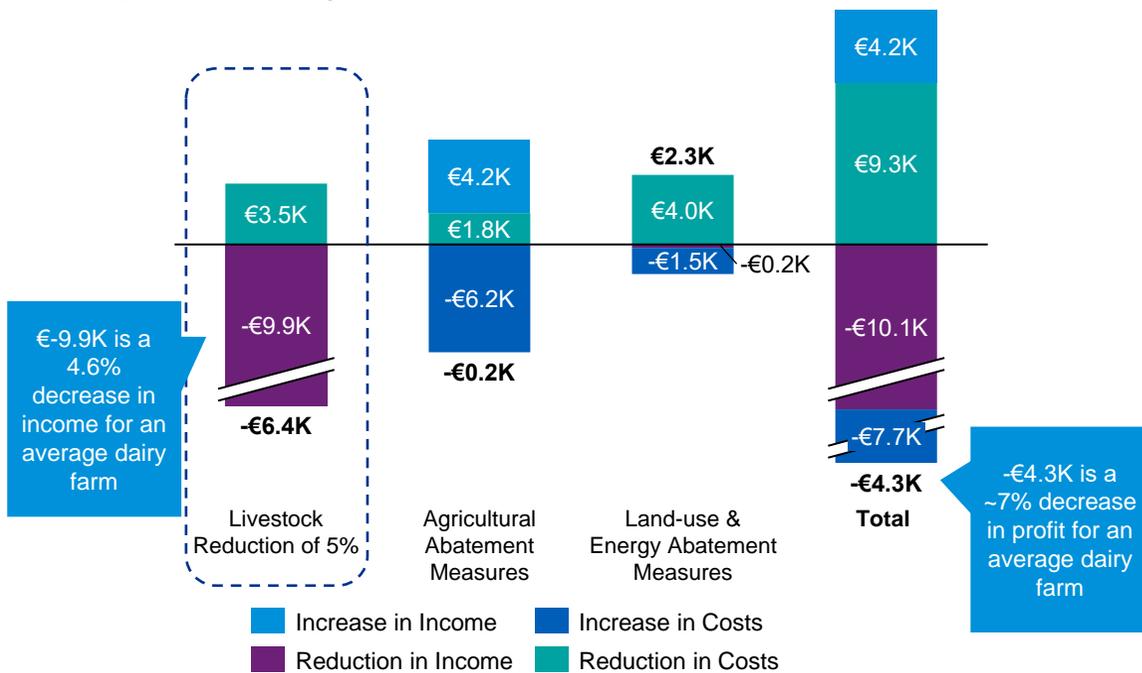
14.1A

Farm level
impacts



Mitigation measures, combined with a 5% livestock reduction will see a reduction in profit of ~€4.3K per a dairy farm.

Impacts on a dairy farm's income/cost under Scenario 3X



€-9.9K is a 4.6% decrease in income for an average dairy farm

-€4.3K is a ~7% decrease in profit for an average dairy farm

Scenario 3X is the full application of the MACC with increased uptake on some measures, additional mitigation measures, as well as a reduction in dairy livestock of 5%.

Key takeaways

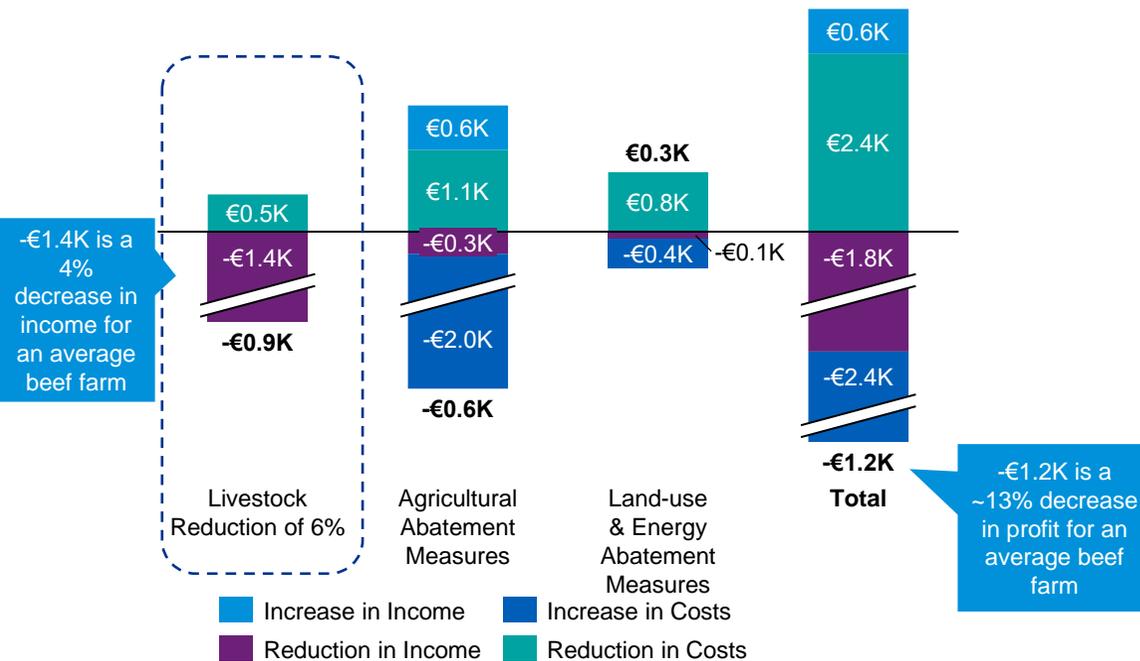
- Under Scenario 3X, the dairy sector sees a livestock reduction of 5%. This decreases income by ~€9.9K (-4.6%) for an average dairy farm. This is offset by the reduction in costs of ~€3.5K, mainly for feed and concentrates
- However, several fixed cost; such as machinery costs, other fixed/overhead costs, and labour costs are more inelastic and less likely to decrease with the livestock reductions. As the livestock reduction increases, these fixed cost will reduce the farm's optimum efficiency and limit economies of scale
- Overall, the implementation of Scenario 3X measures and the livestock reduction of 5%, would result in a decrease in profit of ~€4.3K (-7%) for the average dairy farm
- We have assumed that subsidies and income from other sources for the farm stay constant with the livestock reduction

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: The percentage decrease in income and income include allowance for subsidies and other farm income sources. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.



Mitigation measures, combined with a 6% livestock reduction will see a reduction in profit of ~€1.2K per beef farm.

Impacts on a beef farm's income/cost under Scenario 3X



Key takeaways

- Under Scenario 3X, the beef sector sees a livestock reduction of 6%. The livestock reduction results in a decrease in income of ~€1.4K (-4%) for an average beef farm. This is offset by the reduction in costs of ~€0.5K from a reduction in feed and concentrates, and other costs
- However, a number of fixed cost such as machinery costs, other fixed/overhead costs, and labour costs are more inelastic and less likely to decrease with the livestock reductions. As the livestock reduction increases, these fixed cost will reduce the farm's optimum efficiency and limit economies of scale
- Overall, the implementation of Scenario 3X measures and the livestock reduction of 6% would result in a decrease in profit of €1.2K (-13%) for the average beef farm
- We have assumed that subsidies and income from other sources for the farm stay constant with the livestock reduction

Scenario 3X is the full application of the MACC with increased uptake on some measures, additional mitigation measures, as well as a reduction in beef livestock of 6%.

Source: Teagasc, CSO, KPMG analysis, IFJ consultation. Note: The percentage decrease in income and income include allowance for subsidies and other farm income sources. A value axis break was used to shrink the display of some information, to enhance readability for the smaller segments.

14.1B

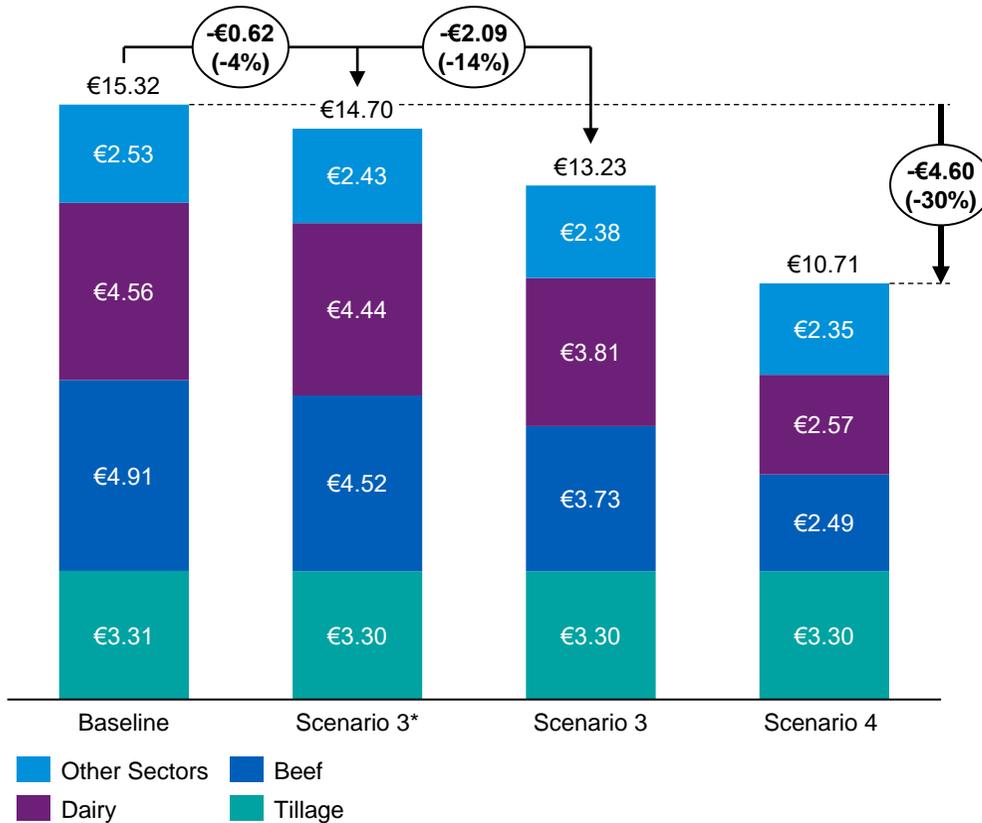
Economic
impacts -
Economic
output



Primary agriculture's economic output - Scenario 3X

Scenario 3X would create a relatively small reduction in primary agriculture's economic output, a decline of ~€0.62bn (-4%).

Direct, indirect and induced economic output, by 2030, €bn



Key takeaways

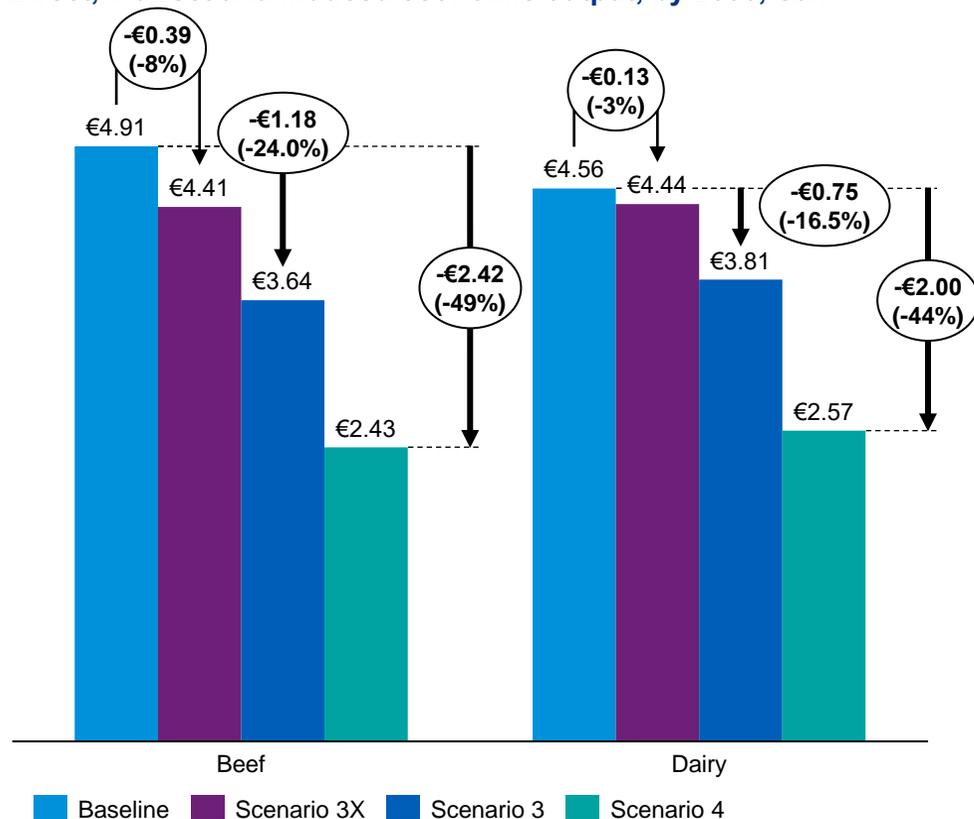
- Scenario 3X considers a livestock reduction of 6% for beef, 5% for dairy, and 3% for sheep, pork and poultry
- Note that the carbon reductions achieved via the land-use and energy abatement measures are not attributed to agriculture in the national GHG inventory. However, these measures produce benefits and/or costs for the agriculture sector
- For primary agriculture, economic output is reduced by ~€0.62bn (-4%) in Scenario 3X**
 - The herd reductions are accompanied by a loss of income and a reduction in spending flowing to the beef and dairy supply chain. The forward impact on meat and dairy processors is not included here
- The negative impact is higher for Scenario 3 and 4, in line with the higher livestock reductions assumed in these scenarios

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis. Note: figures include capital formation, livestock breeding, and wider supply chain activities (suppliers of agricultural inputs), may differ slightly from other sources. Meat and dairy processing is not included.

Primary agriculture's (beef and dairy) economic output - Scenario 3X

Scenario 3X results in a ~8% (€0.39bn) decrease in the economic output for beef and ~3% (€0.13bn) for dairy.

Direct, indirect and induced economic output, by 2030, €bn



Key takeaways

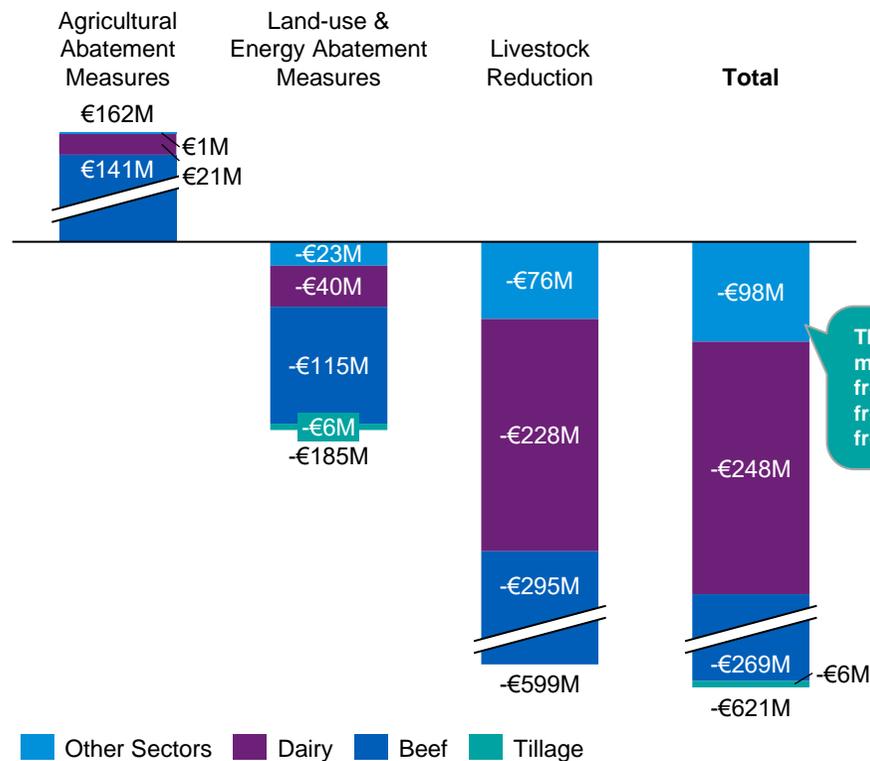
- Scenario 3X incorporates a livestock reduction of 6% for the beef sector. **This decrease in beef livestock leads to a reduction in income and expenditure on inputs, resulting in a ~€0.39bn (-8%) decrease in economic output**
- Scenario 3X also incorporates a 5% livestock reduction for the dairy sector. **This decrease in dairy livestock results in a ~€0.13bn (-3%) decrease in economic output**
- Scenario 3 incorporates a livestock reduction of 22% for the beef sector. **This decrease in beef livestock leads to a reduction in income and expenditure on inputs, resulting in a ~€1.18bn (-24%) decrease in economic output**
- Scenario 3 also incorporates a 18% livestock reduction for the dairy sector. **This decrease in dairy livestock results in a ~€0.75bn (-16.5%) decrease in economic output**
- Scenario 4 produces the largest decline in output, in line with the higher livestock reduction
- These impacts are based on a reduction in farm income and spending flowing to the beef and dairy supply chain. The forward impact on meat and dairy processors is not included here

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis. Note: figures include capital formation, livestock breeding, and wider supply chain activities (suppliers of agricultural inputs), may differ slightly from other sources. Beef and dairy processing is not included.

Economic output - Scenario 3X

Under Scenario 3X, economic output in primary agriculture is decreased by ~€621m for the agriculture sector.

Direct, indirect and induced economic output, by 2030, €m



Key takeaways

- Scenario 3X livestock reductions results in a ~€599 decrease in economic output for the agriculture sector. This decrease is made up of the following:
 - The dairy sector contributes the greatest share of this decrease, with a decrease of ~€228 million
 - The beef sector also sees a large decrease in economic output as a result of the livestock reduction, with a decrease of ~€295 million
 - The sheep, pigs, poultry and tillage sectors see a decrease of ~€76 million
- The total decrease in economic output for Scenario 3X is €621 million**

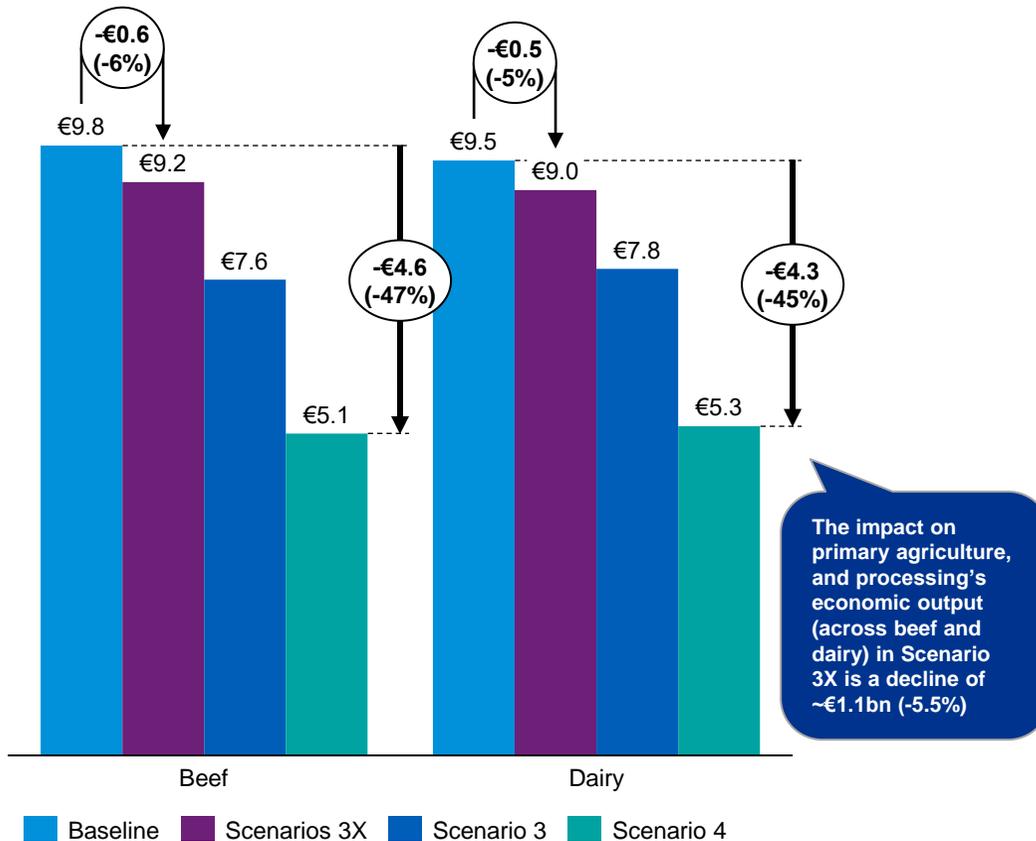
Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis.

Economic impacts

Primary agriculture and Processors' economic output (beef and dairy)

Scenario 3X results in a ~€1.1bn (-5.5%) decrease in the economic output across primary agriculture and processors.

Direct, indirect and induced economic output, by 2030, €bn



Key takeaways

- In addition to primary agriculture, livestock reductions have an impact on beef and dairy processors. The low margin processing sector will feel an immediate impact from any livestock reductions
- Most Irish beef processors are currently working under capacity. Many only work four days a week, with a weekly slaughter of 36,000. Any downward shift in supply could lead to some smaller factories closing, with an impact on competition within the beef sector
- Reducing dairy livestock would immediately have an impact on the efficiency of dairy processing plants. A 10% reduction would not necessarily equate to a 10% cut in production, however, larger livestock reductions such as a 40% cut, would drastically impact processors' viability and could lead to plant closures
- **The overall decline in economic output across primary agriculture and processing in Scenario 3X is ~€1.1bn (-5.5%):**
 - When considering the livestock reduction for beef, economic output across primary agriculture, and processing falls by ~€0.6bn (-6%)
 - When considering the livestock reduction for dairy, economic output across primary agriculture, and processing falls by ~€0.5bn (-5%)

Source: CSO (2021), KPMG analysis. Note: figures include beef and dairy processing, may differ slightly from other sources.

14.1C

Economic
impacts -
Employment

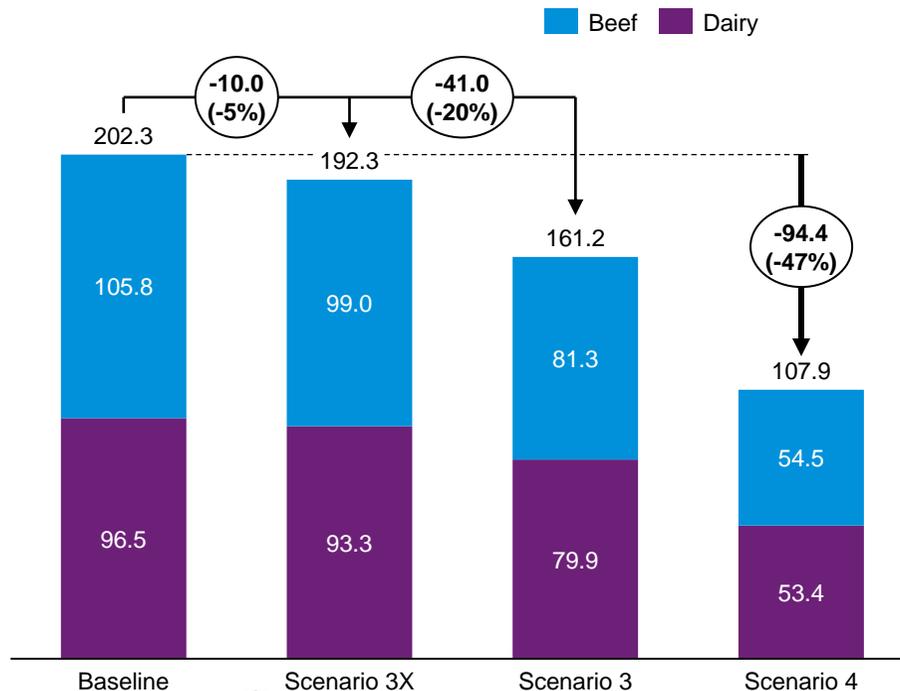


Economic impacts

Employment - impact on employment outside the farm gate (Scenario 3X)

A 5% reduction in dairy and 6% reduction in beef livestock numbers could result in a ~5% decrease in related employment outside the farm gate.

Processor and farm supply chain employment by sector in Scenario 3X, 3 & 4 (with livestock reductions), 000s (FTE)



**Impact on employment outside the farm gate:
primary agriculture supply chain and processors**

Key takeaways

- The graph on the left provides an **illustrative example** of the potential employment impact of livestock reductions on the beef and dairy farm supply chain, as well as primary beef and dairy processors
- In addition to direct farm employment, the decrease in output associated with livestock reductions could result in a loss of employment in the wider (upstream) supply chain that supplies inputs to the agricultural sector and for (downstream) dairy and beef processors
- The decreased spending on inputs associated with the decrease in output for beef and dairy farms produce a loss in income for numerous businesses, this will ultimately have a negative impact on employment in the wider supply chain and rural communities
- The reduced output in Scenario 3X could **reduce full time equivalent (FTE) employment in the farm supply chain and for processors by ~10,000 (-5%)**

Source: DAFM (2021), CSO (2021), Teagasc (2019), KPMG analysis

14.2

Assumptions & Limitations

Assumptions & Limitations

A number of assumptions have been included and limitations identified in our Scenario analysis.

Assumption / Limitation																																							
<p>Application of Committee on Climate Change Sixth Carbon Budget Balanced Pathway mitigation measures from Scotland to Ireland</p>	<ul style="list-style-type: none"> In order to include additional mitigation measures, this research drew on work completed by the UK Committee on Climate Change (CCC) and the Scottish Rural College (SRUC). The CCC provided data on their Balanced Pathway Scenario for Scotland which is included in their Sixth Carbon Budget assessment report. Measures in the Balanced Pathway Scenario were reviewed for their applicability in the Irish context, as summarised below. 3NOP was the only measure selected (below in green) and the remainder were excluded due to a risk of double counting with existing measures already included or those deemed to be unsuitable or too novel for the Scenarios, summarised below. Further information on the SRUC measures can be found here - https://pure.sruc.ac.uk/ws/portalfiles/portal/42113466/Non_CO2_abatement_in_the_UK_agricultural_sector_by_2050_Scottish_Rural_College.pdf 																																						
	<table border="1"> <thead> <tr> <th>CCC/SRUC mitigation measure code</th> <th>KPMG assumption</th> </tr> </thead> <tbody> <tr> <td>3NOP</td> <td>Include (Scenario 2, 3 & 4)</td> </tr> <tr> <td>AD Cattle</td> <td>Exclude - AD measure is already included</td> </tr> <tr> <td>AD Pigs</td> <td>Exclude - AD measure is already included</td> </tr> <tr> <td>Breeding - Current</td> <td>Exclude - Livestock breeding measures already included</td> </tr> <tr> <td>Breeding - Low Methane</td> <td>Exclude - Livestock breeding measures already included</td> </tr> <tr> <td>Breeding Genomics</td> <td>Exclude - Livestock breeding measures already included</td> </tr> <tr> <td>Cover Crop</td> <td>Exclude - AD measure is already included Cover crops for tillage already included</td> </tr> <tr> <td>Cover Slurry Impermeable</td> <td>AD measures, slurry chemical amendments, LESS and cover slurry stores already included</td> </tr> <tr> <td>GM Cattle</td> <td>No abatement delivered in 2030</td> </tr> <tr> <td>Grass Legumes Mix</td> <td>Exclude - Clover measure already included</td> </tr> <tr> <td>Grass Leys</td> <td>No abatement delivered in 2030</td> </tr> <tr> <td>Health Cattle</td> <td>Exclude - improved animal health already included</td> </tr> <tr> <td>Health Sheep</td> <td>Exclude - Potential to be applied in Ireland e.g. in Scenario 2 but conservative approach was taken</td> </tr> <tr> <td>High Starch Diet</td> <td>Exclude - Potential double counting with other livestock feed related measures</td> </tr> <tr> <td>High Sugar Grasses</td> <td>Exclude due to potential double counting with other livestock feed related measures</td> </tr> <tr> <td>Increase Milking Frequency</td> <td>Exclude - several livestock breeding and feed measures already included</td> </tr> <tr> <td>Nitrate Additives</td> <td>3NOP and lipids/fatty acids already included</td> </tr> <tr> <td>Precision Feeding</td> <td>Exclude - Potential double counting with other livestock feed related measures</td> </tr> </tbody> </table>	CCC/SRUC mitigation measure code	KPMG assumption	3NOP	Include (Scenario 2, 3 & 4)	AD Cattle	Exclude - AD measure is already included	AD Pigs	Exclude - AD measure is already included	Breeding - Current	Exclude - Livestock breeding measures already included	Breeding - Low Methane	Exclude - Livestock breeding measures already included	Breeding Genomics	Exclude - Livestock breeding measures already included	Cover Crop	Exclude - AD measure is already included Cover crops for tillage already included	Cover Slurry Impermeable	AD measures, slurry chemical amendments, LESS and cover slurry stores already included	GM Cattle	No abatement delivered in 2030	Grass Legumes Mix	Exclude - Clover measure already included	Grass Leys	No abatement delivered in 2030	Health Cattle	Exclude - improved animal health already included	Health Sheep	Exclude - Potential to be applied in Ireland e.g. in Scenario 2 but conservative approach was taken	High Starch Diet	Exclude - Potential double counting with other livestock feed related measures	High Sugar Grasses	Exclude due to potential double counting with other livestock feed related measures	Increase Milking Frequency	Exclude - several livestock breeding and feed measures already included	Nitrate Additives	3NOP and lipids/fatty acids already included	Precision Feeding	Exclude - Potential double counting with other livestock feed related measures
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Assumptions & Limitations

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation									
<p>Application of Committee on Climate Change Sixth Carbon Budget Balanced Pathway mitigation measures from Scotland to Ireland (cont'd)</p>	<ul style="list-style-type: none"> Based on expert feedback we note that Ireland and Scotland's agricultural sectors share similar characteristics and as such we developed a series of multipliers to reduce or uplift select mitigation measures for application in Ireland. The 3NOP measure described in the SRUC research was adjusted to reflect the livestock populations in Ireland compared to Scotland, as summarised below. The multipliers were applied to the mitigation potential provided by the CCC to get the estimated mitigation potential for Ireland. This method assumes a direct correlation between livestock numbers and mitigation potential which is used as a proxy for the abatement potential in Ireland as well as a direct comparison between Scottish and Irish agricultural characteristics. Please note that 3NOP is not currently an available technology in Ireland. The mitigation potential for this measure is assumed to begin in 2025. 								
	Mitigation measures	Sector Application	Scotland Cattle (head)	Scotland Sheep (head)	Scotland no.s (head)	ROI Cattle (head)	ROI Sheep (head)	ROI no.s (head)	Multiplier ROI mitigation
	3NOP	Dairy, Beef	1,712,260		1,712,260	7,314,400		7,314,400	4.272
<p>The SRUC describes the 3NOP measure as follows:</p> <ul style="list-style-type: none"> 3NOP (3-nitrooxypropanol) is a chemical that reduces the production of enteric methane by ruminants when added to their rations. It does so by reducing the rates at which rumen archaea convert the hydrogen in ingested feed into methane. Specifically, 3NOP inhibits methyl-coenzyme M reductase, the final step of CH₄ synthesis by archaea (Duin et al., 2016). In a meta-analysis, Dijkstra et al. found that the effect on enteric CH₄ emissions was -38.8%+/-5.5% for dairy and -17.1%+/-4.2% for beef cattle (2018). The measure entails the ingestion of a small amount of 3NOP each day, typically in the range of 0.05-0.2 g NOP for each kg of dry matter intake (Jayanegara et al., 2018). For housed animals the 3NOP could be mixed in with the ration. The enteric CH₄ of dairy and beef animals were reduced by 30% and 20%, respectively. The current uptake is assumed to be 0%. The cost is modelled as £38 head-1 y-1. 									

Assumptions & Limitations

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
Allocation of measures across livestock categories	<p>The EPA National Inventory Report – Annex 3.3. provides Animal Population figures. The cattle numbers show 21% dairy cows and 79% all other cattle. This implies that dairy cattle account for 24% of total agricultural emissions in 2019 and all other cattle accounted for 38%. It was considered that this emissions split did not truly reflect the realities of the sectors.</p> <p>Bord Bia figures show that in terms of our national slaughter profile, 57% of animals slaughtered annually originate on dairy farms while 43% originate from beef farms. We therefore adopted a 57%/43% split in cattle numbers between dairy and beef.</p> <p>The EPA National Inventory Report provides a breakdown of emissions by Dairy & Beef in Table 2.A. However this info is only for the latest year, 2019, whereas our report uses the recalculated figures for 2018. The recalculated 2018 figures only provide a breakdown of emissions for Cattle, not or dairy and beef. Therefore, we applied the 57%/43% to the recalculated 2018 figures for cattle emissions to get the split for cattle. Recalculated 2018 emissions are provided for sheep, swine and other livestock (which is taken as a proxy for poultry, being the largest proportion of this category).</p> <p>Allocation figures for individual measures were revised with input from sector experts (e.g. a measure that we intended to apply a 57/43 dairy/beef split to, the experts could overwrite this if they think a greater share for dairy is more appropriate. But if no comment has been made/accepted, then we go with 57/43 as default split, based on emissions).</p>
Mitigation potential	<p>Teagasc MACC 2018 provides the carbon reduction potential of a number of mitigation measures which we have applied to each of the four scenarios. This carbon reduction potential is reported as an 'average annual mitigation potential', assuming linear uptake of measures, representing the mean mitigation potential between 2021-2030. For the purpose of this assessment, we have assumed the mean mitigation potential for each mitigation measure is reached in 2030.</p>

Assumptions & Limitations

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
<p>Conversion of grassland to arable</p>	<p>The list of Carbon Sequestration measures include a measure on the conversion of grassland to arable systems. This measure is derived from preliminary research conducted by Teagasc, as set out below:</p> <p>“Ploughing permanent pasture for annual crop production results in a net loss in soil organic carbon. This is mainly due to:</p> <ul style="list-style-type: none"> - the disturbance and breakup of soil aggregates, which physically protect carbon - a reduction in below-ground inputs of C into the soil - reductions in the fungal:bacterial biomass ratio. <p>The increased use of cover cropping, residue incorporation and reduced tillage intensity can offset approximately 50% of this loss. If sandier, free-draining soils, with low C capacity are preferentially converted to arable, this will further reduce the impact on SOC. If 200,000 ha of permanent pasture is converted to cropland, SOC loss will be 0.836 million tonnes CO₂e per year. If cover cropping and straw incorporation are adopted on these areas this loss is reduced to 0.536 million tonnes CO₂e per year.”</p>

Assumptions & Limitations: Economics - Agricultural Measures

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
Improved dairy economic breeding index (EBI)	<ul style="list-style-type: none"> • Cost/Benefit Type: Benefit (Change Output/Income) • Total Annual Net Benefit/Cost: €86.0M, €50 - €70 per animal • Notes: The Teagasc Dairy Roadmap projects that by 2025 average EBI will increase to €180/cow with a research herd target of €230/cow (Teagasc 2016). Milk delivered per farm will increase to over 570,000 litres.
Improved animal health	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Output/Income • Total Annual Net Benefit/Cost: €6.8M, €0.7 - €1 per animal • Notes: Net cost/benefit per an animal calculated by taking the total benefit and divided by number of cattle and sheep. Assumed the cost for sheep is 30% of that of cattle Cow Equivariant
Low-emission slurry spreading	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: -€15.7M Scenario 1 -€19.2M Scenario 2 - 4, (-€5 to -5.4 per ha) • Notes: Net cost per ha calculated taking the total cost and dividing it by total beef and dairy farming ha. The cost per ha is not the actual cost to spread on ha of slurry.
Extended grazing	<ul style="list-style-type: none"> • Cost/Benefit Type: Reduction in Costs • Total Annual Net Benefit/Cost: €6.3M, €6.5 per animal • Notes: Teagasc analysis showed that for every one day reduced costs to the extent of €3.24 for dairy cow-1 and €0.006 per day for suckler beef systems.

Source: Teagasc, KPMG analysis

Note: Each measure is defined as being a net benefit or costs which takes into account the net changes in costs/income for each measure

Assumptions & Limitations: Economics - Agricultural Measures

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
Improved beef liveweight gain	<ul style="list-style-type: none"> • Cost/Benefit Type: Benefit (Change Output/Income) • Total Annual Net Benefit/Cost: €13.1M, €3.8 per animal • Notes: Net cost/benefit per an animal total cost divided by total number of beef cattle under 2 years old (excluding cows, heifers bulls, Cattle > 2 yrs)
Adding lipids/fatty acids to diets	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: -€2.7M, Scenario 1, -€6.4M Scenario 2 - 4. (-€30 to €45 per animal) • Notes: Teagasc calculated the cost for the change in diet to be €45/dairy cow. Scenario 2 – 4 assumes a greater uptake of farmers and therefore a great costs for the sector.
Slurry chemical amendments	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: -€1.35M Scenario 1, -€1.33M Scenario 2 - 4. (-€370 to -€400) per farm • Notes: "Teagasc assumed uptake of 20% of farms (mainly dairy and pig farmers). Average cost per a farm calculated by dividing total cost by 20% of number dairy farms and 100% all pig farmers.
Improved beef maternal traits	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: €15.25M, €14 to €16 per beef cow • Notes: Teagasc states the reductions in costs were mainly driven by improved health and survival, reduced mature cow maintenance feed requirements and shorter calving interval. Net cost/benefit beef cow calculated by dividing the total cost by the number of breed cows

Source: Teagasc, KPMG analysis

Note: Each measure is defined has being a net benefit or costs which takes into account the net changes in costs/income for each measure

Assumptions & Limitations: Economics - Agricultural Measures

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
Reduced crude protein in pig diets	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: - €0.61M, -€0.3 to -€0.5 per animal • Notes: Net cost per pig calculated by dividing the total cost by the total number of pigs. The cost of the diet manipulations was assumed in the range of €-10 to €10 per 1000 kg of feed, depending on market conditions for feed ingredients and the cost of the synthetic amino acids.
Increased use of sexed semen	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: -€0.66M, -€20 per animal • Notes: The current cost of sexed semen straws is €38 compared to €18 for conventional semen therefore the net cost per a dairy cow is €20. When the cost is applied at a dairy farm assuming that the use sexed semen on 20-25% of their herd. No benefit included.
Draining wet mineral soils	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: -€6.1M Scenario 1, (-€90 - 110 per Ha) • Notes: Net cost/benefit per Ha is calculated by dividing the total cost by 10% of total Ha of farming to give a rough average per a hectares for a farm (assumed 10% of wetland is drained, 2030Teagasc 2013)
Inclusion of clover in pasture swards/Multi-species swards	<ul style="list-style-type: none"> • Cost/Benefit Type: Reduction in Costs • Total Annual Net Benefit/Cost: €0.48M, (€1.30 to €1.50) Ha • Notes: Teagasc analysis the cost associated with this measure includes the cost of clover establishment (€12 per kg of seed sown, with 5 kg sown per ha) with savings associated with reduction in 17,400 tonnes N applied at €1.18 per kg N. The cost savings were shared with C sequestration from grasslands, as grass/clover pastures can sequester more C compared to Lolium-only pastures with a similar N fertilisation rate.

Source: Teagasc, KPMG analysis

Note: Each measure is defined as being a net benefit or costs which takes into account the net changes in costs/income for each measure

Assumptions & Limitations: Economics - Agricultural Measures

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
Nitrogen (N) use efficiency	<ul style="list-style-type: none"> • Cost/Benefit Type: Reduction in Costs • Total Annual Net Benefit/Cost: €9.51M Scenario 1 , €24.4M Scenario 2 - 4. (€20 - €25 per Ha) • Notes: Teagasc analysis assumes that of the two-thirds of grassland soil at sub-optimal pH, one third of this area (429,000 ha) would be brought to optimal pH conditions with the application of 7.5 t lime ha-1. Net benefit per Ha calculated by dividing the total net benefit by assumed update of 429,000 ha. Scenario 2 – 4 assumed greater uptake.
Switching N fertiliser formulation from CAN to protected urea	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: Scenario 1 -€4.2M, (-€12 to -€14 per Ha) • Notes: Teagasc analysis states the commercially available urease stabiliser-coated urea fertiliser retails at a similar price to CAN (€1.12 per kg N), the cost of this measure reflected the need to replace straight urea (€0.86 per kg N) with urea + NBPT.
Lower age of slaughter	<ul style="list-style-type: none"> • Cost/Benefit Type: Reduction in Income/Output • Total Annual Net Benefit/Cost: €20.1M Scenario 2 – 4, (-€15 to -€30 per animal) • Notes: Reduced average age of 51 days resulting in a decrease in both income/output and costs
Nitrogen (N) use efficiency	<ul style="list-style-type: none"> • Cost/Benefit Type: Reduction in Costs • Total Annual Net Benefit/Cost: €9.51M Scenario 1 , €24.4M Scenario 2 - 4. (€20 - €25 per Ha) • Notes: Teagasc analysis assumes that of the two-thirds of grassland soil at sub-optimal pH, one third of this area (429,000 ha) would be brought to optimal pH conditions with the application of 7.5 t lime ha-1. Net benefit per Ha calculated by dividing the total net benefit by assumed update of 429,000 ha. Scenario 2 – 4 assumed greater uptake.

Source: Teagasc, KPMG analysis

Note: Each measure is defined as having a net benefit or costs which takes into account the net changes in costs/income for each measure

Assumptions & Limitations: Economics - Agricultural Measures

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
3NOP	<ul style="list-style-type: none"> • Cost/Benefit Type: Increase in Costs • Total Annual Net Benefit/Cost: -€0.45M Scenario 2 – 4, , (-€25 to -€30 per animal) • Notes: The cost is modelled as -€25 to -€30 head-1 y-1 based off UK studies

Source: Teagasc, KPMG analysis

Note: Each measure is defined as having a net benefit or costs which takes into account the net changes in costs/income for each measure

Assumptions & Limitations: Economics - Energy Measures

A number of assumptions have been included and limitations identified in our scenario analysis.

Assumption / Limitation	
Increased Farm Energy Efficiency	<ul style="list-style-type: none"> • Cost/Benefit Type: Decrease in Costs • Total Annual Net Benefit/Cost: €160M • Notes: Teagasc analysis state an uptake was predicted to be 50% (plate coolers), 25% (VSD) and 12.5% (PV and heat recovery). We have assumed 30% of dairy farms will Increased farm energy efficiency. Payback was predicted to be 3 years (plate cooler) and, when used in combination with plate coolers, 15 years for VSD and >20 years for heat recovery and solar PV. Approximate capital costs are: plate coolers €2k, Variable speed drive €6k. <p>Source: Teagasc, KPMG analysis Note: Each measure is defined has being a net benefit or costs which takes into account the net changes in costs/income for each measure</p>
Economic impacts	<p>Output multipliers where adapted based on the following sources:</p> <ul style="list-style-type: none"> • Miller, A.C., Matthews, A., Donnellan, T., and O'Donoghue, C. (2011). Agriculture Food SAM (AgriFood SAM) for Ireland • CSO (2015) Input-Output Tables <p>Other data sources include:</p> <ul style="list-style-type: none"> • CSO (2021), DAFM (2021), Eurostat (2021), Teagasc (2019), IBISWorld (2021)



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