Rialtas na hÉireann
Government of Ireland

Spending Review 2020

Teagasc: Animal & Grassland Research and Innovation Programme

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Key Findings

Teagasc is a state agency that provides integrated research, advisory and training services for the agri-food sector in Ireland. The Animal & Grassland Research and Innovation Programme (AGRIP) is the largest Research Programme in Teagasc accounting for approximately 35% of the overall Research Budget of approximately €75 million per annum. Exchequer funding represents 60% of AGRIP funding while the remaining 40% is funded through external sources (20%), livestock income & farm operational receipts (13%) and commodity levies (7%).
The main objectives of AGRIP include:

- Increase the profitability and competitiveness of Irish animal production systems.
- Improve the environmental sustainability of Irish animal production systems.

This Spending Review examines the progress of AGRIP towards these objectives and their alignment with sectoral targets as set out in Food Wise 2025. The findings include:

- AGRIP objectives are broadly aligned with Food Wise 2025 and are generating technologies and practices for animal and grassland production systems that can contribute to aggregate output. Initiatives such as PastureBase and Grass 10 provide examples that align with Food Wise 2025 actions and how research findings can translate to on-farm implementation.
- AGRIP has provided evidence and identified technologies that can improve the productivity and competitiveness of farms, and many of the principles and technologies are transferrable across the sectors particularly in relation to grassland and breeding management. However, the asymmetrical trends between sectors remain with dairy consistently outperforming beef and sheep enterprises in terms of income. Within sectors there is also considerable variation in terms of profitability and likelihood of adopting new technologies. The Teagasc National Farm Survey Sustainability report shows that the most profitable farmers are more likely to adopt innovative technologies that are underpinned by research. The challenge remains to encourage the remaining farmers to engage with research content and to adopt new technologies. However, this does not negate the need to provide robust scientific evidence and develop technologies which falls within the remit of AGRIP.
- AGRIP has contributed to improving the environmental and sustainability performance indicators of Irish agriculture particularly in terms of unit efficiency. However, unit efficiency gains must be considered in the context of overall emissions and further progress will be needed, informed by research, to meet future targets in line with enhanced environmental ambitions.

Despite these achievements, a number of recommendations are identified including:

- Continue to liaise with DAFM to ensure alignment of research goals and policy objectives, particularly for the next Agri Food Strategy currently being developed.
- Ensure the principles set out by AGRIP continue to bolster the productivity of farms and that this evidence is disseminated and demonstrated to a wider audience to encourage adoption of innovative technologies particularly form less profitable sectors.
- Improve the measurement of environmental performance and develop low emission technologies to improve the sustainability of animal production systems. The interaction between AGRIP and the other Research Programmes offers one mechanism for accelerating progress in this area as demonstrated by the improvement in nitrogen use efficiency on grassland and anaerobic digester/biogas studies.

1. Introduction

Teagasc is a state agency that provides integrated research, advisory and training services to the agriculture and food industry and rural communities. The Teagasc mission is to support science-based innovation in the agri-food sector and wider bio-economy that will underpin profitability, competitiveness and sustainability. This is achieved through the close coupling of research and knowledge transfer in four programme areas, of which the Animal & Grassland Research and Innovation Programme, the focus of this Spending Review, is one.[1]

Each programme is composed of research, development and knowledge-transfer/industry-development departments. Research is conducted at seven dedicated locations, while knowledge transfer professionals are located throughout the country.

Principles of the Animal & Grassland Research and Innovation Programme (AGRIP)

Teagasc's vision for the AGRIP is that it would be an internationally recognised leader in animal and grassland research that produces new leading technology and models that drive the agri-food industry forward. AGRIP accounted for 35% of the Teagasc Research budget over the period 2013-2019 with an average annual budget of €23.7 million out of a total Research budget of approximately €75 million, which totalled to €166.3 million over this period. This amount was funded primarily through core exchequer funding (c. 62% per annum), although the share of funding has been reduced over these years as other sourced funding has increased through competitive research funds from state agencies and generated income.

The objectives of AGRIP are to:

- Increase the profitability and competitiveness of Irish animal production systems.
- Improve the environmental sustainability of Irish animal production systems through improved nutrient use efficiency and reduced greenhouse gas emissions.
- Enhance the quality and safety of Irish meat and milk products.
- Assist in the delivery of new technology to key stakeholders.
- Become a leading international science authority on technologies for pasture-based systems of animal production.
- Become a leading international science authority on animal improvement (dairy, beef and sheep) through breeding, genetics and genomics,

[1] https://www.teagasc.ie/about/research--innovation/research-programmes/

Objectives of the Spending Review

The Spending Review will focus on the objectives set out by Teagasc for the programme. It will determine the effectiveness of the existing programme to meet its intended objectives. Three research questions are central to this Spending Review. These are:

1. Does the existing programme align with Food Wise 2025 targets?
2. Does the programme increase profitability and competitiveness in Irish animal production systems?
3. Has the programme contributed to the environmental sustainability of farms involved the Teagasc programme?

The objective of the Spending Review is to address these questions by evaluating the current Animal & Grassland Research and Innovation Programme.

This paper is set out in sections as follows:

- Section 2 provides an overview of Teagasc followed by a description of the AGRIP.
- Section 3 provides an overview of the performance of AGRIP to date including an overview of some of the key research programmes and their results
- Section 4 presents the findings in relation to the research questions outlined above.
- Section 5 offers conclusions and recommendations.

Methodology and Limitations

This review followed the principles of the Spending Review process and focused on the success in achieving the AGRIP objectives. The research was desk based and led by the Economics and Planning Division within DAFM, with collaboration from the Teagasc and reviewed by interdepartmental colleagues and IGEES staff in DPER.

Demonstrating the impact from research programmes is widely recognised as a challenge, particularly for agricultural based research given the diversity of the agricultural sector. There is a large international literature (e.g Alston and Pardey, 1996; Alston et al., 1995; Alston et al. 2000; Evenson, 2001;) confirming that investment returns in agricultural science are high, indicating that the costs of public research investment are considerably outweighed by collective benefits. Causality is always a challenge but the first step is to identify the research activity that has generated the benefits. This will usually be a unique activity so causality is implied. Typically in these evaluations, conservative assumptions are made about adoption rates and costs. However, providing evidence of achievements is imperative considering the competition for resources at policy level (Midmore 2017). It is also important to distinguish the expected impact of a research programme and the subsequent impact on the sector. A research programme is tasked with generating

the evidence and new technologies to improve practices and to communicate these benefits. Specialist KT departments are part of AGRIP (and other Teagasc research programmes) and these link closely with, and support, the Teagasc advisory and education programmes. Notwithstanding this, many AGRIP researchers are heavily involved in dissemination and knowledge transfer to farmers.

Accordingly, this analysis was mainly descriptive to provide an overview of the existing programme and to collate the achievements to date in line with the objectives. Specifically, the funding structure and staff allocation for AGRIP was examined, the outputs in terms of publications, new technologies and wider contributions to policy was assimilated and discussed. This data was used to evaluate the results of the current programme in achieving the spending reviews stated objectives through desk-based analysis and to identify any other policy instruments that may help to progress the programme further.

The key data that was utilised in this analysis included:

- Published Teagasc reports including the National Farm Survey, the Sustainability Report and Internal Reports
- Other published reports and academic publications.

2. Context

Teagasc

Teagasc, the Agriculture and Food Development Authority, was established in 1988 as the national agency with overall responsibility for the provision of research, training and advisory services to the agriculture industry. It subsumed the training functions of the national advisory[2] and training body (ACOT) and the research functions of An Foras Talúntais (AFT)[3] replacing the previous two organisations. The three pillar approach of Teagasc operates on an annual budget of in excess of €160 million, employing 1,100 staff at 55 locations throughout the country, and serving approximately 45,000 Irish farmers (> 30% of all Irish farmers). The Research function of Teagasc commanded 53% of the total budget in 2019, with 35% accounted for under the Knowledge Transfer Directorate (Advisory Service 23% and Education 12%) and the remaining 11% accounted for under the Operations Directorate.

Teagasc's mandate states the principal functions of Teagasc shall be:

- To provide, or procure the provision of educational, training and advisory services in agriculture, including such educational, training or advisory services in agriculture as may be specified by the Minister for the purpose of giving effect to any directive, regulation or other act adopted by an institution of the European Communities.
- To obtain and make available to the agricultural industry the scientific and practical information in relation to agriculture required by it.
- To undertake, promote, encourage, assist, co-ordinate, facilitate and review agricultural research and development (including research and development in relation to food processing and the food processing industry)

Research

Teagasc is the leading organisation in the fields of agriculture and food research in Ireland, undertaking innovative research programmes in:

- Animal & Grassland Research and Innovation Programme (AGRIP)
- Crops, Environment and Land Use Programme (CELUP)
- Food Programme (FOOD)
- Rural Economy and Development Programme (REDP)

Teagasc collaborates extensively with colleagues in Irish universities. The post-graduate fellowship programme, which supports more than 200 MSc and PhD students annually in their research centres, enhances this collaboration. They

[2] https://www.teagasc.ie/about/our-organisation/teagasc-past---training/

[3] Growing Knowledge – Fifty Years of Research and Development in Irish farming and Food, 2008.

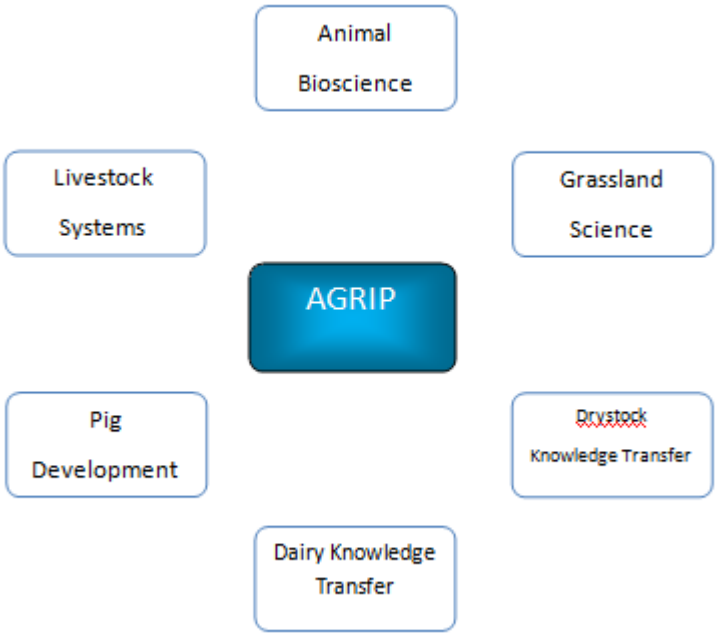
participate extensively in EU Framework Programmes and have developed bilateral agreements with research organisations in Europe, the USA and New Zealand.

The Irish economy in general, agricultural producers and consumers specifically, have benefited substantially from the technological development and new information emanating from research undertaken by Irish scientists from Teagasc's research programmes.[4]

Animal & Grassland Research and Innovation Programme

A key area of research for Teagasc is around the utilisation of grassland as a means to sustain the substantial livestock production in Ireland. AGRIP can be divided into three research departments and three knowledge transfer or development departments. The research departments include, Animal Bioscience, Grassland Science and Livestock Systems. Two departments are dedicated to Knowledge Transfer (Dairy Knowledge Transfer and Drystock Knowledge Transfer) and the other is the Pig Development Department.

Figure 1: AGRIP Departments



[4] www.teagasc.ie/about/research--innovation/

The Animal & Grassland Research and Innovation Programme takes place across the country, specifically, Athenry, Co. Galway, Grange, Dunsany, Co. Meath and Moorepark, Fermoy, Co. Cork.[5]

Staff

Staff numbers have marginally increased since 2013. The total number of AGRIP staff has grown from 293 to 325 from 2013 to 2019, representing an 11% growth. This also includes 100 Walsh Scholars [post graduate students][6]. In 2019, Research staff accounted for (167) 51% of the staffing, Knowledge Transfer staff account for (30) 9% and Support staff (technical, administrative and farm operatives) account for (128) 39%. The small increase in staff numbers is fully accounted for by contract staff (generally funded from external funding), and the number of permanent staff has declined slightly over the period. A breakdown is provided in Table 1 below.

Table 1. Staff at Programme Level (Full Time Equivalents)

	2013	2014	2015	2016	2017	2018	2019
Research Staff							
• Permanent Researcher	35	33	34	35	36	39	38
• Contract Researcher	19	18	16	11	11	12	15
• Post Doc Researcher	0	12	16	16	14	11	14
• Walsh Scholars	92	97	99	104	98	109	100
KT Specialist Staff							
• Specialist	23	23	22	16	14	16	16
• Advisers (Permanent)	0	0	0	8	6	7	7
• Advisers (Contract)	0	0	0	0	4	7	7
• KT Walsh Scholars	0	0	0	0	0	0	0
Support staff							
• Technologist Permanent	6	5	6	10	7	7	11
• Technologist Contract	0	0	0	0	5	5	4
• Technician Permanent	41	46	48	43	40	35	34
• Technician Contract	0	0	0.	0	13	11	10
• Admin	9	10	11	10	11	13	17
• Farm	68	66	61	60	53	56	52
Total Research & Specialist Staff (including Walsh Scholars)	293	310	313	313	312	328	325
Total Research & Specialist Staff (excluding Walsh Scholars)	201	213	214	209	214	219	225

[5] https://www.teagasc.ie/about/research--innovation/research-programmes/

[6] https://www.teagasc.ie/about/research--innovation/postgraduate-scholarships/walsh-scholarships--knowledge-transfer/

Programme Funding

The AGRIP has received the highest percentage of funding dedicated to research within Teagasc, on average from 2013 to 2019, as illustrated in Figure 2. The next most important is the FOOD programme, followed by the Crops, Environment and Land Use Programme (CELUP).

Figure 2: Teagasc Research Funding 2013-2019

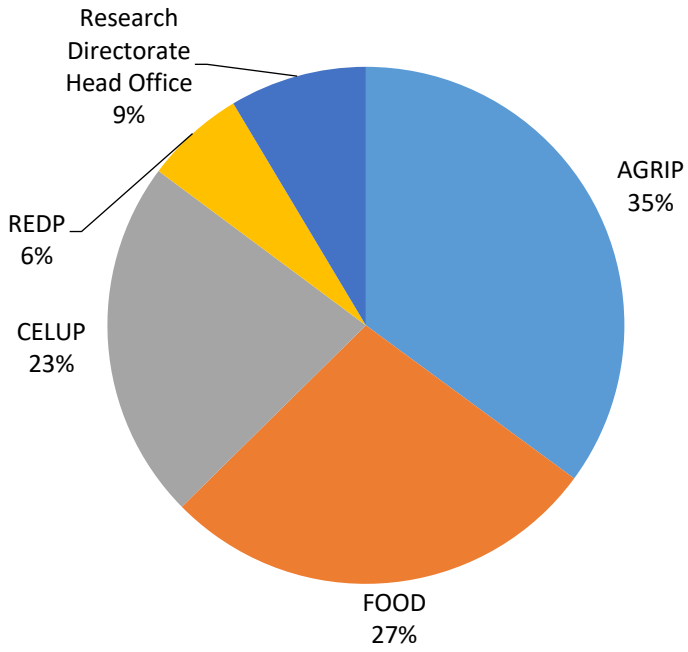


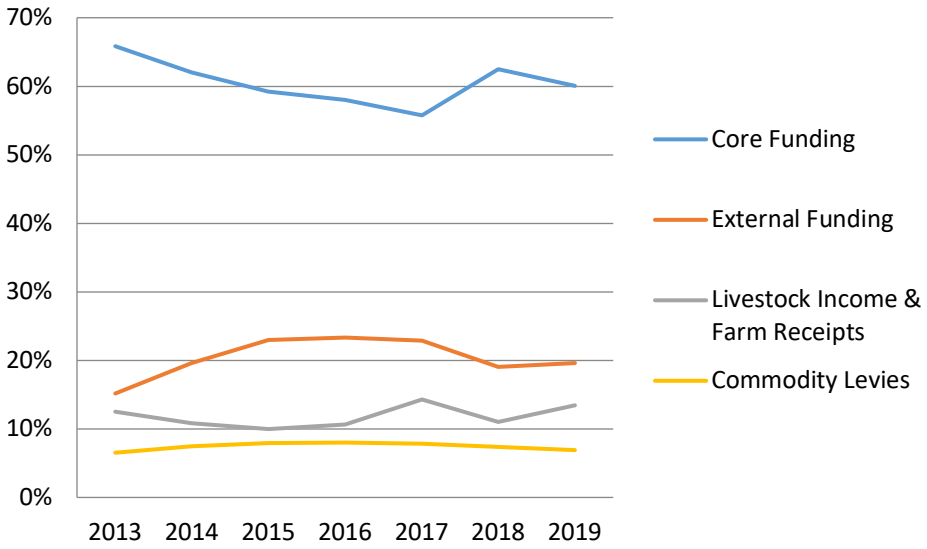
Table 2 summarises the internal and external funding and expenditure for the AGRIP over the last seven-years. The total budget has increased from €22,609,000 in 2013 to €25,742,000 in 2019. Total income increased from €7,723,000 in 2013 to €10,293,000 in 2019. Total income as a percentage of expenditure increased from 34% in 2013 to 40% in 2019. The level of external funding has increased significantly in recent years; increasing from €3.4 million in 2013 to €5.4 million in 2017.

Table 2: Funding (internal and external) and Expenditure: AGRIP							
	2013 €000	**2014 €000**	**2015 €000**	**2016 €000**	**2017 €000**	**2018 €000**	**2019 €000**
Total Budgeted (€)	22,689	21,685	22,854	23,637	23,937	24,288	24,858
Core Funding (% of total)	14,886 (66%)	14,132 (62%)	13,904 (59%)	13,403 (58%)	13,538 (57%)	15,722 (63%)	15,450 (60%)
External funding (% of total) *of which DAFM*	3,429 (15%) *650*	4,465 (20%) *1,940*	5,388 (23%) *3,063*	5,392 (23%) *2,804*	4,875 (20%) *2,265*	4,796 (19%) *1,446*	5,056 (20%) *1,010*
Livestock Income & Farm Operational Receipts (% of total)	2,819 (12%)	2,465 (11%)	2,344 (10%)	2,468 (11%)	3,656 (15%)	2,765 (11%)	3,452 (13%)
Commodity Levies (% of total)	1,475 (7%)	1,708 (8%)	1,856 (8%)	1,851 (8%)	1,903 (8%)	1,861 (7%)	1,784 (7%)
Total Outturn (€)	22,609	22,770	23,492	23,114	23,972	25,144	25,742
Budgeted/Outturn Variance +/(-)(€)	(80)	1,085	638	(523)	35	856	884
Pay Costs (% of total)	11,856 (52%)	11,681 (51%)	11,872 (51%)	11,816 (51%)	12,286 (51%)	12,635 (51%)	13,326 (52%)
Non-pay costs (% of total)	10,753 (48%)	11,089 (49%)	11,620 (49%)	11,298 (49%)	11,686 (49%)	12,509 (49%)	12,416 (48%)
Total Income (% of total expenditure)	**7,723 (34%)**	**8,638 (37%)**	**9,588 (40%)**	**9,711 (42%)**	**10,434 (44%)**	**9,420 (37%)**	**10,293 (40%)**

Notes: Core funding: funds provided directly from the state grant to Teagasc; External research grants: competitive funds received from national and international funding agencies (DAFM, EPA, SFI, FP7/Horizon 2020, etc.); Contracts: funds from third parties for specific research activities, e.g. industry, charities, etc; Other funding: includes laboratory analysis income, interest from property, legacies, etc. Income refers to "own" independently generated income from commodity levies, livestock income, farm operational receipts and external research funding.

Figure 3 shows the critical nature of the core funding as it ranges from 57% to 66%. While the proportion of core funding from the exchequer through DAFM has dipped slightly over time as other funding streams have increased, the importance of core funding to the AGRIP is highlighted in this chart.

Figure 3: AGRIP Funding Sources 2013-2019



3. AGRIP Developments

Business planning and programme assessment are part of the Business Planning and Performance Evaluation Unit. Peer assessments reports and associated action plans, International Scientific Advisory Board reports and the organisational level business plan all have to be approved by the Teagasc Authority. The C&AG 1999 report on Performance Measurement in Teagasc noted that there were some good examples in place of impact targets for some Teagasc objectives and that these should be developed upon. In light of this Teagasc established a Programme Evaluation Unit in 2003 to formalise and develop its evaluative capacity. The external and internal performance evaluation systems and associated governance structures established since then and described above, mean that a comprehensive suite of targets and indicators are now in place and reported on.

Teagasc also has an internal review system in place as part of its multi annual Statement of Strategy and associated annual Organisational Level Business Plan which form the basis of regular performance reviews between Teagasc and DAFM under the terms of the Oversight and Annual Performance Agreement, 2017-2020. As part of this Strategy a key element of the Monitoring and Evaluation system includes:

- Cyclical Peer Assessments of Research & KT Programmes, and Advisory Regions. Also, education programmes are evaluated in partnership with the Department of Education & Skills inspectorate.

As part of this, Teagasc has peer assessed its research activities as part of a wider process designed to ensure the scientific quality and relevance of its research programmes. The assessments, which are led by Teagasc's Evaluation Unit, are carried out by a panel of international and national peers. Since 2000, there have been 3 cycles of assessments of major research activities. In practice, this meant that research centres and more recently (since 2008) Research Programmes (including AGRIP) are peer assessed on an approximate five-year cycle.

The AGRIP was most recently peer reviewed in 2017.[7] The last peer review report concluded that "Some of the scientists are at the forefront of their field internationally, and accordingly some of the components of the programme are world leading, particularly those involving applied research, most notably that associated with production and/or profitability. The review team was impressed by the research and knowledge transfer activities communicated in the oral sessions as they relate to improved farm production and profitability".

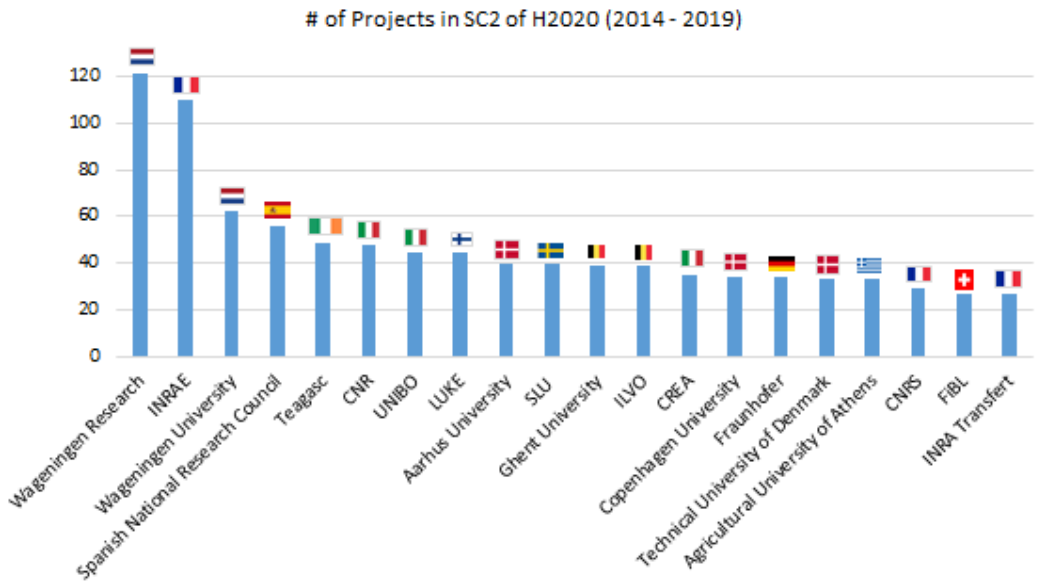
[7] https://www.teagasc.ie/media/website/publications/2019/Teagasc_AGRIP_Peer_Review_Report__Action_Plan_2017.pdf

Recent bibliometric analysis (see Annex 1) shows that for the period 2014-2018 in Agricultural, Dairy & Animal Sciences, Teagasc ranked 6th of all organisations across the EU by number of publications and 4th by number of citations. Over 20% of Teagasc documents are ranked in the top ten percentile for this category. Comparing to Irish universities, Teagasc ranks first by number of publications and also by number of citations. Over 20% of Teagasc articles in this category rank in the top 10 percentile for citations and Teagasc articles have the highest citation impact.

The number of scientific publications from the AGRIP has increased from 162 in 2014 to 230 in 2018; this is equivalent to an increase of 4.86 publications per full time research scientists to 6.12 in 2018. Additionally, the impact factor has increased from 2.29 in 2014 to 2.67 in 2018. It is worth noting that the number of citations the paper has received in other publications takes time to build up, and is therefore lowest in recent years as new papers are published as can be seen in Annex 1.

Teagasc secured €3.7 million funding for research from the European Commission's Horizon 2020 programme in 2019. In comparison with all other research organisations and universities across Europe, Teagasc is ranked 5th in terms of number of projects awarded in the agri-food stream of European funding since Horizon 2020 began in 2014 (see Figure 4).

Figure 4:



Examples of Research under AGRIP

There are a number of programmes under the remit of AGRIP that aim to develop innovative technologies that are problem-solving and that can contribute to farm level performance. The Research pillar is responsible for providing this evidence. In parallel, the advisory service is responsible for promoting and encouraging the uptake of the technologies and practices informed by the research findings. Confidence among Teagasc advisors, private advisors and farmers themselves in the validity of new technologies is strongly underpinned by the quality of the research which is within the remit of AGRIP. This forms the foundation in providing the evidence upon which new knowledge and technologies can be transferred to farm level.

For example, in collaboration with the ICBF on breeding indexes, controlled experiments conducted under the AGRIP programmes and the analysis of national databases confirm that higher index dairy, beef, and sheep confer an economic and environmental advantage. Advisors and farmers can absorb this evidence to inform their interactions and influence on-farm decision making. An overview of key programmes and outcomes to date are provided below.

Derrypatrick Herd:

The Teagasc Derrypatrick herd is a 100 suckler cow to beef research demonstration herd located in Grange. It is on 65ha with a stocking rate of 2.6 LU/ha. The primary objective of this herd is to evaluate alternative suckler calf-to-beef production systems. The calves from these sires are managed to slaughter in a 20 month heifer or 24-month steer production system. The aim of the study is to determine the effect of selecting high replacement sires in comparison to high terminal sires on animal performance and carcass output.

The current herd calving interval is 365 days, with a six week calving rate of 80%, producing 0.95 calves per year with a 100% of replacement calving at 23 to 26 months of age. Steers are slaughtered at 22 months of age, weighing 396 kg (R+3=), while heifers are slaughtered at 20 months weighing 327 kg (R=3=). The system is producing over 500 kg of carcass output/ha, achieving a gross margin/ha of over €1,000/ha using a base price of €3.75/kg carcass.

BETTER Beef Programme

The aim of the Teagasc-Farmers Journal BETTER Farm beef programme was to develop a road map for profitable beef production through improving technical efficiency within the farm gate. The BETTER farm programme demonstrated to farmers that there were three factors driving the profitability of their enterprise, namely farm gate price, production costs and animal performance/output. The programme ran from 2008 to 2019 (Phase 1 2008 to 2011; Phase 2 2012 to 2016; Phase 3 2016 to 2019).

Between 2008 and 2011 the 16 farmers participating in Phase 1 increased their gross margin by 118% and their output measured by kg/lu by 21%. Farmers participating in Phase 2 of the BETTER Farm Programme increased their gross margins by 53% increasing from €675/ha to €1,029/ha. The vast majority (83%) of gross margin improvements came from increased technical efficiency. Output measured by kg/lu increased by 12%. In Phase 3, gross margins on BETTER Farms increased by 30% and output measured by kg/lu increased by 17%.

Next Generation Herd:

The Next Generation Herd was established at Moorepark as a sentinel research herd to validate the performance of futuristic cows selected using Economic Breeding Index (EBI). It compared an ELITE high EBI group of cows representing the top 5% of cows nationally to the national average.

The performance of the two groups was in line with the difference in EBI. The six week pregnancy rate, end of breeding season pregnancy rates and surviving to fifth lactation were 73%, 93% and 59% of ELITE cows compared to 58%, 81% and 36% respectively for the national average. The profitability of the ELITE cows was €200/cow/lactation greater than the national average cows.

Maternal Herd

The Maternal Herd was established in 2012 to determine if the ICBF Replacement index is a useful tool in identifying cows with superior maternal performance. A herd of 120 maiden heifers were sourced from both the suckler herd and beef cross heifers from the dairy herd. Both these groups contained a sub-group of High and Low Replacement Index heifers. The High group consisted of heifers with 4 or 5 star ratings for the Replacement index while the Low group consisted of heifers with 1 or 2 star ratings.

The results showed large differences between High and Low rated cows on key performance traits such as calf mortality, milk yield, reproductive performance and cow survival. Economic analysis showed an advantage of €110 per year in favour of the higher rated cows.

The INZAC Flock

The INZAC flock was established in 2015 with the dual objective of validating the national maternal index for sheep and secondly to evaluate the compatibility of ewes with high genetic merit imported from New Zealand to Irish grass based production systems. The results showed that the imported animals performed best, especially in relation to traits for health, survival and labour requirements. These genetics are now being incorporated into the Irish breeding programme.

Dairy Calf-to-Beef

The expanding Irish dairy herd means a greater proportion of slaughtered cattle are originating from dairy herds. A study was set up in Teagasc Grange in 2017 comparing the physical and financial performance of three dairy-beef genotype groups, within an efficient grass-based production system these groups consist of male Holstein-Friesens, sired by the top four EBI bulls and two Angus groups, sired by bulls of divert genetic merit for carcass weight and conformation.

The results of the first year of the study showed that dairy-beef systems are high-output grass-based systems, capable of producing in excess of 950 kg of carcass/ha, at slaughter ages of 22 and 23 months for Angus and Holstein-Friesen genotypes respectively. The relative profitability of the three genetic groups is largely dependent on calf purchase price differences. High animal performance from pasture over a long grazing season plus the conservation of high quality silage is critical in optimising the financial performance of the system. This study has developed a blue-print for efficient grass-based dairy-beef systems.

VistaMilk

VistaMilk is a Science Foundation Ireland and DAFM-funded Research Centre hosted by Teagasc Moorepark in partnership with the Tyndall National Institute, Ireland's National Microelectronics Institute, the Telecommunications Software & Systems Group (TSSG) at Waterford Institute of Technology, and the Insight Centre for Data Analytic, including leading Irish/multinational food and ICT companies. The €43m centre, which includes a contribution of €13.6m from industry facilitates a team of over 200 scientists and aims to be an agent of growth for the Irish dairy industry by being a world leader in fundamental and translational research for precision pasture-based dairying. Launched in October 2018, VistaMilk brings together the scientific and IT communities to successfully promote dairy foods and drinks both in Ireland and internationally.

Internationally, the advances developed in the centre will apply to dairy systems in many countries and will be a catalyst for global growth in the Agri-Tech sector. The vision of the VistaMilk Centre is to be a world leader in the Agri-Food technology sector through innovation and enhanced sustainability across the dairy supply chain, positively impacting the environment, animal well-being and the health of consumers. This will be achieved by greatly improving the biological performance of the animals thereby improving resource efficiency, better meeting consumers' expectations and improving profitability and resilience. To achieve the vision for the centre, the resources, capabilities and expertise of the partners will be brought together, to create new innovation opportunities at the interface between Agri-Food and ICT. It will link the Irish Agri-Food industry with Ireland's leading technology research institutes in a large-scale innovation ecosystem.

The future work planned in the animal breeding component of the VistaMilk Centre is based on the results from DAFM funded projects, with the ongoing objective to develop precision genomics using state-of-the-art technologies and is an example of the impact achieved from the DAFM programmes (primarily RSF in this case). While it is too early to measure the impact of VistaMilk, the involvement of 40 industry partners is a significant validation of its potential impact.

Mastitis

CellCheck is the national mastitis control programme, coordinated and facilitated by Animal Health Ireland (AHI). AGRIP provides support to the CellCheck programme in partnership with industry bodies representing farmers, processors, service providers and government. Specifically, AGRIP provides support for the technical working group, developing the Cost Check Economic Calculator and supporting a programme on Selective Dry Cow Therapy, while also liaising with their KT colleagues to support farm-level supports. The goal of the CellCheck programme was that 75% of milk supplied by Irish farmers will have a somatic cell count (SCC)[8] of 200,000 cells/ml or less by 2020. Bulk tank SCC from the Irish national database has shown an increase in the proportion of both herds (from 39% to 66%) and milk volume (from 46% to 68%) with an annual average SCC <200000 cells/mL between 2013 and 2019. Sale of antimicrobial intramammary for lactating cow use has reduced significantly (More *et al.,* 2017). This initiative has been instrumental in the promotion of selective dry cow treatment at farm level to reduce antimicrobial resistance.

Trichloromethane (TCM)

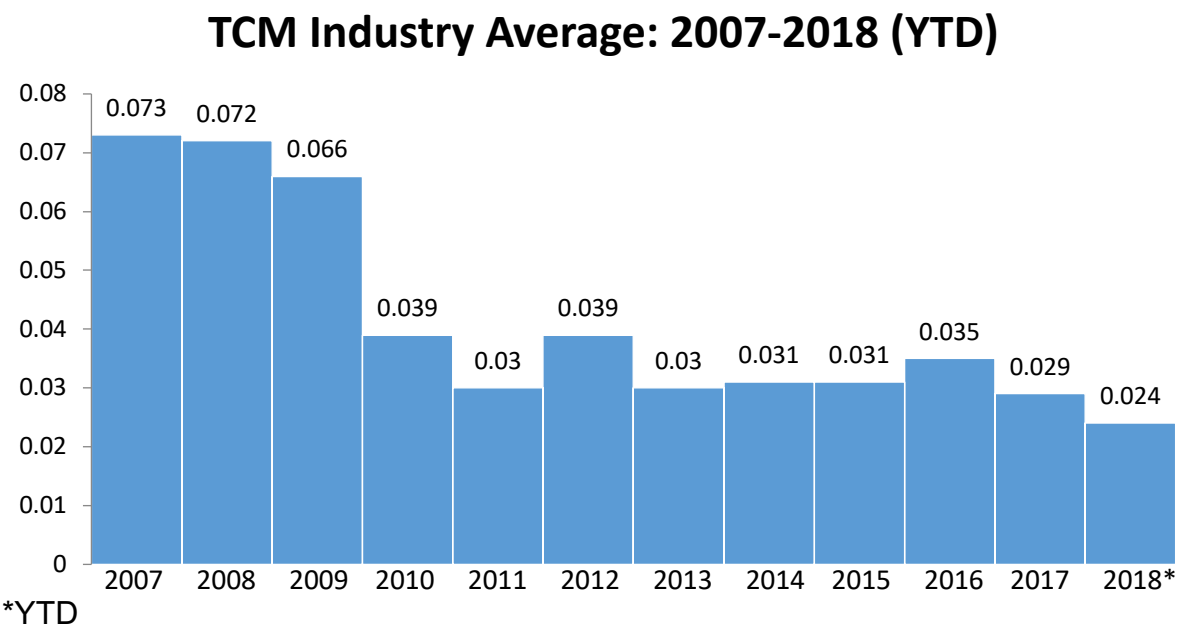
Teagasc/AGRIP has supported the Irish dairy industry in reducing the level of Trichloromethane (TCM)[9] in Irish butter over the last 10-years. In 2007, some consumer data information emerged which indicated that TCM levels were higher in some Irish butters than other competing butters in the market. Teagasc/AGRIP was approached by the dairy industry to develop a programme to reduce the levels.

The outcome from the programme has resulted in a reduction of TCM in butter from 0.073 mg/kg in 2007 to 0.021 mg/kg in 2019; the target level is <0.03mg/kg. The research identified the main reason for the high levels of TCM were the over use of chlorine in the cleaning of milking equipment. New milking protocols were developed by Teagasc/AGRIP and a list of approved cleaning and disinfection products that can be used for the cleaning of milking equipment and provided a list of suitable

[8] SCC is a measure of subclinical infection in a herd
https://www.teagasc.ie/media/website/animals/dairy/MilkQandMastitis.pdf
[9] TCM is a measure of chemical residues left in milk
https://www.teagasc.ie/media/website/animals/dairy/ResiduesMilk.pdf

detergents see here[10]. Additionally, Teagasc/AGRIP provides an on-going service to the dairy industry for the analysis of milk samples for TCM (over 35,000 in 2019). The dairy industry supports the costs of the analysis. See Figure 5 below to show the significant progress that has been achieved towards the target of below 0.028.

Figure 5



*YTD

Grass-fed dairy products

It is estimated that 10% of the global bovine milk supply is derived from pasture-based feeding systems. There has been a recent surge in the availability of "Grass-fed" dairy products, often commanding a premium price. Recent research has shown that the typical Irish cow diet is composed primarily of pasture, accounting for 96% of the diet on a fresh matter basis and 82% on a dry matter basis (O'Brien *et al.,* 2018). This has the potential for Irish dairy manufacturers to capitalize on recent consumer trends for healthier more natural food products.

Teagasc/AGRIP in collaboration with Teagasc/FOOD Programme compare milk and dairy products derived from cows fed pasture versus indoor total mixed ration diets. Pasture derived dairy products had a significantly higher concentrations of Omega-3 fatty acids, CLA, ß-carotene and other beneficial nutrients; better appearance, flavour and sensory credentials. This is important in the promotion of Irish dairy products as being of high quality and nutritionally superior[11]. This work has underpinned the development and recent launch of a new Grass-fed standard for Irish milk by Bord Bia.

[10] https://www.teagasc.ie/animals/dairy/milk-quality/chlorates/

[11] (Proceedings of the Grass-Fed Dairy Conference, https://www.teagasc.ie/media/website/publications/2018/Grass-Fed-Dairy-Conference-Proceedings-2018.pdf)

4. Findings

RQ 1 - Does the existing programme align with Food Wise 2025 targets?

Food Wise 2025 provides an ambitious vision for the development of Irish agriculture, and outlines the manner in which the sector can be supported to achieve its aspirations for 2025 and beyond. Sustainable grass-based production systems and a favourable animal health status are recognised as strengths which must be enhanced, while addressing challenges such as greenhouse gas and air emission targets, biodiversity loss and reduced water quality.

The progress of the various Food Wise 2025 actions mirror the developments of AGRIP. As of Q4 2019, 376 of the Food Wise 2025 actions were active, with 87% of them classed as Target Achieved or Substantial Action Undertaken and the remaining 13% Commenced or Progressing. Furthermore, Food Wise 2025 set a series of aspirations, such as 'increasing agri-food exports value by 85% to €19 billion". As of 2019 Irish agri-food exports have grown from €11.5 billion to over €14.5 billion as shown in the Table 3 below.

Table 3 below shows the value of Irish Agricultural Exports 2014 to 2019 for the most relevant agri-food categories, with the largest accruing in dairy products. The Irish agri-food sector is a significant contributor to growth in economic activity across the rural Irish economy supporting jobs in farming, processing/distribution, export marketing and research. Crucially, in terms of Irish economy impact, every €1 of exports of dairy/meat products represents €0.90 spend within the Irish economy.[12] Many of the actions identified in both Food Harvest 2020 and Food Wise 2025 were the responsibility of Teagasc/AGRIP to deliver and can be found in Annex 2.

Table 3: Irish Agricultural Exports 2014 to 2019

	2014	**2015**	**2016**	**2017**	**2018**	**2019**
	€000,000	€000,000	€000,000	€000,000	€000,000	€000,000
Dairy Produce	3,815	3,884	3,991	4,673	4,587	5,040
Beef	2,131	2,209	2,268	2,403	2,435	2,349
Pigmeat	604	670	734	794	828	891
Sheepmeat	208	242	277	310	316	318
Total	11,515	12,205	12,473	13,846	13,705	14,530

Source: Central Statistics Office, Trade Statistics 2015-2019.

[12] https://www.teagasc.ie/media/website/publications/2019/Dairy-in-the-Irish-economy.pdf

Alignment of the AGRIP with Food Wise 2025

The research, education and knowledge transfer activities of the AGRIP play critical roles in making this vision a reality. Teagasc is one of the key knowledge providers among others for Ireland's agri-food sector. The AGRIP is one of four operational programmes that comprise the Teagasc research directorate, and each programme also includes a knowledge transfer component. The AGRIP is a significant component of Teagasc's support for science-based innovation to underpin profitability, competitiveness and sustainability.

AGRIP is comprised of six departments, two of which specifically highlight achieving the goals as outlined by Food Wise 2025 as one of their key objectives, and the other departments objectives directly align with the goals of Food Wise 2025. Teagasc outlines the 7 objectives of AGRIP as the following list. All of which directly or indirectly align with the actions of Food Wise 2025;

1. To increase the profitability and competitiveness of Irish animal production systems. Actions under the Competitiveness theme (Actions 122, 123, 124, 125 and 143) of the Food Wise 2025 strategy directly correlate to this objective.

2. To improve the environmental sustainability of Irish animal production systems through improved nutrient use efficiency and reduced greenhouse gas emissions. Actions under the Environmental Sustainability theme (Actions 7, 8, 9, 10, 15, 25, 28, 29, 31, 32, 34 and 412) of the Food Wise 2025 Strategy directly correlate to this objective.

3. To enhance the quality and safety of Irish meat and milk products. Sectoral actions such as some of those coming under Dairy (Action 219), and Beef (Actions 224, 227, 248, 253 and 254) of the Food Wise 2025 Strategy directly correlate to this objective.

4. To assist in the delivery of new technology to key stakeholders. Actions under the Innovation theme (Actions 185, 186, 197, 420 and 421) of the Food Wise 2025 Strategy directly correlate to this objective.

5. To become a leading international science authority on technologies for pasture-based animal production. Actions 34, 124 and 125 of the Food Wise 2025 Strategy directly correlate to this objective.

6. To become a leading international science authority on animal improvement (cattle and sheep) through breeding, genetics and genomics. Actions include 123, 209, 227, 228, 229, 263 and 267 of the Food Wise 2025 Strategy directly correlate to this objective.

7. To contribute to the achievement of the targets set out in Food Wise 2025.

To illustrate the links between FW targets and AGRIP some core examples are provided below.

Action 124, '*Teagasc, and other research providers to develop measures such as improved grazing management practices, increase soil fertility and sward renewal to increase grass utilisation by 2t/ha on livestock farms'* is an ongoing action that will run for the length of the Food Wise 2025 agri-food strategy. The PasureBase application and Grass 10 multi-year campaign (2017-2020) were launched to help achieve this action.

PastureBase Ireland

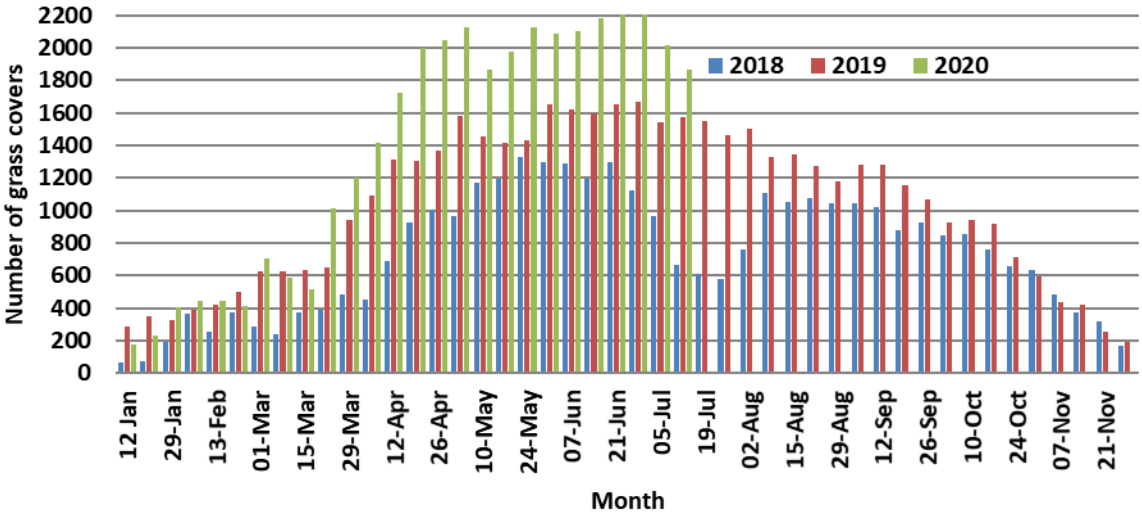
Teagasc/ AGRIP developed PastureBase Ireland (PBI) to promote greater adoption of best grazing management practices at farm level (Hanrahan *et al.* 2017). It is a web-based grassland management application for all grassland farmers incorporating a dual function of a grassland management decision support tool and a centralised national database to collate commercial farm grassland information. PBI is offered to all Teagasc advisory clients and it also stores a vast quantity of data from grass-based production systems in a central database. A number of tools are available under the system including:

- the grass wedge
- spring and autumn rotation planners
- feed budgets
- fertiliser/slurry applications and
- reseed records.

More recent developments include the projected wedge, the weekly grazing planner, offline app, invitation/group section and connecting with all milk processors along with improving performance issues. The Grass Growth Model has also been developed based on validated data from 70 farms which can be used as a predictive tool to help farmers make decisions for grassland practices.

Figure 6 shows the usage of PBI over that last three years; the number of grassland farmers that completed a grass covers to the 1st of June 2020 was 3,168 compared to 2,109 in 2018. From the 19th of April to the 12th of July 2020 there were over 2,000 grass covers being completely weekly on PBI. It is hoped that the number will increase significantly over the coming years.

Figure 6: Number of Grass Covers Weekly



The grazing management recommendation used in PBI is underpinned by grassland research carried by Teagasc/AGRIP over a number of years. This software allows grassland farmers to benchmark themselves against comparable farmers in terms of grassland management, increasing the adoption of best practices resulting in increased grass utilization at farm level (Hanrahan *et al.,* 2018).The level of grass measurement on grassland farms has increase significantly in recent years using PBI in recent years; almost 1,500 grassland farmers performed greater than 15 measurements in 2019. Using data from the Irish National Farm Survey grass utilisation on Irish dairy farms has increased from 6,728 kg DM/ha (dry matter per hectare) in 2008 to 7,796 in 2015; this was associated with an increase in whole farm stocking rate from 1.71 LU/ha to 1.93 LU/ha (Hanrahan *et al.* 2018).

Grass 10

Ireland has a natural advantage over many other livestock producing counties due to it geography location and deep fertile soils. Ireland's cool temperate oceanic climate allows for one of the longest grass growing seasons along with its mild climate allowing animals to graze for the majority of the year. Teagasc believe that Ireland's successful grass-based diet for cattle and sheep can be further enhanced through a campaign called Grass 10. Grass 10 is a Teagasc-led four year campaign (2017-2020) to increase grass utilisation on Irish livestock farms with the objective of achieving 10t grass DM/ha/year utilised and 10 grazings/paddocks/year[13].

[13] Grass10 - Teagasc | Agriculture and Food Development Authority.

This objective can be broadly met through the delivery of a range of activates in four broad areas:

1. delivering best practice,
2. building awareness
3. building capacity and
4. setting standards.

The Grass 10 Programme is delivered by a team of four grassland specialists; one of which is supported by Teagasc and the remaining three financially supported by industry stakeholders. One of their three roles is to provide training to participants. They encourage and support participants to use the PastureBase system to improve decision making on grassland management at farm level. Participants can use this data to compare against peers and to benchmark their own progress over time. Teagasc NFS data has shown that advisory clients have displayed better utilisation than non-clients. Improved grass utilisation reduces input costs which in turn improve profitability. Teagasc analysis has indicated that net profit per hectare has increased by €181/ha for each additional tonne of grass DM utilised on Irish dairy farms, with the figure for drystock farms being in the region of €105/ha. Based on these figures, Teagasc estimates that increasing grass utilisation by 1 tonne DM/ha on all dairy farms would yield an annual economic dividend of €145 million, while achieving a similar improvement on dry stock farms would yield an annual economic dividend of €384 million.

PastureBase and Grass 10 are also driven by a number of other Food Wise 2025 actions, including actions 28, 29, 31, 32, 34, 75, 124, 125, 185, 205, 206, 207, 232, 253 and 420.

Action 15, '*Improve knowledge transfer and exchange to farmers by developing a network across all State Agencies and relevant advisory bodies to deliver clear, coordinated science-based advice on how farmers can adopt sustainable practices that deliver both environmental and economic benefits'* comes under the theme of Sustainability actions. Teagasc launched the ConnectEd Programme in 2015, which is designed to create stronger linkages between Teagasc and businesses that support the agri-food sector.

ConnectEd

The programme seeks to develop networking opportunities for different professions, while at the same time providing high quality professional development opportunities. ConnectEd offers a structured platform for member interaction, including:

• ConnectEd eZine
• Periodic local and national networking events
• Regional seminars
• Social media group communication.

ASSAP

By the end of 2019, Teagasc had also conducted 1,335 farm assessments and developed associated farm plans under the Agricultural Sustainability Support and Advise Programme (ASSAP). The ASSAP advisors work in tandem with the Local Authorities Water Programme on 190 priority areas for actions to mitigate losses to waters focusing on:

- Land management and pesticides
- Nutrient management
- Farmyards.

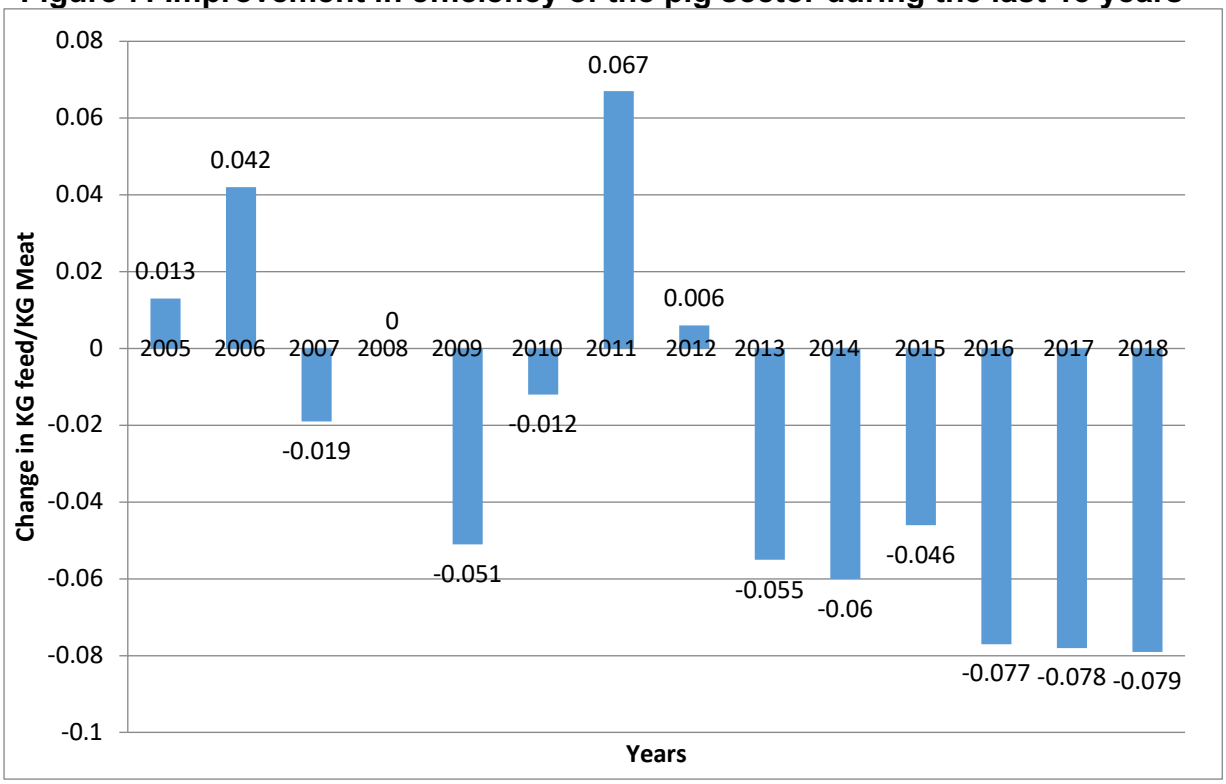
The farm assessment and farm plans are integral parts of the knowledge exchange and will be followed up with regular contact to encourage uptake and monitor impact. Advisors have begun this follow up process of re-visiting farms with 112 second visits conducted by mid 2020.[14] Advisers are now including additional co-benefits in their advice to improve water quality such as biodiversity and gaseous emissions.
Through collaboration with Agricultural Consultants Association, Teagasc also provided various training programmes such as, training on the mitigation of GHG emissions in agriculture and other environmental challenges. Although AGRIP does not directly fund ASSAP it illustrates the interwoven nature of the programmes of Teagasc.

Improvement in productivity in the Irish pig sector

Annex 3 Table 7 shows the evolution of technical indicators and costs for the Irish pig industry 2014 to 2018. The Irish pig sector includes a reduced number of commercial farms (<300) with great potential for fast improvement if clear coordinated scientific KT is implemented. After the establishment of the pig levy in 2013, Teagasc has coordinated the different activities developed in the pig sector together with DAFM and Animal Health Ireland. The coordination of a small network of stakeholders and the use of secondary data combined with performance data to target advice has resulted in faster improvement than expected in the last 5 years. The constant improvement in production efficiency obtained in the last 5 years is shown in Figure 7. This improvement in efficiency has been parallel to reductions in antimicrobial usage, adjustments in feed formulation (reductions in protein levels) and improvements and herd health, all contributing to higher sustainability of the Irish pig herd.

[14] Covid 19 restrictions have meant follow ups have being mainly by phone

Figure 7: Improvement in efficiency of the pig sector during the last 15 years



Action 123, *Improve the use of genomic technologies and better breeding to improve the sustainability of the National herd, including by:*

- *Increasing the level of data recording at farm level.*

- *Increasing the level of genotyping across the national herd to allow for robust, genomics based breeding indexes.*

- *Application of commercially focused breeding indices and sexed semen to increase the beef characteristics of the increased output from the dairy herd and thereby ensuring these animals best meet market specifications.*

Beef and Sheep Index

AGRIP researchers developed the statistical models used in the national genetic evaluations for almost all the traits within the dairy, beef and sheep indexes. Teagasc/AGRIP in collaboration with the ICBF led the development of the lowest cost DNA platform globally which is now used in the national genomic evaluations for cattle and sheep. In May 2020, ICBF announced the passing of a significant milestone with over 2 million cattle in Ireland having a valid genotype, an increase of 1 million in just 3 years.[15] The backend of the sire advice decision support web-service tool deployed by the ICBF for dairy cattle was developed by AGRIP, and a

[15] https://www.icbf.com/wp/?p=15922

dairy-beef sire advice system is currently being built for deployment in 2021. The COW index was developed by Teagasc/AGRIP with the BOW (to aid the sale of calves) which was developed by Teagasc now being deployed and a beef COW under construction at Teagasc.

Sexed Semen

Sexed semen provides many potential advantages to dairy farmers. The most obvious and compelling reason to use sexed semen is because of the sex bias induced in the calf crop, with 90% of the pregnancies resulting in a heifer birth, and only 10% male dairy calves. This in turn means that more beef semen can be used, using bulls with high Dairy Beef Index. This will increase the long term economic and environmental sustainability for the Irish Dairy Industry.[16]

Genomics has revolutionised the cattle breeding industry in Ireland and globally over the past number of years. Through genotyping, significant genetic gain can be achieved, animals' potential can be determined earlier and more accurately, and new, economically important traits can be identified. Despite the profitability and environmental challenges that are now ever-present, Irish farmers have been proactively involved in schemes and pilot programmes such as the Beef Data Genomics Programme (BDGP), DNA Calf Registration and Greenbreed. As a result, the ICBF database now holds over 1.85 million valid genotypes for beef cattle, the largest beef genotype database in the world.[17]AGRIP's research in genetics is further discussed in Research Question 3.

Similarly, Food Wise 2025 actions 75, 76, 185, 186, 197, 239, 263, 267, 270 and 420 all also drive research into the genetics of livestock.

Therefore, there is evidence of alignment between the actions and aspirations of Food Wise 2025 and the principles, objectives and actions of AGRIP and the technologies developed are contributing to sector targets. It is imperative that research objectives continue to align with policy goals, and the development of the next Agri-Food Strategy for the Irish agriculture sector provides an opportunity to recalibrate these goals to ensure that continued cooperation between Teagasc and DAFM.

[16] https://www.teagasc.ie/publications/2020/how-to-improve-likelihood-of-success-with-sexed-semen-in-2020.php

[17] https://www.icbf.com/wp/?p=15922

RQ 2 - Does the programme increase profitability and competitiveness in Irish animal production systems?

AGRIP identifies increasing profitability and competitiveness of Irish animal production systems as their primary objective. Teagasc has a suite of key practice adoption indicators as part of its Level 1 Organisational Business Plan which is approved by the Teagasc Authority, and forms the basis of the agreed programme and regular reviews between Teagasc and DAFM under the terms of the Oversight and Annual Performance Agreement 2017-2020. These measures include:

- The Economic Breeding Index (EBI)[18]
- Grass Utilisation
- Fat and Protein Content
- Compact Calving
- Somatic Cell Count
- Suckler Cow Replacement Index
- Calving Age and Interval
- Participation in Sheep Ireland and
- Increase in Recorded Rams.

The AGRIP identifies the KPI's to be used by Teagasc Knowledge Transfer and Education programmes to increase their adoption at farm level. Increased adoption of these measures will help to improve productivity, which in turn bolsters competitiveness and ultimately profitability. Other factors such as market prices and inclement weather also influence profitability and are beyond the scope of AGRIP.

In terms of output metrics, ICBF data shows that over the period 2010 to 2018:

- the EBI of the Irish dairy herd has increased from €17 to €96[19]
- the 6-week calving has improved from 52% to 64%
- the proportion of cows calving in the January/April period has increased from 79% to 84%.

CSO (2020) data shows that:

- milk yield per cow has increased from 4,980 litres (3.85% fat and 3.37% protein to 5,316 litres (4.14% fat and 3.48% protein).

Hanrahan et al. (2018) found that:

- grass utilisation at farm level had increased from 6,728 kg DM/ha in 2008 to 7,796 kg DM/ha in 2015.

[18] EBI is a single figure profit index aimed at helping farmers identify the most profitable bulls and cows for breeding dairy herd replacements. It comprises of information on seven sub-indexes related to profitable milk production. These are; (1) Milk production, (2) Fertility, (3) Calving performance, (4) Beef Carcass (5) Cow Maintenance (6) Cow Management and (7) Health.

[19] https://www.icbf.com/wp/?p=12466

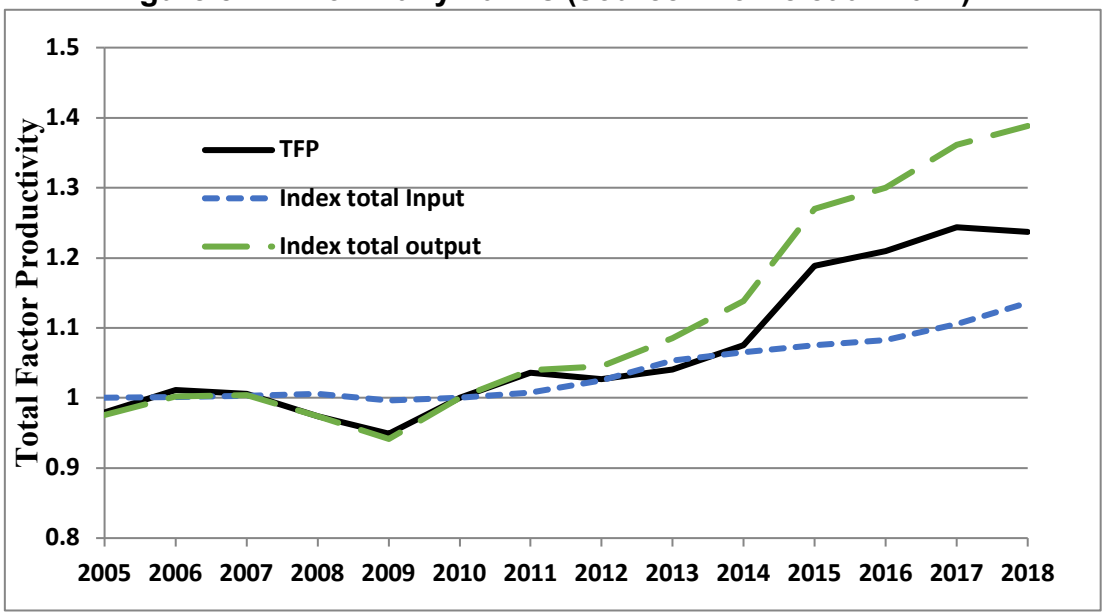
These developments can be best demonstrated in the Irish national dairy herd The EBI of the national dairy herd EBI increased an average of €9 per year. Ramsbottom et al. (2012) showed at farm level that each one unit increase in EBI resulted in an increase of €1.94 in net margin per cow. In addition, milk solids production per cow increased by over 5kg per year over this period on average. Dillon et al. (2018) also reported that herd fertility also improved over the period with:

- mean calving interval reduced from 391 days to 381 days,
- pregnancy rate to first service increased from 46% to 54%,
- 6-week calving rate increased from 61% to 72%,
- mean calving dates reduced from the 11th to the 3rd of March, and
- the proportion of cows calving in the months of January to April has increased from 74% in 2008 to 84% in 2018.

Figure 8 below highlights the total factor productivity (TFP) achieved for dairy farms. A TFP index of 1 indicates no productivity change, a level below one suggests regression and an index above one indicates progress. The trend illustrates that dairy farm productivity has increased over the period. Improvements in technologies and practices developed through AGRIP are likely to have contributed to this trend with the more efficient farmers more likely to adopt new technologies. Thorne *et al.* (2017) showed that Irish specialist dairy farms had the second lowest cash costs (all costs excluding depreciation and imputed opportunity costs for family labour, equity capital and owned land) per kg of milk solids in the EU.

McCormack *et al.* (2018) supported these findings finding that TFP on specialist dairy farms increased by 24% over the period 2010 to 2018. This paper used Teagasc National Farm Survey data and noted the contribution of new knowledge and technological progress, institutional and regulatory change and structural change at farm level as the three broad categories that contributed to TFP. While the abolition of EU milk quotas in 2015 and the structural change at farm level with herd increases enabled dairy farmers to increase their scale, it is widely accepted that these factors alone will not lead to an increase in TFP without the application of new knowledge and progress in parallel. The adoption of technologies in relation to dairy cow genetics and pasture management are key in increasing the productivity of pasture-based systems of milk production (Kelly et al. 2020).

Figure 8: TFP on Dairy Farms (source Thorne et al. 2017)[20]



In terms of international comparisons, Boyle et al., (1992): Boyle, (2002): Donnellan et al., (2011) and Thorne et al.,(2017) have all shown that Irish dairy farms cash costs as a percentage of market based output are one of the lowest in the EU. The most recent study carried out by Hennessy and Thorne (2020), based on representative Farm Accountancy Data Network data, shows that the average net margin (excluding owned labour) in Ireland over the period 2014 to 2017 was €0.08/l. The corresponding figures for Denmark, Germany, France, the Netherlands and the UK being -€0.01/l, €0.027/l, €0.025/l, €0.036/l and €0.046/l, respectively. With the lowest milk price across the countries, Irelands net margin was still at least 43% higher per litre when compared to the next nearest country in relation to net margin (UK). When compared against the Netherlands (which had the highest milk price), the Irish net margin was over over double what was achieved. The corresponding costs of production (excluding owned labour) were €0.38/l, €0.35/l, €0.33/l, €0.32/l €0.30/ and €0.24/l in Denmark, The Netherlands, France, Germany, The UK and Ireland, respectively. This low cost of production is achieved even though milk production in Ireland increased by over 50% while milk production in other EU countries increased on average by less than 12%.

Table 4 below shows the combined annual milk fat and milk protein content 2014-2018. This level of growth in milk composition (3.5%) is impressive when considered against the growth in the main EU milk producing countries. The milk fat and protein composition of Northern Ireland milk is much inferior and it's not increasing at the rate in southern Ireland. Ireland shows year-on-year growth in milk composition and its level of growth in milk composition is largest. The levels of milk composition in

[20] Thorne et al 2017

Ireland are now approaching the top end in this group and the gap with Denmark and the Netherlands has narrowed considerably. This is a reflection of the significant increase in the EBI of the national herd as well as improved grassland management.

Table 4. Combined annual Milk Fat and Milk Protein content 2014-2018

	2014	***2015***	***2016***	***2017***	***2018***	***% increase 2014 - 2018***
Ireland	7.42	7.53	7.55	7.65	7.68	3.50
N Ireland	7.22	7.23	7.23	7.27	7.31	1.24
Belgium	7.42	7.47	7.49	7.54	7.54	1.62
Denmark	7.74	7.70	7.87	7.81	7.81	0.90
Germany	7.49	7.50	7.74	7.73	7.74	3.34
France	7.33	7.36	7.37	7.44	7.40	0.95
Netherlands	7.85	7.90	7.94	7.93	7.92	0.89
Poland	7.19	7.20	N/A	7.23	7.21	0.28

Source Eurostat

Many principles identified in the dairy herd are largely transferrable to the beef and sheep sector, which also rely on efficient breeding and grassland management to improve productivity. The structure of cattle systems has also changed over time with suckler cow numbers reducing by approximately 17% over the period 2000 to 2019 while dairy cow numbers have increased by 22% over the same period. This has resulted in a greater proportion of beef coming from the dairy herd, which may increase further in the coming years. This will result in greater integration between the dairy and beef sectors and also greater alignment of technologies including genetics and grazing management practices. Notwithstanding these developments the trends in profitability for Irish agriculture vary significantly by sector.

Farm Profitability

According to the Teagasc Annual Review and Outlook in 2019, estimated average family farm income for 2019 is €24,900, up 7% on 2018. In 2019 there was a reduction in feed costs on dairy, beef and sheep farms (again following the adverse weather conditions in 2018), as well as additional supports channelled to cattle producers to alleviate the effects of falling beef prices. However, this conceals differences across the various farm types:

- Dairy farms account for about 18% (16,146 farms represented) of the 92,720 farms represented by the NFS. Average dairy farm income increased by 14% to €70,200. This was driven by a rise in the volume of milk produced, despite a slight drop in milk price.
- Estimated average income on cattle rearing farms (25,781 farms represented) increased by less than 11% to €9,200.
- Average income on cattle finishing farms (28,239 farms represented) increased by 9% to €15,800.

- Income on sheep farms (14,322 farms represented) increased by 3% to €13,700.
- The African Swine Fever (ASF) outbreak in China has resulted in a sharp increase in international pig prices, including in Ireland, returning the Irish pig sector to profitability this year. Due to the small number of commercial pig farms Teagasc do not prepare a family farm income estimate for pig farms.

The large variations are driven by differences in both farm size and profitability. Dairy farms are consistently the most profitable farms (see Figure 9). However, it should be borne in mind that almost all dairy farms are classified by Teagasc as full-time farms in terms of the labour input required. Most cattle farms and the majority of sheep farms are classified as part-time in terms of labour input requirements, even though in many cases the farmers may not have an off-farm job, often because they are of retirement age. The 32% of National Farm Survey farms classified as full-time based on labour input had an average farm income of almost €51,800. The remaining farms, classified as part-time farms based on labour input required, had an average farm income of €10,150.

The breakdown of off-farm employment varies by sector, with cattle farmers more likely to work off-farm (42% for Cattle Other farms and 39% for Cattle Rearing Farms). A lower proportion of Sheep and Tillage farmers worked off-farm (32% and 33% respectively), while only 12% of dairy farmers were employed off-farm. The presence of off-farm employment also varies by region with over 40% of farmers in the West employed off-farm compared to 25% in the South, which also reflects the dominance of the dairy sector in that region. The proportion of farm households where the spouse was employed off-farm was 33%.

Figure 9: Family Farm Income 2014-2018 (source Teagasc NFS)

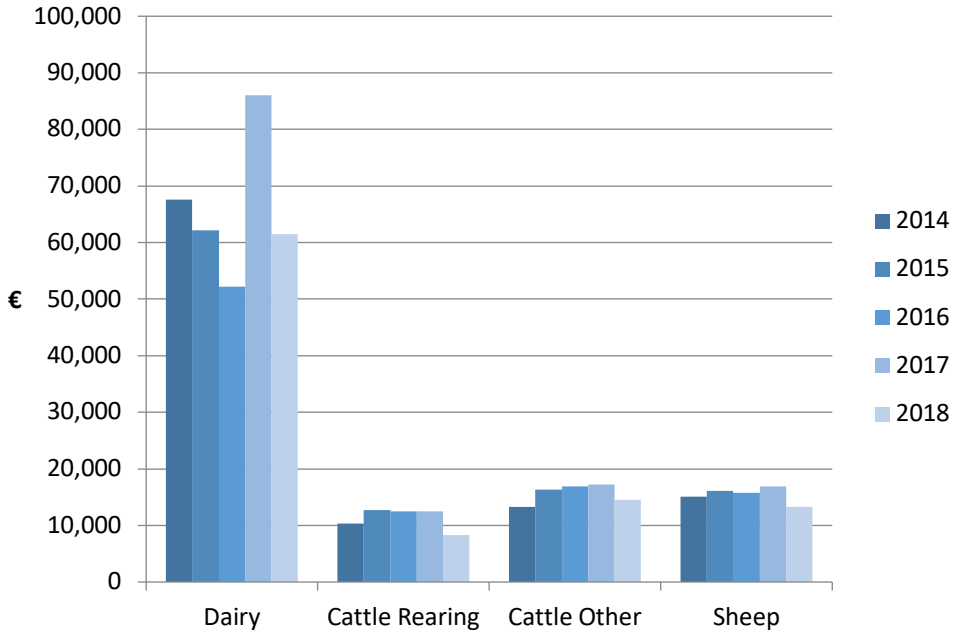
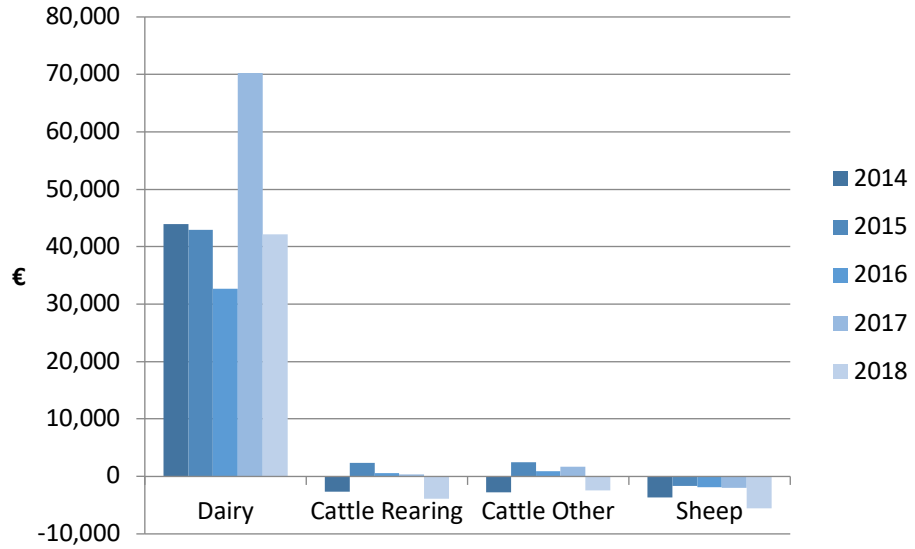


Figure 9 and 10 provide more detail on the trends in farm profitability for dairy, cattle rearing, cattle others and sheep over the period 2014 to 2018[21]. Average Family Farm Income over the 5 years was €15,401 (cattle rearing), €18,717 (cattle others), €67,520 (dairying) and €16,767 (Sheep). As outlined in Figure 8 and Figure 9 it is clear that beef and sheep farms rely heavily on these subsidies to support their incomes. In contrast, on dairy farms FFI less subsides and direct payments is consistently above €30,000. The full breakdown of data is provided in the appendices.

Figure 10: Family Farm Income less Subsidies and Direct Payments

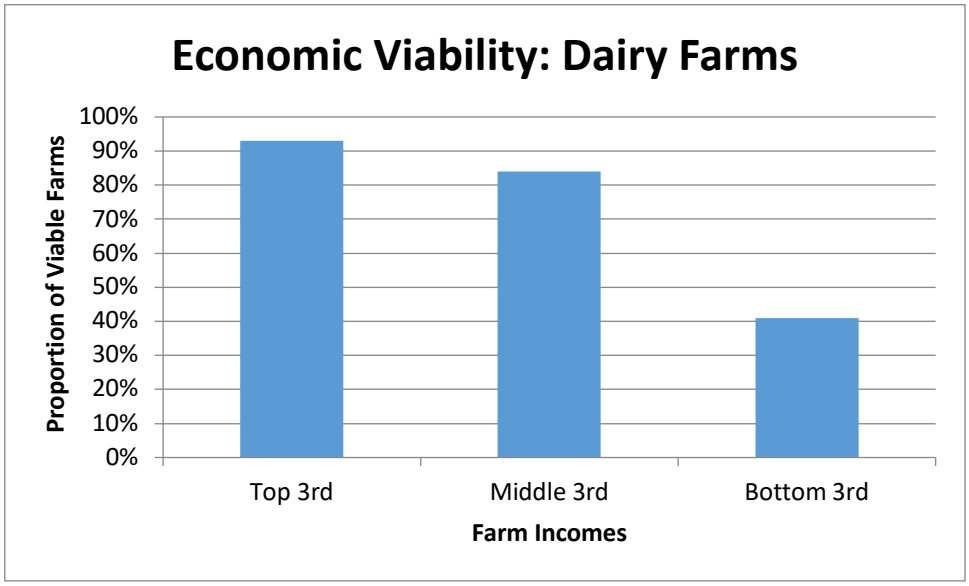


Source: National Farm Survey

While the above data indicates the average figures by farm system over the period, it is also important to note that within each system there is a distribution of the absolute level of, and growth in, profitability. The Teagasc Sustainability Report (see here) provides evidence of within sector performance including economic viability and innovation uptake. The report found that 85% of dairy farms were economically viable. This ranged from 94% for the top one third performing dairy farms to 41% for the bottom third as shown in Figure 11. However, on beef farms only 25% of farms were defined as economically viable. Furthermore, the breakdown within beef farms shows a range from 38%, 12% and 3%, for the top, middle and bottom cohorts of farms respectively as shown in Figure 12.

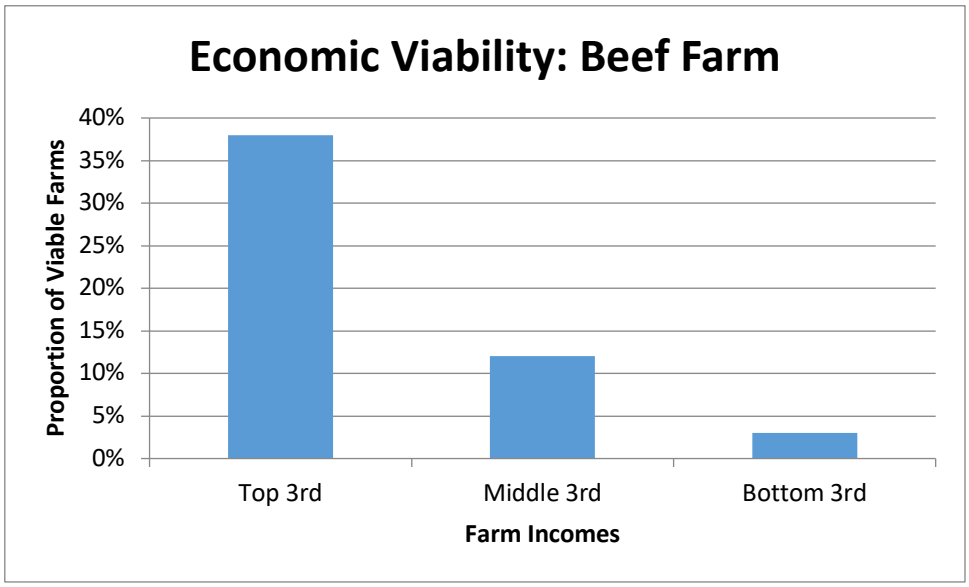
[21] Full tables are available in Annex 4.

Figure 11: Viability of Dairy Farms



Source: Teagasc Sustainability Report 2018

Figure 12: Viability of Beef Farms



Source: Teagasc Sustainability Report.2018

Farm Innovation

The Sustainability report also provides information on innovation adoption with research such as Lapple et al. (2013) and Hennessy and Heanue (2012) confirming the positive contribution of innovative technology adoption to farm profitability. The report identifies five key innovation indicators for dairy and four for cattle and sheep systems. The technologies and practices reflect AGRIP based outputs translated into farm based practices.

The indicators are:

- Milk recording (applicable only to dairy)
- Discussion group membership
- Spring slurry spreading
- Low emission slurry spreading and
- Liming and reseeding for grassland management.

Table 5 below shows the approximate percentage of farmers in the top, middle and bottom economic performing groups using these innovations.

Table 5: Innovation adoption by sector

	Dairy			Cattle			Sheep		
Performance / Innovation	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Milk recording	57%	29%	25%	n/a	n/a	n/a	n/a	n/a	n/a
Discussion group membership	55%	49%	17%	26%	13%	8%	39%	22%	9%
Spring slurry spreading	51%	52%	48%	50%	32%	29%	32%	22%	13%
Low emission slurry spreading	10%	8%	`4%	4%	0.5%	1.5%	n/a	n/a	n/a
Liming	32%	32%	23%	21%	15%	7%	30%	12%	8%
Reseeding	30%	28%	20%	11%	9%	7%	23%	22%	4%

Table 5 illustrates that the better performing farmers are more likely to adopt innovative technologies which are backed up by research. The Teagasc NFS is a representative sample of farms producing in excess of €8,000 of standard output and the survey results highlights clear differences across systems. Family farm income whether measured on a per farm basis, per hectare, per livestock unit or per labour unit is consistently higher on dairy farms (Buckley and Donnellan 2020). Conversely, the reliance on direct payments is higher on beef and sheep farms, and without these supports the market based income accrued is likely to be marginal or negative. These characteristics are likely to limit the degree to which these farmers engage with AGRIP developments and/or KT, but it does not negate the importance of conducting the research and providing the evidence.

Moreover, within each enterprise, for structural reasons the percentage of farmers that are receptive to technological supports varies hugely. The top 20% of beef and sheep farms are positively influenced by the adoption of the new technologies as results from the Teagasc BETTER farm programmes demonstrate. Nonetheless, the most likely cohort of farmers to engage with AGRIP based developments are those of specialist dairy, specialist pig or beef and sheep farms of a scale in excess of €25,000 which amounted to approximately 38,000 farms in 2016 according to the CSO Farm Structure Survey.

In addition, it is widely accepted that the adoption of new technologies is greater on farms that have younger farmers, larger farms with larger herd size, larger gross output and that are more profitable. Both cattle and sheep farms in Ireland have an older age structure, smaller in size, lower gross output and much lower in profitability than in dairy farms. CSO data shows that 75% of dairy farmers have a standard output in excess of €100,000, while the proportion of beef and sheep farmers of similar scale is negligible. In fact, almost half of sheep farms have a standard output of less than €8,000 meaning they are not accounted for in the Teagasc NFS. Almost a third of beef farms are similarly small. The Teagasc National Small Farm Survey (2017) showed that smaller farmers tended to be older with relatively lower levels of education and are less likely to be users of Teagasc Research including that of AGRIP. Therefore, the rate of adoption of new technologies will be much slower in cattle and sheep farms. However, there are indications in recent years that efficiency gains can be obtained as demonstrated from research demonstration and monitor farms and the challenge is to encourage the uptake of these practices.

In summary, AGRIP has led to the development of technologies around breeding, grassland and farm management that can directly improve the productivity of farms if adopted which in turn improves their competitiveness and ability to avail of any profitability opportunities that arise. Clearly, profitability, as demonstrated by Family Farm Income, is asymmetrical by sector, and the challenge is to ensure that the principles that are employed in the more profitable systems are transferable and applied to the less profitable systems, particularly for grassland and breeding practices. This represents the ‘profit from productivity’ approach which is within the bounds of possibilities for AGRIP research as opposed to external factors such as market prices which influence profitability. To monitor the uptake of these technologies in those less profitable sectors, to promote the adoption of these technologies and to continue to uncover new methods and demonstrate their effectiveness will be important areas for AGRIP to continue to address.

RQ 3 - Has the programme contributed to the environmental sustainability of farms involved the Teagasc programme?

Leip *et al.* (2010) showed that Ireland was among the lowest GHG footprint in milk production (kg CO2-eq/kg cow's milk) of EU-27 countries and the fifth lowest footprint for beef production.[22] However, the data to underpin this claim is somewhat dated, and an updated assessment to monitor the continued progress would be useful. The Origin Green Sustainability Report (2016) shows that the average carbon footprint (CO2e/kg of fat and protein corrected milk) has reduced from 1.21 in 2014 to 1.14 in 2016. Greenhouse gas emissions per kg of fat corrected milk (LCA) has reduced from 1.31 kg CO2 eqv in 2013 to 1.14 in 2017.[23]

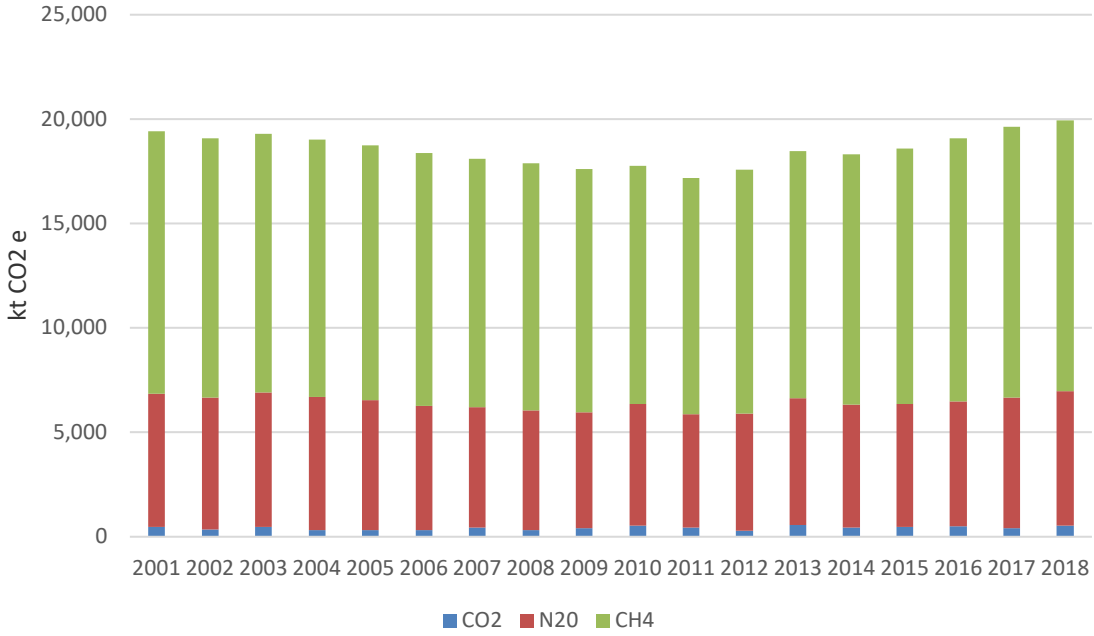
The Teagasc National Farm Survey Sustainability Report shows the progress that has been made in sustainability indicators in all the livestock sectors in recent years. The report confirmed that emissions were improving with a trend towards fewer emissions per unit of product produced. However, the report also showed sectoral differences and found that emissions grew as farms expanded, predominantly on dairy farms as a result of the expansion in milk production due to the abolition of milk quotas and structural changes to scale on farms facilitated by improved grassland management efficiencies. Nonetheless, the intensity measure is useful for international comparisons, and if the output was not produced in Ireland, it would be displaced and produced in other countries which may have a higher carbon footprint per unit of output, which is referred to as carbon leakage (O'Brien et al. 2012).

Emissions of GHG from agriculture in Ireland have increased in recent years as illustrated in the annual national inventory reports published by the EPA (see Figure 13). The vast majority of agricultural GHG are accounted for by ruminant based production reflecting the importance of AGRIP in developing improved technologies to mitigate these factors. Total emissions are dominated by CH4 and N20 with most of these associated with dairy, cattle and sheep farming. Emissions associated with fertiliser use by tillage farms would account for a relatively small share of N20 emissions.

[22] https://agritrop.cirad.fr/558780/1/document_558780.pdf

[23] A. Leip, F. Weiss, T. Wassenaar, I. Perez, T. Fellmann, P. Loudjani, F. Tubiello, D. Grandgirard, S. Monni, K. Biala **Evaluation of the Livestock Sector's Contribution to the EU Greenhouse Gas Emissions (GGELS) – Final Report** European Commission, Joint Research Centre (2010)

Figure 13: Agricultural GHG emissions 2001-2018



The Teagasc Sustainability report also illustrates the complexities of accurately measuring GHG emissions from cattle reared for beef due to the various movements these animals make throughout their lifetime as opposed to dairy cattle that usually make fewer movements. Currently, the 'Life-Cycle Analysis' model for beef production is being updated through the AGRIP. This research will be crucial to complement emerging research from the University of Oxford, to reflect the shorter life spans of GHGs such as methane (approx. 10 years) that at present are calculated on the same basis as some fossil fuels that remain in the environment for centuries.[24] However, the current methodology being used by the EU for compliance with the effort sharing decision on non-ETS emissions, and the targets to reduce these emissions by 20% by 2020 and 30[25] by 2030 relative to 2005 are binding. Accordingly, it is imperative that the AGRIP continues to develop technologies that progress Irish animal and grassland based production systems towards meeting these binding targets. Improving unit efficiencies will be a key part of this objective, but must be considered in the context of overall emissions to ensure that absolute levels are reduced in line with the targets set. Teagasc supply the EPA with GHG emissions forecasts for agriculture which are published and inform policy. Improving the environmental performance of agriculture is clear, but improving the measurement by accurate indicators as part of the AGRIP can contribute to this objective.

[24] https://www.farmersjournal.ie/cattle-emissions-wildly-overstated-544286
[25] 2030 target may include offsets up to 10%

Teagasc research has set out the likely path of aggregate agricultural emissions under what can be characterised as a business as usual scenario (see Donnellan, Hanrahan and Lanigan, 2018). The projections have been updated and are used in the latest EPA projections concerning future GHG emissions from all sectors of the Irish economy (EPA, 2020). Under the baseline/business as usual scenario emissions of GHG from Irish agriculture will continue to grow into the medium term. Teagasc's recent Marginal Abatement Cost Curve (MACC) analysis for GHG sets out how a suite of measures could if adopted by Irish farmers lead to lower emissions from the agricultural sector than set out in the business as usual projections. However, it is important to note that the MACC curve does not account for exchequer costs which can be significant for programmes such as the BDGP.

The MACC sets out 26 actions including carbon abatement from land use such as forestry and soil management, and providing renewable alternatives to fossil fuel. The main agricultural production measures related to AGRIP include:

- Improved efficiencies in farming through genetics and grassland improvements
- Switching to a form of protected urea fertiliser to cut nitrous oxide emissions
- Spring slurry spreading in a low emission method such as a trailing shoe.

Teagasc have also established the Sign Post Demonstration farm initiative to demonstrate the implementation of MACC associated best practices to show farmers how to implement these research based practices on farm level to encourage adoption.

Genetic improvement

Improving the genetics of the national herd has been identified as a basis to improve the environmental performance in the Teagasc MACC.[26] The BDGP Spending Review published in 2019[27] illustrated the link between genetic improvement and environmental sustainability. The broad objectives of the BDGP are to improve the genetic merits of the national beef herd by collecting genotypes and data which enables the selection of the most efficient animals for breeding, which in turn will contribute to lowering the level of GHG emissions associated with the beef herd. The dual benefits from these objectives represent a win-win for both farmers and the state as farmers will gain in profitability from more efficient animals and the associated benefit to the beef sector in terms of value and GHG emissions mitigated will benefit the state. Given the Government policy objectives of improving the competitiveness and quality of Irish beef, as stated in Food Wise 2025, and the need

[26] https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf
[27] https://assets.gov.ie/25649/4092b0f1c806495485644360f489c63c.pdf

for the agri-food sector to contribute towards Irelands target of a 30% reduction in GHG emissions by 2030 (on 2005 levels), the broad objectives of the BDGP are closely aligned, and will contribute to the overall target to address the sectoral responsibility.

The review found that animals of a higher genetic merit, produced lower GHG emissions, and through accurate recording and optimum replacement strategies, the future beef herd would be more efficient, more resilient to adapt to climate challenges, and ultimately provide less emissions than currently is the case. However, improving genetics through breeding programmes is an incremental process, and there are no quick fixes, but the cumulative effect will contribute to reaching agricultural emission targets as set out by national targets in the Climate Action Plan and international agreements with EU targets for 2020 and 2030 reductions relative to 2005 as key examples. These gains must be considered as one part of an overall strategy to achieve these targets and unit efficiency gains must be considered in the context of overall emissions.

The success of any breeding programme is conditional on having

1) a pertinent breeding goal,
2) a good recording system for all relevant traits,
3) accurate genetic and genomic evaluations,
4) an optimised breeding scheme,
5) an easy-to-use decision support system (including advisory service), and
6) robust and demonstrable validation.

Teagasc /AGRIP collaborated with both the ICBF and Sheep Ireland in this research that underpins the identification of traits and their respective weights within breeding goals (Economic Breeding Index: EBI, Dairy Beef Index: DBI, Terminal Index, replacement index, sheep breeding indexes). Teagasc were strongly involved in the choice of which traits to measure and the standard operating procedures of how to measure them. Specifically, the equations underpinning the DIY milk recording are generated by AGRIP and research is currently advancing the suite of traits in the next generation of breeding goals through the development of standard operating procedures for meat eating quality and methane emissions.

It is clear from the evidence and examples provided that the AGRIP is progressing on environmental objectives for the agricultural sector. Given the increased ambition for environmental and sustainability goals on a broad policy agenda, the continuation of progress will be key, and AGRIP driven technologies, innovations and evidence building will be an important facilitator of this progress.

White clover research

Managing grassland with less mineral N fertiliser inputs and with greater reliance on biological N fixation from white clover can reduce costs (less mineral N fertiliser), reduce GHG emissions (industrial synthesis of mineral N fertiliser is energy intensive) and increase the digestibility of herbage. Results from recent research investigating the incorporation of white clover into perennial ryegrass swards in Teagasc Moorepark and Teagasc Clonakilty Agricultural College, has also shown the potential of perennial ryegrass-white clover swards to increase the productivity and profitability of Irish grazing systems. Pasture production increased by 8% in Clonakilty when white clover was included in the sward (at a similar N fertiliser rate of 250 kg N/ha; McClearn *et al.,* 2019) whereas in Moorepark, although pasture production did not increase significantly, the perennial ryegrass-white clover swards receiving 150 kg N/ha grew the same quantity of pasture as the perennial ryegrass-only swards receiving 250 kg N/ha (Egan *et al.,* 2018). Perennial ryegrass-white clover swards tend to be higher quality in mid-season compared to perennial ryegrass-only swards as sward white clover content increases from May onwards. Moorepark and Clonakilty research both show increases in milk and milk solids (MS; kg fat + protein) production from perennial ryegrass-white clover swards compared to perennial ryegrass-only swards (Table 6; Egan *et al.,* 2018; McClearn *et al.,* 2019).

Table 6. Effect of white clover inclusion on pasture production, milk and milk solids yield in Teagasc Moorepark (2013-2016) and Teagasc Clonakilty (2014-2017) grazing experiments

Teagasc Moorepark Experiment	Grass-only 250 kg N/ha	Grass-clover 250 kg N/ha	Grass-clover 150 kg N/ha
Pasture production (t DM/ha)	13.7	14.0	13.7
White clover content (%)	-	23	27
Milk yield (kg/cow)	6,108	6,498	6,466
Milk solid yield (kg/cow)	460	496	493

Teagasc Clonakilty experiment	Grass-only 250 kg N/ha	Grass-clover 250 kg N/ha
Pasture production (t DM/ha)	15.6	16.8
White clover content (%)	-	23
Milk yield (kg/cow)	5,222	5,818
Milk solid yield (kg/cow)	437	485

McClearn *et al.* (2020)[28] reported an economic analysis of the biological results from the Clonakilty experiment and showed that including white clover into perennial ryegrass swards increased profitability by €305/ha. Ongoing analysis of the trial results indicate that the combined animal performance gains and cost savings from reduced N fertiliser use in perennial ryegrass-white clover swards has the potential to significantly increase annual farm profitability, while also reducing GHG emissions by up to 10%.

Other AGRIP Contributions

AGRIP collaborates with CELUP on a number of areas of environmental sustainability. One important area is improving nitrogen use efficiency (NUE) on grassland farms, where research on slurry spreading, grassland management and soil fertility have led to improvements in NUE. AGRIP also collaborates on research in the area of anaerobic digestion/biogas production with a number of partners, although this research programme is mostly led by the CELUP programme with further support from REDP within Teagasc. Current projects include:

- Farm-based biogas, an internally funded project which aims to optimise anaerobic digestion processing to Irish conditions, design sustainable production system of feedstocks and assess emissions associated with recycling of digestate as well as fugitive emissions from these systems
- GEBTech, an SEAI funded project focusing on slurry/digestate amendment reducing GHG and ammonia emissions during storage, while improving biogas yield during AD process of co-digestion of slurry with other feedstocks
- FLEET, also funded by SEAI and focusing on modelling economic sustainability of alternative feedstocks used for anaerobic digestion processing
- EIP Small Biogas Demonstration Programme, funded though DAFM, which through engagement with farmers aims to design and test economic and environmental sustainability of a small scale, on-farm anaerobic digestion plant installed on a number of participation farms and act as a blueprint for future rollout of the system.

In summary, the AGRIP programme is providing evidence for more sustainable production methods through efficiencies, genetics, white clover and alternative production systems. However, the policy ambitions for a greener agricultural sector are clear and the challenge is to continue to develop low emission technologies which must continue to be a core goal of the AGRIP programme.

[28] https://www.sciencedirect.com/science/article/pii/S0022030220301740#!

5. Conclusions

This Spending Review paper focused on the AGRIP as part of the Teagasc Research programme. It is the largest funded Research programme. Core funding accounts for over half of its funding. The remainder of the funding is raised externally or through income earned, and both the share and the absolute levels have increased over time implying recognition of the work being carried out. AGRIP has multiple objectives and this Spending Review examined the progress made towards some of their key objectives.

In terms of the alignment with Food Wise 25 targets, the AGRIP objectives resonate with the sector targets and AGRIP has developed technologies that can assist the sector in achieving their export targets. The need to generate new technologies and provide evidence falls within the remit of AGRIP and the subsequent adoption of these practices on farm level falls to Teagasc's advisory and education programmes as well as the specialist Knowledge Transter departments within AGRIP. Nonetheless, it is important that research objectives continue to support agricultural sector targets particularly with the new 2030 Agri Food Strategy which is currently being developed.

AGRIP has also developed technologies to improve the productivity of farming systems which improves the competitiveness of these enterprises to enhance profitability. Initiatives such as Grass10 and PastureBase are assisting decision-making on grassland management and farmers that use these technologies are more productive that those who do not. [29] Although the NFS data shows that the dairy sector has achieved significantly higher incomes than other sectors such as cattle or sheep, the research programme should continue to provide new technologies and practices to follow the 'profit from productivity' approach. External factors such as price or weather are strong influences on profitability and income achieved, but that does not negate the need to conduct this research. The challenge is to mirror the principles employed in the most efficient farms and transfer them, where applicable, to the other sectors, particularly around grassland and breeding management. To develop these technologies further, disseminate and demonstrate their benefits and encourage their adoptions will be key areas for AGRIP to focus on.

In terms of environmental ambitions and sustainability, the work of AGRIP has led to some improvements in terms of unit emissions from ruminants, but overall emissions have continued to increase despite policy targets and challenges remain particularly for farms that are expanding in scale primarily in the dairy sector. The key challenge is to continue to develop innovations and methodologies that improve the environmental efficiency of units produced, while simultaneously ensuring that overall emissions do not increase in order to manage the sector in the future. Improving the measurement of emissions, and ensuring that agriculture can meet the broader policy targets will be important areas for AGRIP to focus on. Enhancing collaboration across Teagasc Research programmes could be strengthened further with nitrogen use efficiency, and the anaerobic digestion/biogas area led by CELUP, as examples that could be enhanced.

[29] Hanrahan, *et al* 2017.

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7. Annex

Annex 1

Table 7 Bibliometric analysis for the Animal & Grassland Research & Innovation Programme 2014 to 2018										
Year	**P**	**C**	**CPP**	**J exp**	**Cat exp**	**J Exp**	**Cat Exp**	**Impact**	**FTE**	**Pubs FTE**
2014	162	1889	11.7	1563	1363	1.21	1.39	2.29	33.4	4.86
2015	131	1040	7.9	889	810	1.17	1.28	2.22	33.6	3.90
2016	147	768	5.2	688	578	1.12	1.33	2.20	36.0	4.08
2017	189	505	2.7	438	363	1.15	1.39	2.32	37.9	4.99
2018	230	172	0.8	136	111	1.26	1.55	2.67	37.6	6.12

The definitions for the metrics used for this report can be found in Annex 1.

The Metrics used for this report are;

Count (number) of publications (P) – by Teagasc authors – provided in *Web of Science* & *Incites*. Where A1 publications were not indexed in Web of Science Core Collection, additional data was added (see methodology for further details).

- **Number of Citations to those publications (C)** – a simple count of the number of citations gathered by the publication, provided in *Web of Science* & *Incites.* This was summed by year and for the 5-year period for each department, programme and Teagasc overall, and by researcher for the permanent researchers.
- **CPP (Citations per publication):** This is the ratio of total C to total P for each researcher, department, programme or Teagasc overall, per year and/or for the 5-year period, as relevant.
- **Journal expected citations (J Exp):** This is the expected citations for a similar publication normalised for the journal, year and document type. It is provided by *Incites* for each article from their analysis of all the publications indexed in *Web of Science*. For individuals, departments and programmes, this was summed for the relevant set of articles to provide the listed figure in the tables.
- **Category expected citations (Cat exp):** The *Web of Science* assigns each journal to one or more subject categories. Broad disciplines are represented as smaller subfields. This narrow definition of subject is an important characteristic of the schema, as citation behaviour may significantly vary among subfields. Similarly, *Incites* analyses publications based on the categories. This metric is the citation count expected for the same article type across that category and year. Similarly to J exp, this was summed for each set of articles – individual, department or programme – to provide the figures in the tables.
- **Journal Actual/Expected Citations (J Act/Exp, also called Journal Normalised Citation Impact)**: This is the ratio of the actual number of citations gathered by an article compared to the expected count (J Exp) and provides an indication of how the article is performing. A value of one (1) indicates that the performance is on average,

whereas a value greater than one indicates it is performing above average for the journal. For individuals, departments, and programmes this was calculated by dividing the sum of the actual citations by the sum of the expected citations for the relevant set of articles, to give the figures listed in the tables.

- **Category actual/Expected citations (Cat Act/Exp, also called Category Normalised Citation Impact)**: Similarly, this is the ratio of the actual citations gathered by an article compared to the expected count for the relevant category and provides another indicator of performance. A value of one (1) indicates that the performance is on average, whereas a value greater than one indicates it is performing above average for the category. This was calculated in the same way as the J Exp ratio above to give the figures in the tables.
- **Average Impact Factor (labelled "Impact" in the data files)**: The Impact Factor is a journal metric provided by *Web of Science* and is one indicator of the influence of the journal. The impact factor (IF) of an academic journal is a measure reflecting the yearly average number of citations to recent articles published in that journal. *In any given year, the impact factor of a journal is the average number of citations received per paper published in that journal during the two preceding years*. IF varies widely across subject areas and should only be used, with caution, to compare journals in similar fields. This is the figure provided under the column headed "Impact" in the accompanying tables.
- **Permanent FTE:** This is the number of Full Time Equivalent permanent researchers in each department or programme. The Full Time Equivalent (FTE) was calculated by year for Departments and Programmes. It is the number of permanent researchers in each department for the year, adjusted to take account of researchers start and/or leave dates. Where it was known, the FTE data was adjusted to take account of extended leave, such as Maternity, Parental or long-term sick leave, for example a period of 9 months leave reduces that person to 0.25 FTE for the relevant year. Heads of Programme and Heads of Departments were added to the relevant Department lists for FTE calculations. Percentage time on research for researchers in management positions was assigned as follows: Heads of Programmes (HoPs) – 10% (0.1 FTE), Heads of Departments (HoDs) – 50%. (0.5 FTE). For Programmes, the FTE is the total for all departments in that Programme.
- **Total Permanent FTE (Total Perm FTE):** This figure, the total permanent FTE for the period, was calculated for each Programme by summing the Department FTEs, and for Teagasc overall, by summing the Programme figures.
- **Publications/permanent FTE (Pubs/FTE):** This is the ratio of the number of publications to the number of Full Time Equivalent permanent researchers overall, or in each department or programme as applicable**.**
- **H-index:** This is a metric provided for individuals only. **The figure provided is a 5-year H-index calculated only for the 5-year period covered by this report** (and only including the A1 publications as listed – for instance any publications by Teagasc authors while at a previous employment are not included)**.** The h-index is an author-level metric that attempts to measure both the productivity and citation

impact of the publications of a scientist or scholar. The definition of the index is that a scholar with an index of h has published h papers each of which has been cited in other papers at least h times. Thus, the h-index reflects both the number of publications and the number of citations per publication.

Annex 2

Food Wise 2025 Actions Relevant to AGRIP

List of a selection of Food Wise 2025 actions that align with the objectives of AGRIP.

Action Number	
9	Update Teagasc's Marginal Abatement Cost Curve for Irish agriculture on a more frequent basis to ensure the latest technological developments help inform an assessment of a wider range of GHG mitigation measures that could be rolled out at farm level.
10	Continue to enhance and roll out at farm level the Carbon Navigator Initiative which provides online software to assist farmers in understanding how their farms produce GHG emissions, identify mitigation capacity and to set targets and a pathway to reduce emissions. Teagasc in conjunction with other stakeholders to examine whether the navigator tool could be used to measure other important environmental parameters such as biodiversity.
28	Teagasc to develop and rollout a Nutrient Management software tool to enhance cost-effective use of feed, fertiliser and slurry to minimise nitrogen (nitrate, ammonia and nitrous oxide) and phosphorus losses.
29	Introduce knowledge transfer programmes to improve and broaden awareness levels on the efficient use of nutrients on farms, thereby reducing losses of valuable and costly nutrients to water and to air, so providing for economic and environmental sustainability goals.
31	Teagasc to develop soil specific advice for both organic and inorganic manure use to take account of mineralisation across soils to help inform optimal fertiliser application rates and timing.
32	Teagasc to carry out a soil nutrient census to track soil fertility trends.
34	Teagasc to enhance PastureBase Ireland tool as a resource to help improve grassland and nitrogen management and increase grass utilisation.
75	Expansion of the current discussion group model to provide access to up to date research and information, in the areas of grassland and soil management; genetics and breeding; financial management/business planning and price volatility management; animal health and welfare; environment and farm safety. This should to be backed by a number of commercially operated beef demonstration farms.
76	Implement a third phase of the Teagasc/Farmers Journal BETTER Farm Beef Programme with an emphasis on transferring best practice in management and breeding to the maximum number of farms.
123	Improve the use of genomic technologies and better breeding to improve the sustainability of the National herd, including by: • Increasing the level of data recording at farm level. • Increasing the use of breeding indices in purchase decisions. • Increasing the level of genotyping across the national herd to allow for robust, genomics based breeding indexes. • Application of commercially focused breeding indices and sexed semen to increase the beef characteristics of the increased output from the dairy herd and thereby ensuring these animals best meet market specifications.

124	Teagasc and other research providers to develop measures such as improved grazing management practices, increase soil fertility and sward renewal to increase grass utilisation by 2t/ha on livestock farms.
125	Teagasc, other research bodies and industry to develop the use of precision technologies applicable to pasture based production.
185	The primary production research activities of national research bodies, including Teagasc and academia, to be focussed on grass land productivity, animal breeding/genetics, soil nutrient usage, animal health improvements, crop production, economic analysis of Irish agriculture, food ingredient, product and process innovation.
186/421	Teagasc in collaboration with relevant HEIs and others to research emerging precision technologies, data analytics, sensor technology, DNA technology and possibilities for mining big data to improve decision making, availing of existing resources and capabilities.
197	Teagasc and the dairy industry to complete the €10 million upgrade of Moorepark Technology Limited pilot plant.
205	All milk producers should be strongly encouraged to carry out grass measurement as the efficient use of grass is one of the key advantages of the Irish dairy sector
206	Strategies should be developed to increase the fertility of Irish grassland soils in order to address deficiencies in P, K and lime
207	Dairy farmers should set a target of increasing grass utilisation to 10 tonnes / ha
209	Industry stakeholders need to ensure that sexed semen continues to be rolled out to Irish dairy farmers and that continued research in the technology is undertaken
219	Ireland's success in added value sectors such as farmhouse, artisan and higher end cheeses and butters will continue to be recognised, developed and encouraged
223	Increase fertility levels and decrease calving intervals in suckler herds
224	Facilitate the rapid operationalisation of all aspects of the Beef HealthCheck programme, including batch-level, herd-level and geographic reporting
227	Exploit potential of genomics to add value at farm level by improving breeding and at processing level in areas such as meat quality and meat tenderness
228	Further develop the potential use of sexed semen for breeding selection and improving genetic profile and profitability of the proportion of the beef hers coming from the dairy sector
229	Intensify the level of research aimed at informing the formulation of the breeding indexes used in the sector and the distribution of the traits therein
230	Focus on net margin per hectare as a measure of profitability and kilograms of beef produced per hectare as a suitable measure of efficiency
231	Increase the number of livestock farmers in Knowledge Transfer Programme
232	Develop infrastructure through knowledge transfer programmes and farmer education to ensure improved grassland management. This will include increasing the proportion of grassland farmers participating in weekly grass measurement from 1,250 today to 3,000 by 2020 and 5,000 by 2025
233	Support research efforts and knowledge transfer tools to better utilise the beef output from the dairy bred calves in a systemised manner
234	Review mechanism for linking the knowledge developed on Teagasc/Farmer's Journal BETTER Farm Beef Programme and the new Suckler Cow demonstration farm in Athenry with widespread application at farm level
235	The development and implementation of policy in this area, and extension to sheep as well as cattle, is currently the subject of consultation with stakeholders with a view to making real progress on a collaborative basis.
239	Focus on assisting the production of the market required carcass specification and production systems which are designed to maximise return both to the farmer and the

	processing industry
248	Investigate opportunities for including animal welfare standards and human health benefits of grass fed beef in the marketing messages for Irish beef
249	Explore options for increased returns from meat and bone meal, and tallow through industry and agency R&D
252	Complete the establishment of the Meat Technology Centre
253	Explore research projects on the advantages of Irish grass fed beef systems in comparison with other production systems with regards to animal welfare, health and taste along with any other relevant areas. This should include a consideration as to the definition of 'grass fed'
254	Consider the merits of developing a standing national resource with expertise in the field of animal health economics and disease modelling
263	Genetic improvement: focus on ewe fertility and on breeding resilience and resistance to diseases which impact on the productivity of flocks, such as foot-rot and on improving the consistency of product supplied to processors
264	Work collaboratively with processors, Bord Bia, Teagasc and Sheep Ireland to modify the very seasonal nature of Ireland's sheepmeat supply, and maintain our presence, and access to markets throughout the year
267	Engage further with Sheep Ireland on the design and implementation of breeding indices based on marketing insights
268	Increase sheep farmer participation in Knowledge Transfer Programmes
270	DAFM to continue to support and engage with Sheep Ireland on their work to drive better genetic gain for the flock
276	Develop a Carbon Navigator tool for sheep producers
278	Investment in pig production facilities particularly energy efficiency to reduce input costs
289	Roll out a carbon footprinting assessment and improvement programme for pigs
290	Opening of upgraded pig research facility in Moorepark with prompt dissemination of research findings to the industry
291	Support pig farms by researching grain varieties in the tillage sector for feed use
420	The primary production research activities of national research bodies, including Teagasc and academia, to be focussed on grass land productivity, animal breeding/genetics, soil nutrient usage, animal health improvements, crop production, economic analysis of Irish agriculture, food ingredient, environmental sustainability practices, monitor effects of seafood production on European designated sites, product and process innovation.
423	Explore research into the potential reduction of methane generation arising from cattle and roll-out appropriate mitigation

Annex 3Table 3: Trends in the profitability of cattle rearing farms 2014 to 2018					
	2014	**2015**	**2016**	**2017**	**2018**
Gross output (€)	48,021	49,689	48,387	48,921	47,405
Direct costs (€)	16,246	15,126	14,881	15,108	16,505
Gross margin (€)	31,775	34,563	33,506	33,813	30,901
Overhead costs (€)	17,800	16,939	16,817	17,517	18,477
Family farm income (€)	13,975	17,624	16,689	16,296	12,424
Subsides & direct payment (€)	16,626	15,206	16,126	15,932	16,319
Family farm income excluding S&DP (€)	-2,651	2,418	562	363	-3,896

Table 4: Trends in the profitability of cattle other farms 2014 to 2018					
	2014	**2015**	**2016**	**2017**	**2018**
Gross output (€)	59,358	60,718	60,152	61,204	59,984
Direct costs (€)	21,343	20,263	20,339	20,359	22,509
Gross margin (€)	38,016	40,456	39,813	40,844	37,475
Overhead costs (€)	20,833	19,993	20,061	20,566	21,433
Family farm income (€)	17,182	20,463	19,752	20,278	16,042
Subsides & direct payment (€)	19,963	17,957	18,835	18,542	18,494
Family farm income excluding S&DP (€)	-2,781	2,506	917	1,736	-2,453

Table 5: Tends in the profitability of dairy farms 2014 to 2018					
	2014	**2015**	**2016**	**2017**	**2018**
Gross output (€)	187,634	185,929	177,242	224,811	223,829
Direct costs (€)	70,810	71,463	72,816	77,986	97,759
Gross margin (€)	116,824	114,466	104,426	146,826	126,070
Overhead costs (€)	50,895	50,663	50,874	56,302	62,273
Family farm income (€)	65,928	63,803	53,551	90,524	63,796
Subsides & direct payment (€)	21,961	20,868	20,824	20,251	21,645
Family farm income excluding S&DP (€)	43,967	42,935	32,727	70,273	42,151

Table 6: Trends in the profitability of sheep farms 2014 to 2018					
	2014	**2015**	**2016**	**2,017**	**2018**
Gross output (€)	50,651	51,186	51,614	54,698	54,898
Direct costs (€)	17,504	17,738	18,266	18,133	21,248
Gross margin (€)	33,147	33,448	33,348	36,564	33,650
Overhead costs (€)	17,145	16,996	16,453	17,355	18,371
Family farm income (€)	16,002	16,452	16,895	19,209	15,279
Subsides & direct payment (€)	19,604	18,146	18,818	21,159	20,787
Family farm income excluding S&DP (€)	-3,602	-1,694	-1,923	-1,950	-5,508

Table 7: Evolution of technical indicators and costs for the Irish pig industry 2014 to 2018					
Technical Indicators	2014	2015	2016	2017	2018
Average herd size, number of sows	752	753	775	729	762
Pigs sold / Sow / Year	25.3	24.8	26.25	27	26.9
Avg Daily Gain, g/d wean to finish	670	694	697	708	717
FCR, wean to finish	2.49	2.43	2.42	2.44	2.43
Live weight at sale, kg	106.2	108.7	108.6	110.8	112.5
Kg Pigmeat sold / Sow / Year	2052	2058	2179	2285	2319
Kg Feed / kg Pigmeat	3.66	3.61	3.57	3.56	3.55
Financial performance					
Feed cost / kg dead, cents	117	108	102	100.6	105.6
Total Cost / kg dead, cents	160.2	153.4	149.9	150.7	154.7
Price / Kg Dead, cents	167	148	149	162	144
Margin over Feed, cents	50	40	47	61.4	38.4
Total Margin, cents	6.8	-5.4	-0.9	11.3	-10.7

Source:Teagasc eProfit Monitor; representing an average of 122 farms and 85,000 sows

8. Quality Assurance

Quality Assurance Process

To ensure accuracy and methodological rigour, the author engaged in the following quality assurance process.

- ✓ Internal/Departmental
  - ✓ Line management
  - ✓ Spending Review Sub-group and Steering group
  - ✓ Other divisions/sections – Central Votes Section and the Public Service Reform and Delivery Office.
  - ☐ Peer review (IGEES network, seminars, conferences etc.)
- ✓ External
  - ✓ Other Government Department
  - ✓ Advisory group
  - ✓ Quality Assurance Group (QAG)
  - ☐ Peer review (IGEES network, seminars, conferences etc.)
  - ☐ External expert(s)
- ✓ Other (relevant details) – Teagasc

DAFM Spending Review of AGRIP 2020

Action Plan for Implementation of Recommendations

Date: November 1st 2020

Submit to: Prof. Frank O'Mara, Director of Research, Teagasc.

This action plan outlines the recommendations from the *DAFM Spending Review of AGRIP 2020* and specifies the actions to be taken, if any, to implement the recommendations outlined, allocates responsibility for these actions and set a target date by which the recommendation is to be implemented.

No.	Recommendation	Actions to be taken	Person responsible	Date for completion
1	Continue to liaise with DAFM to ensure alignment of research goals and policy objectives, particularly for the next Agri Food Strategy currently being developed.	• Teagasc representative on the Agri-Food Strategy to 2030 - Stakeholder Committee is Mr. Liam Herlihy (Chairman of Teagasc). • Teagasc has made submissions to the committee in the areas of: Climate Smart, Environmentally Sustainable Agri-Food Sector; Viable and Healthy Primary Producer; Innovative and Competitive Agri-Food Sector, Driven by Technology and Talent • The new Teagasc Statement of Strategy will be in line with the new Agri-Food Strategy to 2030 • AGRIP contribution to Annual Programme of Activities sent to DAFM each year as required under Section 13.3 of the Agriculture (Research, Training and Advice) Act, 1988.	Frank O'Mara	Dec 2020 Annually
2	Ensure the principles set out by AGRIP continue to bolster the productivity of farms and that this evidence is disseminated and demonstrated to a wider audience to encourage adoption of innovative technologies particularly from less profitable sectors.	The AGRIP will continue to bolster productivity on all farms. This will be achieved by: • Strong collaboration with Teagasc KT programme to facilitate the adoption of key technologies at farm level. • Joint farm development programmes with key stakeholders in the industry- both dairy and meat processors, AHI, ICBF etc. • National programmes such as Grass10, Sheep BETTER farm programmes; Green Acres dairy calf to beef programme etc. • Public events- Open Days, farm walks, conferences etc. • Communication: Today's Farm, Website, Social media- Facebook, Twitter, etc.	Pat Dillon /Frank O'Mara.	Dec 2022
3	Improve the measurement of environmental performance and develop low emission technologies to improve the sustainability of animal production systems. The interaction between AGRIP and the	Key challenges facing the agri-food industry include climate change, deterioration in water quality, increased ammonia emissions and requirement to improve animal health and welfare. Therefore it is essential that there is strong collaboration between Teagasc AGRIP and CELUP programmes. Teagasc has recently developed a Marginal Abatement Cost Curve for both Green House Gas Emissions and Ammonia emissions. These include 14 and 13 mitigation measures in relation to GHG and Ammonia	Pat Dillon /Frank O'Mara.	Dec 2022

	other Research Programmes offers one mechanism for accelerating progress in this area as demonstrated by the improvement in nitrogen use efficiency on grassland and anaerobic digester /biogas studies.	respectively. To facilitate the adoption of these mitigation measures at farm level Teagasc is about to launch the new Signpost farm programme. This is a collaborative programme between all the main stakeholders in the agri-food industry.		

End