Science and Technology Driving Sustainable Growth in the Agri-Food Sector

Teagasc submission made in response to the Consultation Paper for the Successor to Strategy for Science, Technology and Innovation

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Teagasc response to SSTI Consultation Paper

Teagasc welcomes the Government initiative to develop a new Strategy for Science, Technology and Innovation. Research, new technologies and innovation are critical for the progress of the Irish economy. Ireland continued to invest significantly in publicly funded research and innovation throughout the period of the economic downturn. This has led to a strong science base in many areas, including in agriculture, food science and related disciplines. Now that the country is emerging from this period, there is the opportunity to further strengthen the system and increase the economic return by increasing the investment. This needs to be done in a strategic manner if the taxpayer is to see the maximum return on the investment. This is the significant role to be played by f a well-constructed SSTI.

Teagasc endorses the National Research Prioritisation Exercise which recommended targeting public investment in research at areas that are most likely to return a dividend in the form of jobs and economic growth. One of these areas is the agri-food sector. We believe that the strategy has been successful and has contributed strongly to the economic recovery now taking place in Ireland, and to which the agri-food sector made a significant contribution. Later in this report, we highlight examples of recent impacts of Teagasc led research on the agri-food sector which have contributed to its on-going strength

Given the success of the NPRE since its inception, Teagasc recommends the continuation of this strategy of prioritising research oriented towards the Irish enterprise base. Assisting the Irish enterprise base to become more knowledge intensive through developing and deploying new technologies and other know how will assist it to compete internationally and continue the recovery in the Irish economy. This is particularly the case for indigenous industries such as the agri-food industry, which predominantly rely on Irish research to meet its knowledge needs.

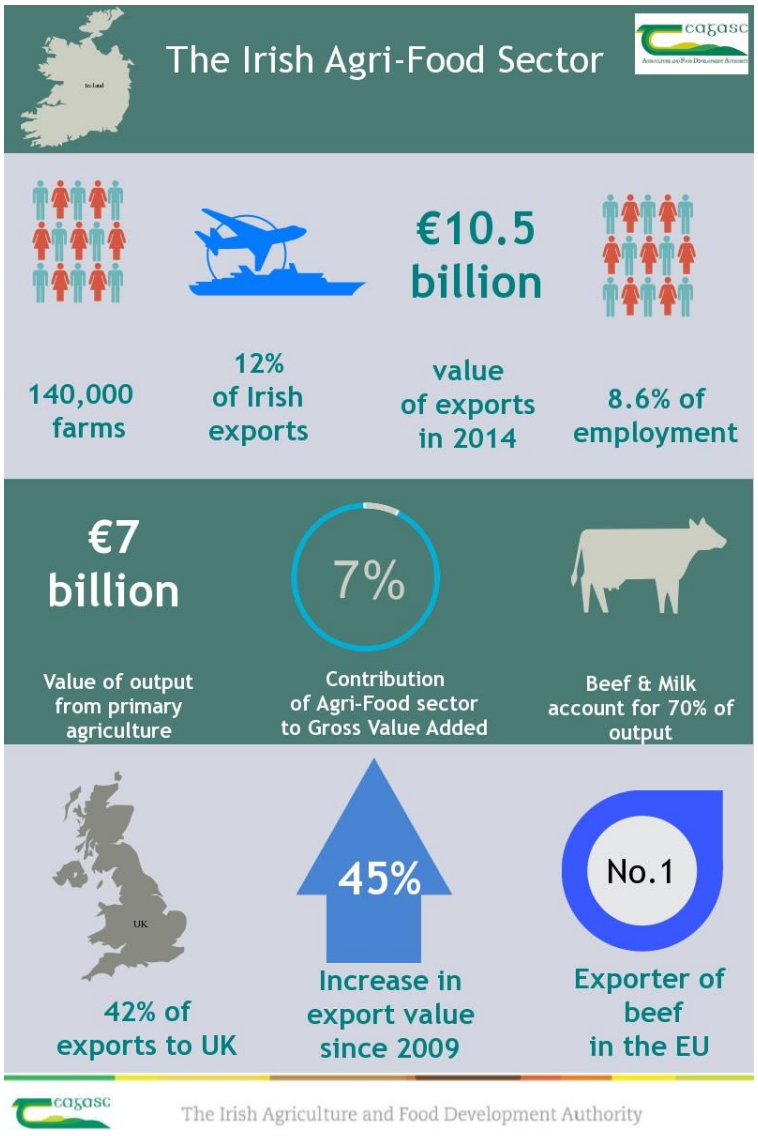
Teagasc also recognises the need to invest in research to support and underpin policy. This is particularly relevant in the agri-food sector where policy choices can critically impact on the sector. Some recent examples are the reform of the Common Agricultural Policy, s, international climate change agreements, and EU Directives around water quality (e.g. Water Framework Directive and Nitrates Directive). In the section on research impacts below, we highlight several examples where research has helped to secure favourable policy outcomes for Ireland. Teagasc also recognises the need for investment in fundamental research for the generation of new knowledge. However, such research should ultimately be aimed at improving the economic and wellbeing of the country and the health and wellbeing of its citizens.

Notwithstanding the requirement to invest in research for policy and research for knowledge, Teagasc firmly believes that the bulk of public investment in research and innovation should be directed to support the Irish enterprise base.

In this submission, we give some background on the recent progress in the Irish agri-food sector. Teagasc is the largest public research institute outside of the university system in Ireland, and it has a statutory role to provide the research needs of the sector, and in the next section we provide some details on our scientific performance and some examples of where research has underpinned the progress of the sector. In the following sections, we provide specific material relating to the eight pillars in the Consultation Document.

The Irish Agri-Food Sector

The export value of the Irish Agriculture Food and Drink sector topped €10 billion in 2014 representing a 45% increase since 2009. The wider agri-food sector, encompassing fishing & forestry, food, beverage and wood processing, accounted for 8.6% of employment in Ireland in 2013. The recent ending of milk quotas after 31 years in existence is likely to give a further surge in agricultural production and exports, and an additional 16,000 jobs in the dairy sector are anticipated.



According to the Department of Agriculture, Food and the Marine, the Agri-Food sector is one of Ireland's most important indigenous industries, employing in the region of 170,000 people. Over 100,000 of these workers are engaged in primary agriculture with a further 48,500 in food processing; the remainder are employed in the beverage and wood processing industries. The sector accounts for half of purchased Irish goods and services by the manufacturing industry and just over half of exports by

indigenous manufacturing industries. Furthermore the Agri-Food sector in Ireland contributes a value of €24 billion to the national economy.

Main Commodities Output and Exports

- The contribution of primary agriculture to the Irish economy in 2013, at 2.4% of GDP, is around twice that of the EU average, while the larger agri-food sector accounts for 7.2% of GDP. Agri-food exports account for 12% of exports from Ireland and over 25% of total foreign earnings.
- Cattle and milk output accounted for around 70% of agricultural output (excluding the value of forage crops) at farm gate prices in 2013.
- In terms of the destination of Irish food and drink exports in 2013, the United Kingdom at around 42%, remained the principal market with sales of just over €4 billion. Continental EU markets account for 31% of food and drink exports, with a combined value in excess of €3 billion.
- In 2013 Ireland exported in excess of 90% of its net beef output, making it the largest beef exporter in the EU and fourth largest in the world. Agri-food exports comprising dairy products & ingredients accounted for 30%, Beef & veal 21% prepared consumer foods 18%, beverages 14%, seafood 5%, pig meat 4%, while live animals 2%, sheep and sheep meat together with poultry and edible horticulture accounted for 2% each.

The Net Contribution of the Agri-Food Sector to the Inflow of funds to Ireland

The agri-food sector makes a very significant contribution to the net inflow of funds to the Irish economy. A recent analysis highlights that the 'bio sector'

- contributes approximately 30% of the total net earnings from primary and manufacturing industries
- This is approximately double the sector's contribution to exports. The main reasons for the sector's disproportionately large net contribution to earnings from exports are; its low import dependence, accounting for half of all purchased Irish goods and services by the manufacturing industry, and the low levels of profit repatriation among its processing firms.

This contribution is also reflected by the fact that for every €100 of exports, the 'bio sector' accounts for significantly higher net foreign earnings than the 'non-bio sector'. In 2005, this was €48 for the 'bio sector' as opposed to €19 for the 'non-bio sector'. The largest disparity between the 'bio sector' and the 'non-bio sector' was in the import content of exports. These were €38 per €100 in the 'bio sector', but €58 per €100 of exports in the 'non-bio sector'.

Key facts

-Supplies the majority of produce to Ireland's €14bn domestic grocery and food service sector
-Ireland is the largest net exporter of dairy ingredients, beef and lamb in Europe
-Ireland is the largest exporter in Europe of powdered infant formula
-Ireland exports over 80% of its dairy and beef production
-Ireland is the UK's largest supplier of food and drink
-Irish beef is stocked by more than 70 retail chains across Europe
-Ireland exports over half the pig meat it produces – to over 60 countries around the world.

Teagasc role and performance in meeting the science and technology needs of the agri-food sector

Teagasc occupies a unique and important position in the Irish agri-food research landscape. It is the largest public research institute outside of the university system in Ireland. Teagasc is an independent government agency under the auspices of the Department of Agriculture, Food and Marine, with a statutory role in the provision of research for the Irish agri-food sector. Many countries have comparable government agencies to provide agri-food research, e.g. INRA in France, INIA in Spain, USDA Agricultural Research Service in the USA, AgResearch in New Zealand, MTT in Finland, etc.

Teagasc was established under the Agriculture (Research, Training and Advice) Act 1988, which states that its principal functions shall be:

- To provide, or procure the provision of educational, training and advisory services in agriculture, including such educational, training or advisory services 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).

This mandate gives Teagasc responsibility for meeting the knowledge and technology needs of the entire food chain and the authority to integrate research, advice and education services to deliver the innovation support necessary to add value to Ireland's agri-food sector. There are other research performing organisations with significant agri-food research capability in the third-level sector, particularly UCD and UCC. However, unlike universities and third level colleges, which have as their primary function, the education of graduates, and whose research programmes are much wider than agriculture and food, Teagasc's mandate just relates to agri-food research, training and extension. The mandate of Teagasc thus distinguishes it from other research-performing organisations.

The Teagasc funding from grant-in-aid and other sources is used to deliver a research programme that covers animal, crop, food, soils, environment, and rural economics and development. This large programme (supplemented with research conducted in other institutions) has served the research and innovation needs of the industry well over the years.

Teagasc scientific output has increased over recent years (Table 1), despite reductions in staffing and funding. Peer-reviewed publications are not an end in themselves for an organisation like Teagasc, which seeks to have an impact on industry and society, but they remain the best and most cost-effective way for a science organisation to promulgate its research, build an internationally-leading brand, and assess the quality, productivity and impact of its science. Peer-reviewed publications are not an alternative to or a distraction from achieving industry impact, but rather they are the solid, science-based foundation on which industry impact can be achieved. As a result, Teagasc places great emphasis on producing a significant body of scientific work which is of a high standing nationally and internationally.

Table 1: Annual publication (peer reviewed scientific articles) performance for Teagasc from 2009 to 2013

Teagasc Performance by Year								
Year	Total Publications	Total Citations	Citations / Publication	Journal Actual / Expected Citations*	Category Actual / Expected Citations*	Total Permanent FTE Researcher Years	Pubs / Permanent FTE Researcher	Average Impact Factor
2009	328	3121	9.515	1.83	1.95	98.68	3.32	2.163
2010	349	3075	8.811	2.14	2.40	94.48	3.69	2.687
2011	405	2691	6.644	3.24	3.88	90.17	4.49	2.826
2012	434	1444	3.327	9.87	10.60	93.70	4.63	2.718
2013	422	407	0.964	2.78	235.26	93.40	4.52	2.813

The SCImago Research Group publishes an annual global institutional ranking analysis called the SIR (SCImago Institutional Ranking). The SIR analyses the research outputs of universities and research-focused institutions and presents a range of bibliometrics indicators for each institution based on publications in scholarly journals indexed by Scopus.

The SIR is published in July and the data presented here was taken from the analysis which was published in July 2013. Further information on the SCImago methodology and indicators can be found at www.scimagoir.com.

The SIR lists institutions according to outpu,t but they also present a range of indicators, which can be used to analyse the scientific production of the institutions listed. These indicators are outlined in Table 2.

Table 2 Indicator key for SIR analysis

Indicator	Looks at	Taken to mean
Output	Total number of documents published in scholarly journals indexed by Scopus (includes A1s, conference papers, letters etc.)	Scientific output
%IC	% output with a foreign affiliation.	% international collaboration
NI	The impact of an article compared to the average impact of a similar type article in the same journal in the same year. 1 = world average; >1 = above world average; <1 = under world average.	Average normalised Impact
%QI	% output in the top 25% of scholarly journals within their respective categories according to the SJR (SCImago Journal Ranking)	% high impact publications
Spec	The thematic variance in an institutions scientific output.	Specialisation index: scale 0 – 1, indicating generalist vs specialist
%Exc	% output of an institution that appears in the 10% most highly cited papers for their field	Scientific Excellence
% Lead	% of output where the institution is the main contributor, ie. the corresponding author	Scientific Leadership
%EwL	% of Exc documents where the institution is the main contributor, ie. the corresponding author	Excellence with Leadership

Within Ireland, 21 institutions were looked at, including the universities, the IoT's and the research hospitals. Table 3 shows the SIR analysis for Irish institutions, ranked according to % Exc, i.e. the percentage of the institution's papers falling within the 10% most highly cited papers in their field.

Table 3: SCImago Insitution Ranking for Ireland, 2013, ranked according to %Exc*.

ORGANISATION	SECTOR	OUTPUT	%IC	NI	%QI	SPEC	%EXC	%LEAD	%EWL
TCD	HE	8598	49.16	1.71	59.97	0.45	20.17	61.27	10.56
TEAGASC	GO	1405	40.85	1.37	72.88	0.9	18.8	57.72	9.01
UCD	HE	10083	49.85	1.55	61.6	0.45	18.52	56.75	7.87
RCSI	HE	1653	45.8	1.5	67.09	0.75	17.56	51.6	7.92
UCC	HE	6369	48.78	1.36	54.59	0.49	16.89	63.18	9.39
NUIG	HE	4472	52.55	1.38	52.44	0.51	16.82	58.68	8.42
DUBLIN INST ADV STUDIES	HE	538	85.87	1.42	65.24	0.96	16.7	29.93	2.66
SVUH	HL	1129	30.2	1.53	63.06	0.86	16.49	63.77	7.22
ST JAMES'S	HL	1245	39.04	1.61	59.6	0.82	16.41	54.62	6.26
OUR LADY'S HOSP	HL	641	42.75	1.52	56.63	0.88	15.65	49.45	3.29
MATER	HL	905	37.46	1.47	60.22	0.84	15.35	56.24	5.45
NUIM	HE	1766	54.59	1.24	49.26	0.62	15.21	59.23	7.7
DIT	HE	1347	36.97	1.18	44.17	0.7	14.97	66.96	9.31
WIT	HE	537	44.13	1.04	28.12	0.86	14.77	66.48	10.23
CIT	HE	473	42.71	1.19	38.05	0.84	14.54	47.57	5.34
DCU	HE	3481	43.46	1.2	45.39	0.61	14.51	67.08	8.19
CORK UNIV HOSP	HL	758	29.55	1.52	53.96	0.86	13.11	65.96	6.28
ADELAIDE & MEATH HOSP	HL	745	33.69	1.53	50.07	0.86	12.72	63.49	4.92
BEAUMONT	HL	1069	30.31	1.32	59.12	0.83	12.22	62.02	5.3
UL	HE	3067	42.55	1.08	38.73	0.64	11.72	68.11	7.6
GAL UNIV HOSP	HL	589	24.45	1.25	55.86	0.85	11.56	58.74	5.25

* Scientific excellence: the percentage of the institution's papers falling within the 10% most highly cited papers in their field

HE - Higher Education

GO - Government

HL - Health

From the SIR, Teagasc's excellence rate (%Exc) is second only to TCD with 19% of its publications among the 10% most highly cited within their field. It is fifth nationally when ranked by excellence with leadership (%EwL) with 9% of its publications in this category. Teagasc is the main contributor on 58% of its publications, which is an indicator of scientific leadership (%Lead). Teagasc placed more publications (%QI = 73%) in top quartile SJR Scopus ranked journals, within its field, than any other Irish organisation and according to previous SCImago reports (data not shown) Teagasc did the same in 2012 and has steadily increased the number of publications in top quartile journals since 2009. Teagasc has international collaborators (%IC) on 41% of its publications and it is a highly specialised research institute (SPEC = 0.9), the second most specialised in Ireland. According to the SIR the average impact (NI) of Teagasc's publications is 37% better than the world average and which places it above UCC, DCU, NUIM, DIT, WIT, CIT and UL.

In order to analyse Teagasc's global performance, a sub-set of similar organisations was chosen from the 2013 SIR reports. These were, INRA, INIA, IRTA, SCRI, BBSRC, AgResearch NZ, Wageningen University & Research Centre, MTT AgriFood Research and BBSRC which encompasses IFR, IBERS, Rothamstad, Roslin Institute, John Innes Cntr, IAH, TGAC and the Babraham Institute. SIR data for the subset is shown in Table 4, ranked according to % Exc, i.e. the percentage of the institution's papers falling within the 10% most highly cited papers in their field. Missing from the subset is SRUC (also SAC) as they weren't listed in the report.

Table 4: Subset of similar institutions from the 2013 SIR report, ranked according to %Exc*

ORGANISATION	OUTPUT	SPEC	%IC	NI	%QI	%EXC	%LEAD	%EWL
BBSRC	4861	0.83	58	1.95	83.11	27.92	47.85	12.83
SCRI	806	0.9	60	1.9	77.42	26.84	43.8	11.11
WAGENINGEN UNIV & RES CNTR	11120	0.75	56	1.65	72.74	22.2	53.27	11.06
TEAGASC	1405	0.9	41	1.37	72.88	18.8	57.72	9.01
IRTA	1443	0.89	42	1.49	69.16	18.58	53.64	9.46
INRA	20162	0.73	48	1.43	71.81	18.3	52.54	8.74
MTT AGRIFOOD RES	768	0.88	38	1.3	58.72	15.48	52.47	6.75
INIA	1246	0.9	36	1.16	70.63	13.88	53.29	6.17
AGRESEARCH LTD	1445	0.85	41	1.19	60.14	13.11	54.39	5.85

* Scientific excellence: the percentage of the institution's papers falling within the 10% most highly cited papers in their field

Teagasc ranks fourth in terms of excellence (%Exc), and is above IRTA, INRA, MTT, AgResearch and INIA. It is above the same group except MTT for excellence with leadership (%EwL). However, it ranks 1st in the subset for leadership (%Lead) as it is the main contributor on 57% of its publications. The average impact (NI) of Teagasc's publications is above that of AgResearch NZ, INIA and MTT Agrifood Research

and similar to INRAs. Teagasc ranks 3rd according to percentage of publications in top quartile journals within their fields (%QI). It is one of the most highly specialised (SPEC) institutes in the subset along with INIA and SCRI.

Peer reviewed publications form the solid scientific basis on which Teagasc seeks to have an impact on the agri-food industry and on policy for the sector. In the table below, some examples of impact in 2013 and 2014 from Teagasc-led research are given. Further examples are available at www.teagasc.ie. These examples show how research can positively impact on the enterprise base and influence enterprise-relevant policy. They are testament to the success of the NRPE.

Table 5. Examples of impact of Teagasc-led research in the Irish agri-food industry

1	**Genomic selection in cattle breeding** Teagasc led research was instrumental in the introduction of genomic selections in the Irish national dairy cattle breeding programme in 2009, being the second country in the world (after the US) to do this. Helped by widespread adoption (circa 60% of bulls selected based at least partly on genomic proofs), the rate of genetic gain of the dairy herd has increased by c. 50% since the introduction of genomic selection. One of the outcomes Since then, Teagasc lave led the development of a unique new cattle genotyping panel (SNP chip) first launched in 2013 which is now widely used for cattle genotyping in Ireland and is central to national cattle genotyping programmes.
2	**Fertility improvement in the national dairy herd** Milk production worldwide has suffered from a decline in dairy cow fertility which is associated with breeding for increased milk production. Ireland has managed to halt and reverse this decline in fertility in the national dairy herd through the introduction and application of the Economic Breeding Index (EBI) which is the tool dairy farmers use to select new stock. Teagasc research led to the high weighting on fertility that is currently used in the EBI.
3	**Protecting the quality image of Irish butter** A proactive research and education campaign has led to a halving of trichloromethane levels in Irish butter. Already below safe levels, the industry wished to further lower levels to ensure the premium position of Irish butter on markets such as the German market. Research was conducted to identify causative factors and to develop protocols to reduce it safely. Best practice protocols were developed and with an on-going monitoring and advisory programme, levels were halved between 2009 and 2013.
4	**Guiding dairy expansion – the Greenfield Programme** Since 2009, the Teagasc-led Greenfield programme has been very influential in preparing farmers for dairy expansion post milk quotas. It involved the Greenfield farm in Kilkenny (a 300 cow herd established from scratch on a converted tillage farm, where land rental, labour and all investment set-up costs have to be met from the income generated by the farm) and two commercial expanding dairy farms. The full performance and financial data for all farms are collected and widely disseminated by Teagasc and the media partner (Irish Farmers Journal). The programme aims to demonstrate to existing and new entrant dairy farmers the skills and technologies required to profitably grow their business. The Greenfield programme has averaged 2-2,500 farmer visitors each year since its inception.
5	**New Cheese Technology Platform** Teagasc has developed a new cheese technology platform that allows the manufacture of cheeses from reassembled milk formulated from dairy ingredients. Advantages include the absence of a whey release step, the complete retention of materials such as odours and flavours, and a greater opportunity to innovate characteristics such as flavour, texture and cooking properties. The technology has been licensed to the Ornua (Irish Dairy Board) who are investing €20 million in a

	facility in Saudi Arabia to manufacture cheeses for the local market using the technology
6	**Fungicide resistance in cereal pathogens** Irish wheat yields are among the highest in the world. This is hugely dependent on efficient control of diseases, with septoria tritici being amongst the most important of these. Teagasc research has shown that the pathogen involved is developing reduced sensitivity to the one of the main group of chemical control agents, the azoles. We have further developed anti-resistance strategies to ensure both effective disease control and minimal resistance development. This has helped to increase awareness among farmers and changed disease control practices which will help to preserve the effectiveness of this group of fungicides.
7	**New soil information system** The completion of the 3rd edition soils map of Ireland provides a major resource for Irish agriculture. The new map now provides soil information at a 1:250,000 scale providing information on soil series, mapped as associations. In addition to the soils map, this project provides a database of soil profile information relating to both the original 450 soil series recorded by An Foras Talúntais as well as an additional 240 soil series recorded in the Irish Soil Information System (SIS) project. The soils map of Ireland will be used by a large range of stakeholders, from researchers, agricultural advisors, farmers, teachers, policy makers to European Commission.
8	**Gluten-free food products** The increased incidence/diagnosis of coeliac disease in Ireland, coupled with consumers following a gluten-free diet for other health reasons has resulted in a significant rise in the demand for high quality gluten-free products. Teagasc has developed an expertise in this area, and has collaborated closely with a number of bakeries. As a result, novel gluten-free breads, with good texture and flavour, and confectionery-type products, have been developed to take advantage of this market.
9	**Proving the high welfare status of Irish beef cattle** Ireland is the 4th largest net exporter of beef in the world. However, concerns relating to the welfare of farm animals are becoming increasingly important within the European Union (EU). A recently completed Teagasc study highlighted the positive welfare attributes of Irish grass-based beef production systems when benchmarked with an intensive beef production system in Belgium. The results of the study are playing a key role in developing the competitive image of Irish beef and are being used by Bord Bia to highlight the animal welfare friendly practices of our beef production systems. The research has been communicated to retailers, media and NGO's in important European beef markets such as the Netherlands.
10	**Making pastures more profitable** Based on research to evaluate the impact on profitability and productivity of different grass varieties and cultivars, Teagasc has developed the Pasture Profit Index which is a tool to evaluate the overall merit of a grass variety from the point of view of its impact on profitability. This new tool allows farmers make better decisions about varietal selection when reseeding.
11	**Solving the protein problem in malting barley** Prior to the research malting barley growers were experiencing considerable problems in producing malting barley with protein levels that met the required market specification. The research identified fertiliser N strategies that maximise the probability of achieving required protein levels without compromising yields. Implementation of these strategies at farm level has reduced problems with unsuitable protein levels.

12	**Providing the science base for climate change policy** In 2014, the European Council took a major Decision on the Climate and Energy Framework for 2030, and adopted the amendment proposed by Ireland that recognises that agricultural emissions should not be reduced at the expense of food security, and has raised the possibility of agricultural emissions being partially offset by sequestration through e.g. afforestation. Working with the Agricultural Climate Group chaired by the DAFM, Teagasc provided the science base for the amendment. This changed with the recent European Council Decision which explicitly opens the door to Integrated Land Management, in which
13	**Science-based adjustments to the Nitrates Action Programme** The European Council Nitrates Directive aims to reduce water pollution caused or induced by nitrates from agricultural sources. Each Member State must have a Nitrates Action Programme (NAP). Teagasc made a science-based submission on the NAP proposing several changes, which were agronomically beneficial and environmentally benign which were subsequently incorporated into the new NAP.
14	**Teagasc economic analysis assists in CAP negotiations** A reform of the EU Common Agriculture Policy (CAP) was completed in 2013 and sets out EU policy and supports to the sector for the next 7 years. Teagasc conducted research on the impact of CAP reform agreement and its implementation on Irish agriculture and provided this to Department of Agriculture, Food and the Marine (D/AFM) throughout the reform negotiations process. This analysis contributed to the successful completion of the CAP reform under the Irish EU presidency. The Teagasc research highlighted that while more redistributive CAP implementation options would lead to more farmers gaining in terms of direct payment receipts, these gains would come at the expense of farms which produced more of Ireland's agricultural output. The policy choice made by Ireland (which redistributes direct income support to the least extent allowed under the reform) reduces the probability that CAP reform implementation choices will negatively affect future Irish agricultural production.

Pillar 1: Investment in STI and Key Targets/Goals

Key areas to be explored include:

- **What should Ireland's ambition be in STI?**
- **Ireland is currently an innovation follower and lags other small developed countries in R&D intensity. Should we have more ambitious targets for investment?**
- **How can that level of ambition be justified? Where should we target increased funding and how could this be justified?**

Ireland is currently below the EU average for GBAORD (0.64% vs 0.49% of GNP). We are well behind competitor countries such as Finland (1.01%), Sweden (0.83%) and the Netherlands (0.75%). Over the course of this SSTI, the aim should be to increase GBAORD to the EU average which is 0.64% of GNP. This also happens to be the level that GBAORD was at in 2009, so achieving this target would restore it to the level it had attained.

This level of GBAORD is justified by the return on investment in R&D, which has been shown in many studies. For example, the estimated annual internal rate of return to investment in agriculture research has been estimated to be in the range of 40-55% in a number of Irish, US and UK studies. There are many examples of economic benefits derived from agricultural and food research. Ireland now has one of the most cost competitive dairy industries in the world and is producing products at the most technically challenging end of the market, for example infant milk formula. Advances in dairy cow breeding based on research such as the introduction of the national breeding goal, the Economic Breeding Index (EBI) and the introduction of genomic selection (the second country on the world to introduce this into a national cattle breeding programme, after the USA) has delivered huge value to the industry. Irish wheat yields are amongst the highest in the world. Ireland has developed a very high tech mushroom industry which is now our largest horticulture sector.

Teagasc firmly believes that the significant majority of public investment in research and innovation should be directed to support the Irish enterprise base but does recognise the requirement to invest in research for policy and research for knowledge. The National Research Prioritisation Exercise has been successful in identifying the priority areas for public investment, and this should continue to guide investment decisions.

Areas that should be prioritised within agriculture and food include:

Animal breeding and genetics
Grass and forage breeding, production and utilization
Animal health
Precision (livestock) agriculture and the role of 'big data'
Agriculture and the environment – water quality, climate change and biodiversity
Soil health, nutrient status and nutrient use efficiency
Food quality and innovation especially in the dairy and meat sectors
Foods for health
Food safety
Crop Production, particularly disease and pest control
Economic analysis and modelling of Irish agriculture
Land-use and spatial analysis
Forestry and Horticulture

It is important to increase innovation emanating from research to derive value from public research investments and to make Ireland a truly knowledge-based economy. Complementarity between public and private research needs to be encouraged. Much progress has been made with tax incentives for R&D, and this should be built on. Moves towards the introduction of a Knowledge Box are to be welcomed.

In achieving and measuring innovation from research, it is important to note that channels other than licencing of technology exist. Contract and collaborative research, consultancy, knowledge transfer through advisory services, specialist training and provision of specialist services are all channels by which value is derived from the public research base.

Pillar 2 Prioritised Approach to Public Research Funding

Key areas to be explored include:

- **How can research prioritisation better serve our national objectives of a strong sustainable economy and a better society?**

The research prioritization exercise has had a significant effect on the Irish research ecosystem, putting a focus on areas that have the greatest potential to deliver sustainable economic and societal return. Teagasc feels that the best way for the research prioritization exercise to continue to serve our national objectives is by implementation according to the following principles:

- investment in research and innovation should be targeted at the enterprise base
- Research undertaken within these fourteen areas must necessarily span the continuum from strategic to applied. While the division of funding across the continuum should continue to favour the applied side, all parts of the continuum should receive funding in order to provide a pipeline of ideas as well as a rounded education and adequate opportunities for our brightest young researchers
- For the prioritized areas H (Food for Health) and I (Sustainable Food Production and Processing), a joint strategic research and innovation agenda, Sustainable Healthy Agri-Food Research Plan (SHARP), has been developed by all of the relevant funders in collaboration with industry and research performers. Implementation of this agenda represents the important next step for research prioritization in these areas.
- The prioritized research areas need to be complemented by
    - A real commitment to research for policy. This includes research which underpins the Irish Government's negotiations at EU and International level. A percentage of funding should be allocated to bottom-up research calls where the research areas are proposed by applicants, regardless of the fourteen prioritized areas.

- **How best do we identify emerging areas of opportunity and challenge i.e. horizon scanning?**

This will best be achieved by a range of measures working together, many of which have been identified above:

- A new national Foresight study to identify research priority areas should be undertaken. Teagasc is currently engaged in a Technology Foresight, with the aim of identifying emerging technologies with the highest potential to contribute to the development of the Irish agri-food sector.

- A percentage of funding dedicated to bottom-up research funding calls. These would allow our best researchers to develop innovations outside of the strictures of research prioritisation.
- Ensuring sufficient core funding is maintained for mission-focused research organisations. This will give senior management in those organisations (who are all accountable to Government) flexibility to pursue a balanced research programme, and identify emerging areas of opportunity.

Pillar 3 Enterprise-level R&D and Innovation Performance

Key areas to be explored include:

- **A review of the outcomes of SSTI 2006-2013 shows that targets for the public research base were largely achieved or exceeded. Opportunities exist for further progress in regard to enterprise RD&I activity. How can public policy best support and more effectively optimise the impacts of enterprise RD&I investment - what actions could be taken to:**
  - **strengthen the number of innovation performers in the multinational sector?**
  - **broaden RD&I activity in the indigenous sector and build absorptive capacity?**
- **Do we need to enhance the suite of enterprise support programmes to further drive innovation in industry and/or is there scope for consolidation of the existing range of support programmes?**
- **How can we incentivise firms that are R&D active to scale their research efforts?**

As a first step, it is necessary to identify the barriers to innovation at a sectoral level. These will be different for different industries and a 'one-size-fits-all' approach will not yield results.

There is currently a culture of low industry investment in R&D. In order to change that culture, radical measures (e.g., tax incentives) are needed for a number of years. As the culture changes, these may no longer be necessary.

In the food area, Teagasc has developed a co-location model whereby food companies locate some of their research staff at Teagasc Moorepark. These staff carry out company research, but collaboration agreements with Teagasc mean that they access and collaborate with the research staff of Teagasc and also access (through rental) the Moorepark Technology Limited pilot plant facility. Several indigenous Irish and multinational food companies in the infant formula sector currently have staff located on-site at Moorepark in such collaborations, renting office and laboratory space from Teagasc. Teagasc has plans to develop a dedicated Food Innovation Hub at Moorepark to provide customised suites of offices/laboratories to companies so that this model can be fully exploited.

A number of other measures are suggested:

- MNC's that don't currently have a base in Ireland should be allowed to qualify as industry partners for the EI Innovation Partnership scheme, as long as it can be shown that it represents a first step in the consideration of Ireland as a base for future investment. In that way, MNCs could begin to develop a relationship with Irish research performers at low risk to themselves. That relationship could go on to form the basis for future investment in Ireland. As the link is based on research, it is more likely that the company will invest in research in Ireland, rather than just manufacturing.
- The level of IDA support for MNCs should be related to their investment in R&D
- A greater investment in staff exchange and placements between industry and the public-research base would help to foster collaboration and to increase company investment in R&D.

Pillar 4 International Collaboration and Engagement

Key areas to be explored include:

- **How can we further increase/strengthen the effectiveness of our international collaboration and engagement across all areas of STI investment in pursuit of economic and societal goals?**
- **What additional measures can be taken to maximise the engagement of industry as a partner in this regard?**
- **What additional measures could be taken to enhance Ireland's participation in Horizon 2020 and other EU Programmes - industry, academia, SMEs and MNCs?**
- **Are there research policy or programme developments taking place at EU level where enhanced engagement by Ireland could provide opportunities for research collaboration and ultimate economic or societal benefit?**

- Non-Irish institutions are generally not eligible for funding from Irish funding agencies. We propose that project leaders should be allowed to allocate a small percentage (e.g., 5 – 10%) of the project budget to collaborators who are based in institutions outside of Ireland. This would naturally be subject to the overall review process and the demonstration that this represents good value for money. As a partner, we are now seeing such opportunities open up from Norwegian, Australian and NZ funding agencies. Such a feature would allow Irish researchers to strategically align with top international research groups. This would be very beneficial for the development of the Irish-funded research project and for involvement in future consortia for Horizon 2020 and other funding programmes.
- ERA-NETs represent an excellent opportunity to foster Irish involvement in European research consortia. Through this mechanism, Irish funding agencies can continue to fund researchers based in Irish institutions, but instead of funding a stand-alone Irish project, the agency will be funding Irish involvement in a much larger European project. As a portion of the funding can only be won by Irish applicants (virtual common pot), there is an incentive for established European research consortia to involve an Irish partner. This can be the basis for a fruitful collaboration, which can lead to future Horizon 2020 applications. The recently published SHARP strategic research and innovation agenda makes a commitment that "national funders will in the first instance favour investments which enable Irish participation in European consortia and attempt to address them through these pan-European funding instruments". This commitment is very welcome. In the context of encouraging industry involvement in Horizon 2020, it would be very useful for the agencies with a remit to fund industry involvement in research to join strategically-important ERA-NETs as partners. This could lower the entry barrier for industry (indigenous and MNC) that wish to get involved in European consortia.
- It is vital to take every opportunity to engage with the European Research Area. Joint Programming Initiatives, ERA-NETs, Programme Committees, Advisory Committees (e.g., Standing Committee on Agriculture Research), European Innovation Partnerships, all provide an opportunity to influence the European research agenda. Organisations should be encouraged to take up these opportunities to engage with the EC. It would be also useful for Ireland to establish a directory of the people who are linked in to these official European groupings, so that individual researchers will know where to feed ideas for future topics and where to get information.

- The opportunity to use European research infrastructure, resources and programmes should be widely publicised amongst the research community. It appears that take up of these opportunities is relatively low and could possibly be improved through increased promotion.
- Ireland should link with relevant global research initiatives outside of the EU. Examples are the CGIAR (Consultative Group of International Agriculture Research) consortium of International Agricultural Research Centres, research programmes of the FAO (Food and Agriculture Organization) of the UN, the World Bank, and the Global Research Alliance (GRA) on Agricultural Greenhouse Gases.
- There is an opportunity for Ireland to use its research and development expertise to contribute to relevant global challenges such as food security, climate change, and rural development, and to provide expert economic policy analysis. For example, Teagasc signed an MOU with Irish Aid in February 2015 which provides for collaboration to enhance Ireland's contribution, through agricultural research, training and extension, to developing countries. The agreement supports Ireland's objectives of reducing hunger and under-nutrition in African countries. Teagasc is partnering in a number of initiatives with Irish Aid, NGOs, CGIAR and African national institutes that harness Irish expertise and knowledge to support improved food security in targeted countries in Africa.

Pillar 5 Organisational/Institutional arrangements to enhance research excellence and deliver jobs

Key areas to be explored include:

- **What could we do to further enhance our landscape and institutional arrangements to maximise the impact of research excellence and deliver jobs?**
- **Is there a need for a complementary market focused research centre structure in Ireland and how should that be organised?**
- **How can Ireland optimise its strategic advantages of location, scale and environmental quality as a fundamental component of its research infrastructure?**
- **How can we further increase/strengthen the effectiveness of our national collaboration and engagement across all areas of STI investment in pursuit of economic and societal goals?**

Teagasc is the only institute of scale in Ireland established by Statute outside of the universities and IoTs (the Marine Institute is the next biggest but is significantly smaller than Teagasc). It is focused on meeting the knowledge needs of the agri-food sector. The strengths of an institutional arrangement (clear mission focused on the enterprise, ability to plan and sustain long-term research programmes and capability, focus on industry impact) are clear and should be capitalised on.

For institutes to be effective, they do need programme money in order to plan and implement research programmes. Being funded on a project basis does not allow the advantages of an institution to be realised.

The small number of research institutes in Ireland is very different to some comparable countries (e.g. Finland and New Zealand).

Co-ordination is needed between research providers in Ireland. Currently, this is mainly driven by project level funding and EI/SFI centre funding which is effective, but institutions themselves could be more active in developing deep institutional collaborations. Teagasc has developed alliances with UCD (National Agriculture Partnership) and UCC (Food Research Ireland) and has just signed a MOU with the Tyndall Institute.

The tentative moves towards joint calls by finding agencies are welcome but the distinct missions and specialisations of different funding agencies needs to be recognised.

Emerging technologies will impact on all sectors of the economy, so organisation and funding of research must respond to this. Old barriers must be broken down and more flexibility, collaboration, multi-institutional and multi-disciplinary approaches are needed.

Ireland's location on the north west of Europe makes it a climatic area which is relatively unique in Europe and therefore makes Irish researchers and institutes attractive for EU projects where contrasting climatic conditions are desired. This is often the case for agriculture and

environment related projects. Ireland needs to ensure it has the facilities and resources to capitalise on these opportunities.

Irelands size and location makes it a good candidate for test-bedding various agricultural, maritime and environmental technologies. Opportunities to use this advantage should be developed.

Pillar 6 World class IP regime and dynamic systems to transfer knowledge and technology into jobs

Key areas to be explored include:

- **The establishment of Knowledge Transfer Ireland has seen an important evolution in our knowledge transfer system but what more can we do to enhance further the transfer of knowledge into jobs?**
- **In terms of Intellectual Property policy, are there specific interventions or supports of a legislative or non-legislative nature that would improve the business environment and act as an incentive to create and sustain an innovative culture?**

A significant issue is the low absorption capacity of SMEs in understanding IP issues etc. KTI could play a greater role in providing training and increasing awareness in these areas, to smooth such negotiations and manage expectations of the industry better. Also with significant increase in funding through industry led research initiatives, more needs to be done to assist funding agencies in providing more guidelines and indeed rules regarding IP ownership and preferential rights re licensing> Lastly there is very low level of understanding among PROs and industry of EU State Aid rules, and relevance in collaborating with industry and recent amendments and their implications-training, guidance and expertise in this area would greatly facilitate collaborations between industry and PROs. Workshops in this area would be welcome.

In achieving and measuring innovation from research, it is important to note that channels other than licencing of technology exist. Contract and collaborative research, consultancy, knowledge transfer through advisory services, specialist training and provision of specialist services are all other channels by which value is derived from the public research base.

Pillar 7: Government-wide goals on innovation in key sectors for job creation and societal benefit

Key areas to be explored include:

- **What steps need to be taken to further the translation of investments in STI into the achievement of stated public policy goals? How can the Strategy enable research programmes to optimally support policy development and actions to address key national challenges in areas such as environment, health, etc.**
- **What are the synergies between Government's goals in building a better society and the goal of creating jobs and economic growth?**
- **How can we address national challenges and also provide economic opportunities through development of new products, processes, systems?**
- **How can we address local and national challenges that are also regional and global challenges - how can Ireland through its research turn national challenges into global opportunities in areas such as sustainable land use, urban and rural development, and vulnerabilities to global trends and changes?**
- **How can Ireland harness the opportunities presented by the major developments on observation systems, including the analysis and use of Earth Observation data by a wide array of sectors and users?**

Steps to be taken to further the translation of investments in STI into the achievement of stated public policy goals

Strategic research and innovation agendas need to be implemented. For example, for the prioritized areas H (Food for Health) and I (Sustainable Food Production and Processing), a joint strategic research and innovation agenda, Sustainable Healthy Agri-Food Research Plan (SHARP), has been developed by all of the relevant funders in collaboration with industry and research performers. Implementation of this agenda represents the important next step for research prioritization in these areas.

It is important to ensure that the research conducted will meet the knowledge needs of the enterprise sector which is targeted. Therefore meaningful consultation must take place with stakeholders, and involvement of end-users in research should be encouraged.

Proper knowledge transfer systems need to be put in place. For agriculture research, a vibrant and properly resourced public extension service is necessary. For food, Teagasc has developed a Knowledge Transfer strategy which incorporates Food Technology Portfolio of key offerings, a CRM system, and biannual technology showcases branded as Teagasc Gateways.

Synergies between government goals in building a better society and creating jobs and economic growth

Employment and economic growth are key elements of a fair society, so in general, the two are very compatible. Therefore, in the context of the SSTI, there should continue to be a targeting of research investment towards the enterprise base.

Economic growth must occur in a balanced way across all the country. Agriculture and food is a very dispersed industry extending into every parish in the country, and growth and development in agri-food is a major contributor to balanced rural and regional development.

Addressing national challenges and providing economic opportunities

The NRPE has been successful in addressing national challenges (which are mostly linked to global challenges such as food security, energy security, obesity) while at the same time providing opportunities to the enterprise base in Ireland.

In targeting which areas of the enterprise base should be supported, the four criteria used in the NRPE are still very relevant:

1. The priority area is associated with a large global market or markets in which Irish based enterprises already compete or can realistically compete
2. Publicly performed R&D in Ireland is required to exploit the priority area and will complement private sector research and innovation in Ireland
3. Ireland has built or is building (objectively measured) strengths in research disciplines relevant to the priority area
4. The priority area represents an appropriate approach to a recognised national challenge and/or a global challenge to which Ireland should respond

Turning national challenges into global opportunities

Ireland should ensure that its research priorities in these areas align as much as possible with international research agendas, e.g. H2020, although it must be recognised that research for the Irish enterprise base should take primacy over research targeted to global priorities.

We should seek to attract global companies to Ireland based on our R&D excellence (and other factors). An example of success in this area is the infant formula industry. Most of the big global companies have facilities in Ireland, with the high quality of milk produced in Ireland and the relevance of research in bodies such as Teagasc being among the attractors. This in turn helps Irish exports to international markets.

Ireland can market its agri-food knowledge and innovation systems abroad, e.g. the newly formed Sustainable Food Systems Ireland.

Earth Observation Systems

Terrestrial observation from space will be transformed in the next decade with multiple observations per day from low cost optical satellites and new high resolution RADAR satellites eliminating existing barriers to EO data in Ireland; cost and cloud.

EO data will be the background to freely available products around forecasting time and location specific weather events to long term yield and growth forecast for crops and grass. Mobile technology will deliver information on current conditions when and where it's needed. The integrated nature of Ireland's agri-food sector from research to advice to marketing presents an ideal test bed for multinational technology companies based in Ireland to develop products and services across northern Europe.

For EO technology and service development Ireland is not on the "edge of Europe" but is instead at the centre of North Atlantic region- allowing for growth and worldwide excellence in terrestrial observation in the region but also oceanographic, costal and atmospheric sciences in which Ireland already leads. To harness and grow the existing potential in Ireland demonstration of a commitment to EO is needed in the form of a dedicated EO big-data centre or ground receiving station for EO data along with continuing and increasing science and policy engagement at the International level (e.g. through Group on Earth Observations).

As a "big data" problem the full exploitation of this extraordinary future data flow will depend on expanding skills in data analytics (especially parallel computing) along with geo-spatial specialists.

Pillar 8: Research for knowledge and developing human capital

Key areas to be explored include:

- **What more can we do to best harness the potential of our knowledge base for sustainable economic and social well-being?**
- **What additional steps can government take to ensure the development of human capital across the population to ensure the success of the new Strategy?**
- **How can we ensure that the requisite links between research and scholarship are maintained across all RPOs?**
- **In order to achieve a sustainable research capacity, are the outputs of our research system at doctoral and postdoctoral level the right ones in terms of volume, quality and relevant discipline?**
- **How can the new Strategy support and strengthen the reforms taking place under the Higher Education Strategy and align with the new National Skills Strategy and develop capacity to enable Ireland to deal with new and emerging challenges across the full breadth of government strategies?**
- **How can we better leverage our research talent into the economy? How can those individuals active in research (and those seeking to be), both in the public and private sectors, be best supported to perform and progress including through optimum researchers' careers, recognition and mobility mechanisms.**
- **How can gender equality in publicly funded research activity be further enhanced?**
- **How can the Action Plan for Jobs 2015 objective to increase the number of researchers in enterprise be fulfilled?**
- **Should research and innovation performers be supported to engage citizens more actively in the innovation process to achieve optimal outreach to the public?**

There is an urgent requirement to provide an appropriate career structure for early career researchers, in particular, after the post-doctoral researcher phase. The career structure should have clearly defined levels and should be recommended for both academic institutions and industry.

Within the agri-food research sector it is difficult to attract the best people to fill positions in research. A structured career path would assist in addressing this issue.

At undergraduate level universities are not adequately preparing graduates to undertake and pursue careers in research. There is a need for research led training to be incorporated in agri-food related courses provided by universities, institutes of technology and agricultural colleges.

While the throughput of PhD graduates within the agri-food sector is sufficient there is an insufficient number of post-doctoral researchers within the sector. The current salary scale and terms and conditions for post-doctoral researchers are making it unattractive to PhD graduates and this needs to be improved to enhance its attractiveness.

Within the 2008 report *Towards a Framework for Researcher Careers* there was a strong emphasis on training graduates and researchers for careers in academia. There is a need to focus on promoting careers in enterprise and industry and also promoting the benefits to industry of employing researchers.

To assist in the promotion and development of appropriate and relevant research skills to industry it is suggested to develop a funding stream that is part-funded by government and part-funded by industry. This would assist in promoting the outputs of our research system.

It is also suggested that industry placements be incorporated as a key element in PhD programmes to enable students to develop practical business skills and to actively expose companies to research. An international placement with a relevant research institution or company could also be incorporated in PhD programmes. This would enhance the development of the researchers' skills in addition to increasing collaboration and promoting mobility.

To ensure the successful development of human capital and sustainable research capacity it is critical that an attractive career structure for researchers pursuing careers in academia and industry is prioritised and developed.