Department of
Agriculture,
Food and the Marine
An Roinn
Talmhaíochta,
Bia agus Mara

Stimulating Sustainable Agricultural Production through Research & Innovation (SSAPRI)

A Research Agenda to guide public investment in primary agricultural research in Ireland

Coordinated by the Research Division,
Department of Agriculture, Food and the Marine (DAFM)

Image of landscapes, courtesy of Bord Bia

MINISTER'S FOREWORD

The agri-food sector is our largest indigenous industry with a gross annual output of over €22 billion, exports worth over €8bn per annum with some 135,000 people employed in sector. The sector is a playing a key role in Ireland's export led economic recovery and I am determined, as Minister for Agriculture, Food and the Marine, to grow the sector to its' fullest potential.

In this context, I am delighted to present **SSAPRI- Stimulating Sustainable Agricultural Production through Research and Innovation.** It was recommended in Food Harvest 2020 that '*DAFM should establish structures to facilitate greater input and resources from the agriculture industry into the design and structure of primary research programmes'.* I am delighted that the establishment of the Agri Research Expert Advisory (AREA) Group and the subsequent production of this report, co-ordinated by Research Division in my Department, has implemented this recommendation in full.

I firmly believe that this Strategic Research Agenda (SRA), which aims to guide public investment in agricultural production based research, will provide the scientific knowledge to underpin the growth targets in the Department's Food Harvest 2020 report. Despite the current economic difficulties, I strongly believe in research and innovation and I will do my utmost to ensure that resources are made available to the research community to address the research priorities identified in this report.

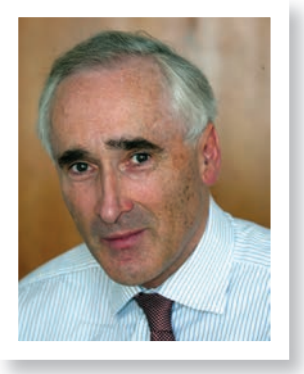
Notwithstanding this, I am conscious of the fact that Irish researchers need to continue to lever funds from the EU in order to complement any exchequer funding. I am also keen to see further industry involvement in proposals funded under my Department's three competitive research funding programmes, FIRM, RSF and CoFoRD[1]. Collaboration at all levels is of crucial important to ensure the taxpayer gets the best return on any research investments made.

Finally, I would like to acknowledge the level of stakeholder involvement that has occurred in developing SSAPRI in a relatively short period of time and I would like to sincerely thank all members of the Group and in particular the chairman, Mr. Matt Dempsey.

Simon Coveney, T.D, Minister for Agriculture, Food and the Marine

[1] FIRM- Food Institutional Research Measure
RSF- Research Stimulus Fund
CoFoRD- Programme of Competitive Forest Research for Development

CHAIRPERSON'S FOREWORD



The gathering of a group of individuals deeply involved in the agricultural sector to discuss research gaps and initiatives is a most worthwhile development. I was honoured and delighted to be asked to chair a group who gave of their valuable time so freely.

Our task was not to conduct an exhaustive examination of the entire panoply of Teagasc, Universities and other institutional research but rather to try and identify areas that may need re-emphasising or may have slipped through the cracks. The Research Stimulus Fund, operated by the Department, exists for precisely this purpose and while we tried (and broadly succeeded) to categorise them on the basis of objective priorities, inevitably individual preferences and expertise impacted.

We, a group of twenty one, met a total of eight times. The exercise will, I hope, help to guide at least to some extent the Department in allocating the research funds at their disposal under the Stimulus Programme. Other funding agencies may also make use of the report. I would like to thank my colleagues on the group who participated in the meetings with a combination of commitment, intellectual rigour and good humour.

The back up from the Department staff was outstanding. We can too easily denigrate those in the Civil Service without recognising the capacity and hard work that is given so freely. We were the fortunate recipients of both from the Research Division. To them also my thanks.

Matt Dempsey

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EXECUTIVE SUMMARY

Arising from a recommendation contained in the Food Harvest 2020[2] report that *"DAFM should establish structures to facilitate greater input and resources from the agriculture industry into the design and structure of primary research programmes"*, the Minister established an Agri Research Expert Advisory (AREA) Group. The primary objective of this Group was to develop a SRA for primary agricultural production and land use in Ireland to help guide future state research investment in the area.

While primarily intended to guide the content of calls launched under DAFM's own competitive, public good agricultural production research funding programme, namely the Research Stimulus Fund, the Group's SRA should also be used to inform the nature of other publicly funded research relevant to agricultural production undertaken by Teagasc and/or funded by other State agencies.

The SRA has been given the title **SSAPRI- Stimulating Sustainable Agricultural Production through Research and Innovation.**

Specific targeted research topics across four broad agricultural research areas were identified in the SRA and an overview is provided below.

Future investments in agricultural production based research must deliver strategic value for the sector and in turn contribute to achieving the growth targets as outlined in the Food Harvest 2020 report. In order to ensure that the research objectives remain relevant to the needs of the industry, it is proposed to review SSAPRI periodically. The implementation of SSAPRI will be very much dependent on the availability of national and international funds for research. However, before any future investments are made, it was important that the knowledge deficits relevant to the needs of the sector were clearly identified.

Thematic Research Area	Underpinning Key Investment Area
Animals (incl. issues relating to grass management/utilisation)	1. Animal Breeding, Genetics and Reproduction 2. Animal Well-Being (Health and Welfare) 3. Grassland Management and Breeding 4. Animal Nutrition and Product Quality 5. Sustainable Production Systems and Systems Analysis
Crops	6. Crop Physiology and Nutrition 7. Crop Breeding and New Varieties 8. Crop Management and New Technologies
Sustainability	9. Bio-energy and Bio-products 10. Water/Soil 11. Climate Change and Transboundary Gases 12. Biodiversity
Socio-economic, Policy and other Cross Sectoral Issues	13. Socio-Economic and Policy 14. Cross Sectoral Issues

[2]http://www.agriculture.gov.ie/media/migration/agri-foodindustry/foodharvest2020/2020FoodHarvestEng240810.pdf

CHAPTER ONE
INTRODUCTION

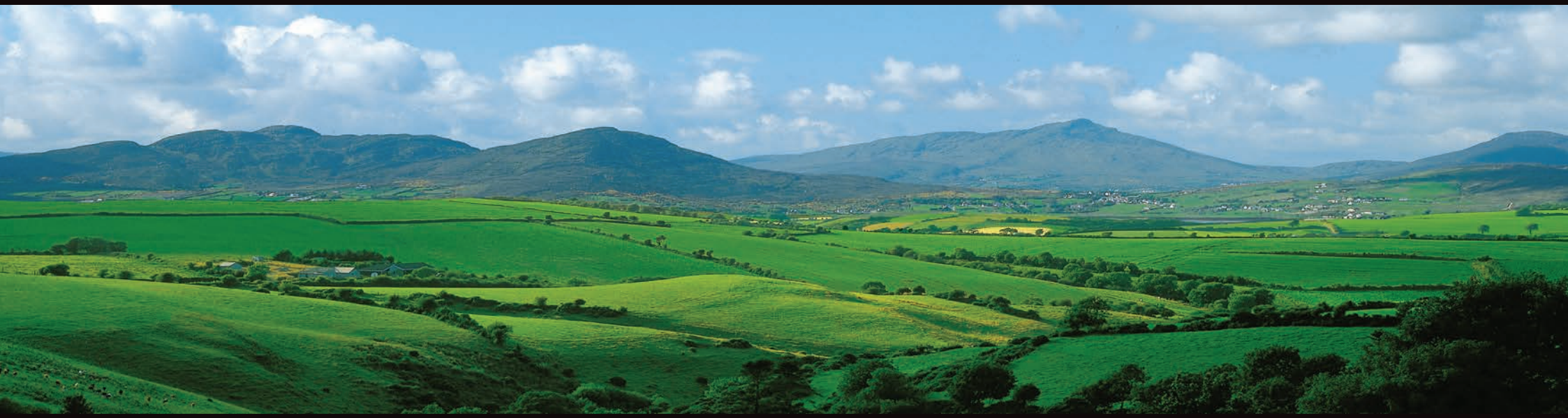

Image courtesy of Bord Bia

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1.1 Ireland's agricultural sector and its contribution to the Irish economy

The agri-food sector is a key part of Ireland's economy, being our largest indigenous manufacturing industry with a gross annual output of over €22 billion. Exports in the sector have grown faster than many other sectors and are worth over €8bn per annum; accounting for 60% of exports by indigenous firms and employment of some 135,000 people. The agri-food sector is the primary outlet for the produce and output of family farms and includes approximately 700 food and drinks firms throughout the country that export to some 170 markets worldwide.

The agri-food sector generates 6.2% Gross Value Added in Ireland and is responsible for 7.5% of employment. The sector is deeply embedded within the wider rural economy with employment, both direct and indirect, dispersed throughout the country. Currently there are 128,200 farm holdings in Ireland with c. 83,300 people reporting agriculture as their primary source of income[3].

Of a total land area of 6.9 million hectares, 4.2 million hectares is devoted to agriculture, of which 80% is predominantly pasture making Irish agriculture primarily a grass-based industry. Beef and milk production currently account for almost 69% of Gross Agricultural Output with pigs (7.4%), cereals (4.5%) and sheep (3.7%) also having a contribution[4]. Ireland's temperate climate allows us to exploit the competitive advantages associated with grass-based production systems compared with high input feed systems.

Importance of Agri-Food and Fisheries at a glance

- **Contributes gross annual output approaching €22 billion**
- **Directly employs over 135,000 people**
- **Provides the outlet for the produce from Ireland's 128,000 family farms**
- **Represents 60% of manufacturing exports by indigenous firms**
- **Domestically sources 71% of its raw materials**

Source: DAFM

3 CSO Farm Structure Survey. 2007
4 DAFM Factsheet on Irish Agriculture. June 2011.

1.2 Contribution of the agriculture sector to national economic recovery

The Government's National Recovery Plan[5] identifies the Agri-Food sector as playing a major role in Ireland's economic recovery. The Plan refers to DAFM's Food Harvest 2020 report which sets out a road map for growing the sector over the next decade.

Food Harvest 2020 sets a number of ambitious targets:

Increasing the value of primary output in the agriculture, fisheries and forestry sector by €1.5 billion. This represents a 33% increase compared to 2007-2009 average.

Increasing the value added in the agri-food, fisheries and wood products sector by €3 billion. This represents a 40% increase compared to 2008.

Achieving an export target of €12 billion for the sector. This represents a 42% increase compared to the 2007-2009 average.

Targets for Agri-Food sector – Food Harvest 2020

The Food Harvest 2020 Report is based on the premise of smart, green growth. ***SMART***, in the sense of investing in ideas, knowledge and skills and encouraging innovation and creativity. ***GREEN***, in the sense of clearly demonstrating and capitalising on Ireland's environmental credentials. Finally, ***GROWTH*** in the sense of efficient and environmentally sustainable production that delivers significant economic growth and allows the sector to play a part in Ireland's economic recovery.

The 'Pathways for Growth'[6] report prepared for Bord Bia by Professor David E. Bell and Mary Shelman of the Harvard Business School suggests that Ireland should adopt a strategy of developing a world-class agricultural industry by 2016 and set itself the goal of becoming the most efficient food and drink country in the world. The report promotes a 'Come See Us: We Are Open for Inspection' promise which is built on our promise that "we are natural and we can prove it" testament that our agriculture industry adheres to high standards for production, traceability and welfare.

A recent study commissioned by the Irish Farmers Association which was carried out by University College Dublin's Professor Jim Phelan and Dr. James O'Connell entitled "The Importance of Agriculture and the Food Industry to the Irish Economy" found that for every €100 of agricultural output, an additional €73 of output is added to the wider economy, creating a total of €9.25 billion output in the Irish economy[7]. The report further highlights how agriculture delivers a real return to the economy and demonstrates its potential for further and continued expansion.

5 National Recovery Plan 2011-2014. (http://www.budget.gov.ie/The%20National%20Recovery%20Plan%202011-2014.pdf)
6 Pathways for Growth- Building Ireland's largest indigenous industry. Prepared for Bord Bia by David E. Bell and Mary Shelman of the Harvard Business School
7 The Importance of Agriculture and the Food Industry to the Irish Economy. Professor Jim Phelan and Dr. James O'Connell, UCD. 2011.

1.3 Role of research in national economic recovery

Ireland's agri-food export oriented sector which is based on an internationally competitive production system and strong world demand for high quality Irish produce has the potential to be a key driver in Ireland's economic recovery in the coming years through an increase in output, export earnings and employment. The Food Harvest 2020 report recognises that substantial investment in agriculture research over the last decade has enabled Irish companies to build up wide-ranging expertise particularly in key dairy and beef sectors and has enabled Irish farmers to be among the most technically efficient in the world. This acknowledged, the sector operates in an environment which faces numerous challenges of a grand scale. In order for Irish agriculture to be a dynamic, competitive export industry operating on a world stage, future policy in the agri-food sector must be focused on areas where competitive advantage can be achieved.

The sector must become more innovative by investing in research, providing what the consumer wants, applying lean manufacturing techniques and ensuring we have scale at every level to maximize our cost effectiveness.

Source: National Recovery Plan 2011 - 2014

CHAPTER TWO

JUSTIFICATION FOR FUTURE IRISH AGRICULTURE RESEARCH INVESTMENT

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2.1 Building on the strengths of agri-food sector

As highlighted in Chapter 1, the agri-food sector is a key part of Ireland's economy, being our largest indigenous industry. The production of milk and meat from low cost grass- based systems in our temperate climate is where Ireland's agriculture sector excels in the global food market in terms of having a competitive advantage. Future agricultural research is needed to keep our industry competitive when benchmarked against producers in other countries.

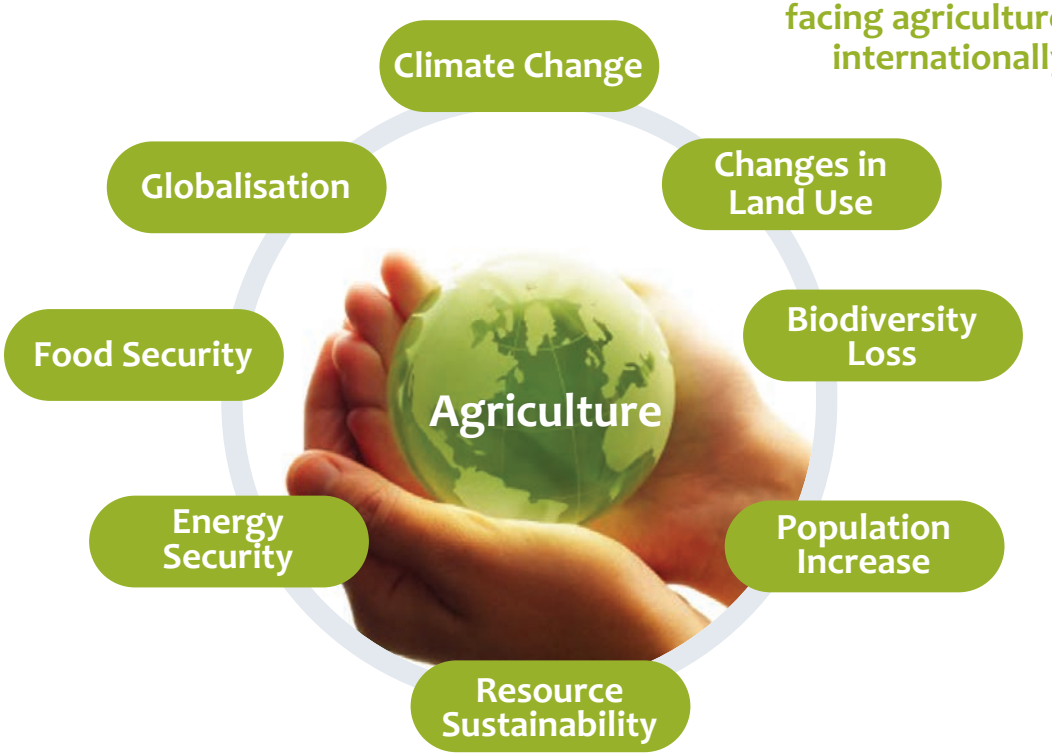
Ireland has a well developed agricultural research infrastructure that is ideally placed to deliver the results needed to underpin the development of the sector enabling the ambitious growth targets of the Food Harvest 2020 report to be realised. Further details of the current research infrastructure and the associated agriculture research strengths are highlighted in **Appendices 1 and 2.** The funding mechanisms for agricultural research, heretofore, are outlined in **Appendix 3.**

2.2 Challenges facing the agri-food sector

The world's population is expected to grow to 9.2bn people by 2050. In a resource constrained environment that has to cope with the challenges of climate change and energy security, providing enough food (increased demand of 70%)[8] to meet demand in 2050 presents a real and significant global challenge. Scientific advances have the potential to bring forward technologies that can boost productivity and in this regard continuing investment in research and development is of paramount importance if we are to have any chance of succeeding in meeting global food demand by 2050.

The global report of the International Assessment of Agricultural Knowledge, Science and Technology for Development[9] indicated that an investment of 1000 billion USD is needed over the next 50 years to deliver the step change in global productivity and to underpin the transition to sustainable production. The transformation of global agriculture systems to meet the challenges outlined above will require a long term investment in research, education and extension by both the public and private sectors in partnership with the farming community. The EU and its Member States have a key role to play in increasing public investment in the innovative research needed to transform agricultural production systems over the next 30 to 40 years. New food production models will have to be considered that will take account of ever decreasing resources while at the same time providing ever increased levels of output. Developing these new systems will result in a different approach to farming practices and the natural environment, the challenge being to develop farming systems that increase agricultural output whilst simultaneously advancing environmental, economic and social goals. This type of multidisciplinary research does not attract high levels of private investment; therefore it will need to be funded by Member States as 'public good' research[10].

8 How to Feed the World in 2050. Proceedings of the Expert Meeting on How to Feed the World in 2050. 24-26th June 2009, FAO Headquarters, Rome.
9 Knowledge, Science and Technology for Development: Global Report (eds B.D. McIntyre, H.R. Herren, J. Wakhungu, R.T. Watson), pp. 495-550. Washington, DC: Island Press.
10 Public Good Research: Research for the benefit of the sector as a whole and not a single private entity.



The concept of 'sustainable intensification' has been cited in many reports[11] and refers to the process of increasing agricultural yields without adverse environmental impact and without the cultivation of more land. This concept underlines the approach required by agricultural research to the challenges outlined above. Agricultural research must strive to develop new production technologies and approaches that maximize the benefits of natural resources while protecting and restoring these resources for future use. Agricultural research must address the sustainability and competitiveness of those who depend on agriculture for their livelihood. Over the last number of decades, advances have been made in the agricultural science area: increase in milk yields, increase in crop yields, longer grazing seasons. Such advances would not have been possible without Government investment. Further progress in the area is dependant on continued and increased investment in order to embrace the new challenges that lie ahead. Research must provide cost effective technologies that enable production systems to expand whilst conserving scarce resources. There must be a broad, inter-institutional and multidisciplinary approach to addressing these challenges. The development of an agriculture sector which is internationally competitive is crucially important to Ireland's future development. In addition, the sector must meet growing public good objectives in terms of enhanced food safety, improved natural resource management, biodiversity protection, climate change mitigation, energy security and meet the demand for environmental goods and services. Robust research coupled with an effective knowledge management system that is integrated with stakeholders has a key role to play in science-based innovation support for the sustainable development and competitiveness of the sector and in meeting a range of public good objectives. The importance of continued investment in research must be underlined if the growth and export targets for agriculture and the food industry set in Food Harvest 2020 are to be achieved.

Ireland, although a small country, can play its part in meeting these challenges as researchers in Ireland have developed an excellent reputation and are at the forefront of research and innovation internationally. Ireland needs to play a key role in this process and it is therefore vitally important that significant research funds are allocated to fund this public good research.

[11] Reaping the Benefits, Science and the Sustainable Intensification of Global Agriculture. The Royal Society. October 2009; The Future of Food and Farming (2011) Final Project Report. The Government Office for Science. London.

2.3 Assessing the impact of agricultural R&D

While it is usual and common to evaluate research programmes in terms of inputs (expenditure, personnel, resources) and outputs (scientific publications, citations, conference presentations, patents, etc), impact based assessment is needed to quantify the ultimate impact on economic activity of the research programmes relative to the level of research costs and the value for public money. There are internationally accepted methodologies for carrying out such impact based assessments and many have been undertaken over the years. The following are considered to be most relevant in the context of the work of the AREA Group.

Irish study

In 2002, Boyle *et al*.[12] published the results of seven such case studies of agriculture research programmes operating in Ireland. These show a very satisfactory value for public money when the impact of the research programmes is evaluated (**Appendix 4**). The estimated average internal rate of return was 55%, which compares very favourably with most other public sector investment projects. The returns estimated from these seven Irish case studies are comparable to international estimates which were reported to be in the range 40 to 50% as highlighted below.

UK study

A recent major Foresight study[13] 'Global Food and Farming Futures', conducted for the UK Government, examined this issue and reviewed the international literature in relation to evaluation of agriculture research funding. It concluded that the rates of return were high. For instance it quotes a study by Beitema and Koc[14] (2009) that reviewed several meta analyses of the rates of return to agricultural R&D covering more than 1,000 studies which concluded that internal rates of return were between 20% and 80% per annum. Another study quoted is that of Alston *et al*[15]. (2000) which reviewed 292 studies reporting returns to agricultural R&D, and, when outliers and incomplete observations were omitted, it found that regression analysis of 1,128 estimates produced annual returns with a mean of 64.6%, a mode of 28%, and a median of 42%. Two other interesting points were made in this Foresight study:

1. As well as gains in productivity and economic return, agricultural research produces social, environmental and policy impacts. Examples of this are contributions to food security, the long term decline in relative food prices, and the contribution to regional economic development because of its locally dispersed nature (i.e., in every parish in the country).
2. The consequences of the decrease in public investment in agriculture R & D and the increasing focus of the reduced expenditure on environmental concerns over recent decades are now starting to emerge as a reduction in the growth of productivity. For example, the study refers to the relative rates of yield increase for major grain crops, which were around 2-3% per annum in the 1980s, but are now significantly less (typically 1–1.5% per annum) and there is evidence of crop yields not increasing at all in some locations.

12 Boyle, G.E., Conry, M.J., Daly, K., Grant, J., Kearney, B., Kehoe, H.W., Lee, J, Lynch, P.B., Morrissey, N., O'Callaghan, E.J., O'Kiely, P., Staunton, L. and Tunney, H. (2003). The Costs and Benefits of Agricultural Research in Ireland. In: Seven Case Studies, Maynooth, 14-Feb.
13 UK Foresight Study: (http://www.bis.gov.uk/foresight/our-work/projects/current-projects/global-food-and-farming-futures/~/media/BISPartners/Foresight/docs/food-and-farming/science/11-584-sr46-funding-agricultural-and-food-security-research.ashx)
14 Beitema N., Koc A.A. 2009 *Agricultural knowledge, science and technology: Investment and economic returns. In International Assessment of Agricultural Knowledge, Science and Technology for Development: Global Report* (eds B.D. McIntyre, H.R. Herren, J. Wakhungu, R.T. Watson), pp. 495-550. Washington, DC: Island Press.
15 Alston J.M., Chan-Kang C., Marra M.C., Pardey P.G. and Wyatt T.J. 2000 *A Meta-Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculeum? Research.* Report 113. Washington, DC: International Food Policy Research Institute

US studies

A recent US study (CAST, 2011)[16] made similar conclusions about the return to investment in agriculture research. It also outlined the reasons why public funded research was needed and why the task could not be left (solely) to the private sector. The report concluded that the private sector faces weak incentives to undertake research in numerous areas. Although it invests in large amounts of R&D that leads to innovations that help raise agricultural productivity and improve the quality of life, the private sector focuses primarily on areas that have significant profit opportunities, meaning a market with strong intellectual property rights and regulatory systems in place. Some examples of why public agricultural research is needed included:

- Farms are too small and certain crops are too minor to bear the cost of R&D to develop most new farm technologies.

- Private agribusiness firms cannot expect to recoup enough benefits to cover the costs of innovations that (1) decrease soil and water erosion and improve air and water quality; (2) analyse impacts of commodity and trade policies; and (3) reveal new information about diet, nutrition, and health as well as about rural and community development.

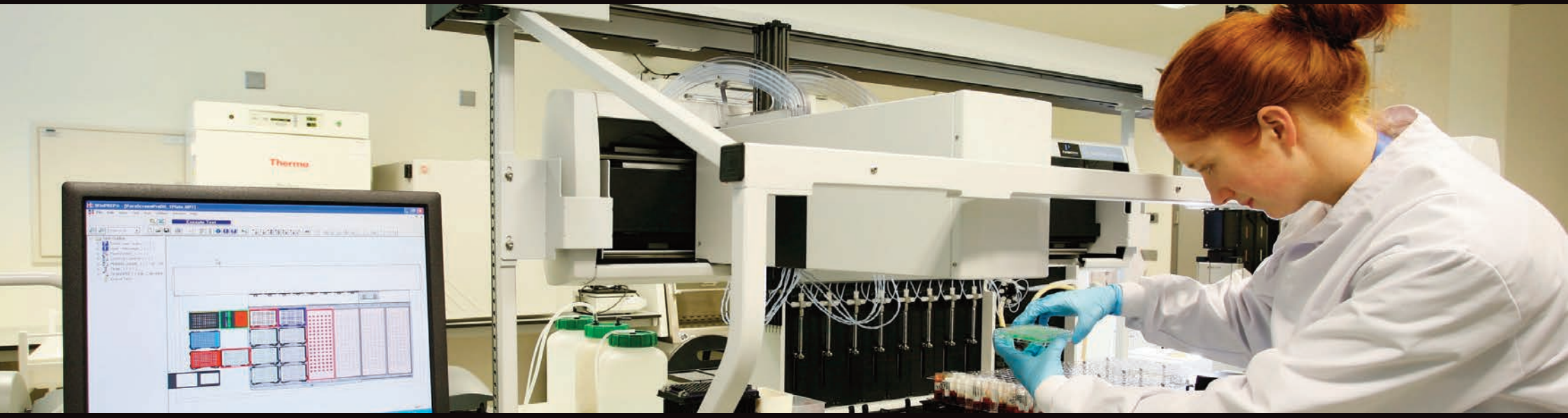
- Farmers and consumers need transparent, objective information so that they can make good investment, production, and consumption decisions, but strong intellectual property rights are critical to open information sharing. Intellectual property rights are a key driver of investment in R&D, innovation, and knowledge dissemination in the public and private sectors. Published patent documents offer a vast, accessible source of cutting-edge technological information. Moreover, charging for outlook information, which is a public good, unduly restricts its use.

- Private firms have limited interest in on-site training of new scientists for the future. Major doctoral student training is not and will not be undertaken by private firms.

Another US report (CAST, 2010)[17] concludes that while great strides were made in agricultural productivity over recent decades as a result of research, the convergence of challenges now facing the sector at one time is unprecedented. These challenges include meeting developed countries' increased demands on agriculture for fuel and ecosystem services; further increasing production per unit of land, water, and nutrient resources; dealing with global population growth; and serving the increased food demands in developing countries. It concludes that future agricultural policy for all nations must include a strong commitment to science if nations are to meet the coming challenges successfully. These challenges present real opportunities for Ireland and our agri-food sector.

16 Council for Agricultural Science and Technology (CAST). 2011. *Investing in a Better Future through Public Agricultural Research.* CAST Commentary QTA2011-1. CAST, Ames, Iowa. (http://www.cast-science.org/websiteuploads/File/Ag%20Research%20final%20QTA2011-1(1).pdf)
17 Council for Agricultural Science and Technology (CAST). 2010. Agricultural Productivity Strategies for the Future: Addressing U.S. and Global Challenges. Issue Paper 45. CAST, Ames, Iowa. (http://www.cast-science.org/websiteUploads/publicationPDFs/CAST%20Ag%20Policy%20IP45%20FINAL168.pdf)

CHAPTER THREE
STRATEGIC RESEARCH AGENDA



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3.1 A strategic research agenda for Ireland's agricultural research

Arising from a recommendation contained in the Food Harvest 2020 report that *"DAFM should establish structures to facilitate greater input and resources from the agriculture industry into the design and structure of primary research programmes"*, the Minister established the AREA Group.

The primary objective of this Group was to ***"develop a SRA for primary agricultural production and land use in Ireland to help guide futurestate research investment in the area."***

In deciding to present the SRA in this manner, the AREA Group recognised the following factors:

The duration of the research needed to address the issues contained in the SRA will vary from short term (3 – 5 years), which is the norm under competitively funded programmes such as Stimulus, through medium (5 – 10 years) to more long term farm systems research (10 – 15 years), which is best addressed through programmes operated by Teagasc;

- The issues identified span the research continuum from basic, through applied, to pre-commercial all of which are covered by the Research Stimulus Fund, one of DAFM's three competitive research funding programmes (See **Appendix 3**). Other research funders may also draw on elements of this document appropriate to the parts of the research continuum falling within their funding remit.

- Recognising the need to build research capacity and capability across the whole spectrum of agricultural activities, the Group nevertheless recommends that, given the likely pressure on public funding for R&D in the short term and the need to contribute to Irish economic recovery, the main emphasis, in the first couple of years, should be on research that helps achieve the growth targets set out in the Food Harvest 2020 report. This will mean focusing on addressing the most pressing knowledge deficits that have greatest impact on the productivity, profitability and sustainability of farming enterprises and on identifying practical solutions that are amenable to on-farm implementation.

- In addition to the delivery of Food Harvest 2020 targets, publicly funded research also needs to facilitate the maintenance and further development of capacity, capability and critical mass along the full research continuum and across all disciplines and sectors of agricultural production research. Consequently, the need to devote some funding to research that addresses these imperatives on an on-going basis remains valid.

- In order to remain faithful to the aims and ethos of the original Stimulus Programme, and recognising that valuable discoveries and innovations applicable to mainstream activities often comes from research in seemingly unrelated areas, the Group recommends that DAFM continues to invest a small portion of Stimulus funding (up to 10%) in more speculative / pioneering / frontiers type research in peripheral agricultural fields in order to stimulate the developmental potential of areas on the margins of mainstream agriculture.

- Agriculture cannot rely totally on the State to fund all the research needed to sustain the sector i.e. that relevant actors within the broad agricultural industry sector (e.g. input suppliers, retailers, farmers, processors etc.) should continue to enter into co-funding arrangements with the research providers, either in cash or in kind or both, especially in relation to near market / commercial research that promises to benefit commercial operations in the short term.

The Group, chaired by Mr. Matt Dempsey, Irish Farmers Journal, comprises of expertise drawn from a wide range of disciplines and production sub-sectors within the agricultural industry. The terms of reference and full membership of the Group, which was supported by staff from DAFM's Research Division, is presented in **Appendices 5 and 6.** The Working Methodology for the Group, including the original template used to capture the knowledge deficits, is presented in **Appendix 7.** The knowledge deficits identified by each of the Sub-Groups are presented hereunder. The knowledge deficits have been ranked from A to D in order of current priority (A being the most important) in the four broad agricultural research areas outlined below. It is important to acknowledge that these research priorities may change overtime. The review clause will ensure that the SRA remains relevant to the needs of the agri-food sector.

AREA Sub-Groups	
1	Animals (including issues relating to grass management / utilisation)
2	Crops
3	Sustainability – bio-energy, water/soil, climate change & transboundary gas emissions and biodiversity
4	Socio-economic, policy and other cross sectoral issues

3.2 Animals (including issues relating to grass management / utilisation)

Beef and milk production currently account for almost 69% of agricultural output at producer prices (excluding forage) and pigs and sheep for a further 11% whilst almost 80% of the agricultural land area of Ireland is devoted to pasture, hay and grass silage and a further 11% to rough grazing[18]. Food Harvest 2020 envisages significant expansion of the livestock sector including a 50% increase in milk production and a 40% increase in the value of beef production. Expansion of the livestock sector, and particularly of dairy production, will only be successful if it is based upon farming practices that are both ***SUSTAINABLE*** and ***COMPETITIVE***. The relative importance of grass-based livestock production to Irish Agriculture should be reflected in the allocation of public funds for agricultural research, whilst acknowledging the significant contribution made by other sectors including pigs and poultry.

18 DAFM Factsheet on Irish Agriculture. June 2011

Knowledge deficits for animals (including issues relating to grass management / utilisation) that if addressed by publicly funded research are likely to yield a significant economic impact belong to five distinct groups:

1. Animal Breeding, Genetics and Reproduction - improving genetic selection and reproductive efficiency with the emphasis on incorporating new technology and scientific understanding into breeding programmes for livestock that are focused on both profit and sustainability, and improving reproductive performance and output.

2. Animal Well-Being (health and welfare) with the emphasis on providing a sound basis for industry-led disease control programmes by quantifying the cost and relative frequency of different diseases and the benefits of control measures, by developing new and improved approaches to disease control and by enhancing surveillance and early warning systems and to mitigate specific health and welfare related issues for the intensive pig and poultry sectors.

3. Grassland Management and Breeding - optimising grass yield and utilisation by both breeding and management practices and developing grazing systems (including by modelling) to enhance overall farm production and profitability and environmental performance.

4. Animal Nutrition and Product Quality– with emphasis on enhancing productivity, feed efficiency, environmental performance, animal health and animal product quality.

5. Sustainable Production Systems and Systems Analysis - issues relating to the environmental and economic sustainability of animal farming enterprises - particularly relating to greenhouse gas emissions and climate change, water use and quality, biodiversity, and providing the evidence base for Ireland's claims in the sustainability area and how these goals can be combined with the goals of production and profitability in win-win situations.

WHAT ANIMAL (INCLUDING ISSUES RELATING TO GRASS MANAGEMENT / UTILISATION) RESEARCH IS NEEDED?

1. Animal Breeding, Genetics and Reproduction

Ranking	Research
A	**Animal genetics / genomic selection technology and other technologies in cattle breeding programmes:**
■	Research to establish the genetic basis for important cost of production traits such as fertility, mastitis, lameness, susceptibility to other diseases, feed intake, feed efficiency, milk production (including suckling animals), growth & maintenance and greenhouse gas (GHG) emissions. An important component of these studies would be the ability to identify accurate ways of capturing these data at the farm level in a user friendly manner
■	Establish the genetic basis of milk and meat quality and evaluate a range of ways for determining milk and meat quality (based on observational, analytical, image-based, dissection-based and/or taste panel data), with the goal of making recommendations regarding the routine collection of these data in future livestock breeding programs
■	Research to facilitate the extension of genomic selection technology across various breeds of beef and dairy cattle. This will require integration of information from a range of different sources (i.e. ancestry, phenotypic and genomic data) into a single genomic evaluation for both male and female animals

Ranking	Research
■	Research is required to establish appropriate health and rearing protocols for young bulls, as well as the collection of high volumes of high quality semen from these bulls. This latter work would include research to establish the potential role of liquid and/or sexed semen in our industry
A	**Multidisciplinary approach to animal reproduction:**
■	A multi-disciplinary approach is needed to deal with the multifactorial nature (genetics, reproductive management, nutritional management and health status) of the decline in fertility that has occurred in particular in cattle. The causes of poor fertility are multifactorial and include issues associated with postpartum uterine disease and other health related factors; anovulation, oestrus expression, embryo and foetal mortality and breed type. Efforts to improve the submission and fertility rates by addressing these factors will lead to significant improvements in reproductive efficiency
■	Improve annual output per sow. Ireland has failed to keep abreast of improvements that have occurred in pig productivity across Europe and needs concerted effort to improve annual output per sow

2. Animal Well-Being (Health and Welfare)

Ranking	Research
A	**Economic modelling of animal diseases**
■	To support the activities of Animal Health Ireland in promoting industry-led disease control programmes - research is needed to provide a solid basis for determining the full economic cost of the various animal diseases and the efficacy of disease control programmes
A	**Johne's disease**
■	To underpin an industry-led programme to prevent the further spread of *Mycobacterium avium subspecies paratuberculosis* (MAP) between and within herds and to support the elimination of MAP from known infected herds - develop optimal strategies for (i) classification of herds (infection status) and (ii) cost effective control of Johne's in infected herds
B	**Animal disease, surveillance and control**
■	To underpin our international reputation about the health status of the national herd and to support export trade in livestock products - provide a central repository populated with credible data on disease frequency, develop a greater capacity for disease investigation and improved tools for disease diagnosis and control

Ranking	Research
B	**Basic research in animal health and welfare-related issues**
■	Research is needed to gain a better understanding of predisposing factors for disease in farmed animals including immune system functioning and to develop objective measures of welfare status in farmed animals
C	**Issues related to health and welfare that may impact on the sustainability of intensive pig and poultry production**
■	To develop low cost solutions to address issues relating to feed safety, health (control of infectious diseases in the absence of in-feed medicines), welfare (housing, transport, environmental enrichment), environmental health (e.g. management of poultry litter) and public health (control of food-borne zoonotic pathogens - *Salmonella* in pigs; *Campylobacter* in poultry; antimicrobial resistance)
C	**Parasite control/anthelmintic resistance**
■	To mitigate against the risks of anthelmintic resistance and of new and emerging parasitic diseases - provide for sustainable use of anthelmintics and develop alternative parasite control strategies, with particular emphasis on the sheep sector

3. Grassland Management and Breeding

Ranking Research

A Grass breeding and genomics

- Identify optimal breeding goals for new grass and clover varieties for grassland systems and explore the scope for application of genome-wide selection in grass and forage breeding

B Grass nutritive value and grazing management

- Determine factors influencing the nutritive value, intake characteristics and animal performance from pasture by season and enterprise, and determine optimum supplementation strategies from production, product quality and environment (including GHG emissions) perspectives
- Determine management and other strategies to increase growth and utilisation of swards for ruminant enterprises, including the incorporation of clover
- Improve the prediction of grass growth and grass intake by grazing animals and consequently increase grass utilisation. This will be achieved by evaluating and improving existing models of grass growth and grass intake

Ranking Research

B Grazing systems modelling

- Improve the prediction of grass growth and grass intake by grazing animals and consequently increase grass utilisation. This will be achieved by evaluating and improving existing models of grass growth and grass intake

4. Animal Nutrition and Product Quality

A Relationship between animal nutrition and health, productivity and product quality at;

- An applied level
- A fundamental level (involving an understanding of the rumen microbiology, partitioning of nutrients and the key genetic, endocrine and metabolic influences on animal performance)

B Nutritive value of feeds

- Improve the characterisation of the nutritive value of feeds (including grass) to allow better diet formulation for improved animal productivity and product quality and reduced nutrient excretion

Ranking	Research
C	**Milk quality**
■	Improve milk quality (occurrence of excessive numbers of total bacteria, sporeformers, thermoduric bacteria and Coliform bacteria counts) by understanding the relationship between the milking process and other critical factors
C	**Feed efficiency**
■	Develop a methodology to rapidly and easily screen large numbers of animals for feed efficiency so as to increase the number and range of phenotypic records available for feed efficiency, with a view to future implementation through genome association

5. Sustainable Production Systems and Systems Analysis

Ranking	Research
A	**Environmental sustainability of livestock production**
■	Develop technologies/practices to decrease environmental impacts (on water, air, and biodiversity) without negatively affecting production and profitability at farm level
B	**Ireland's sustainability performance**
■	Benchmark (including by Life Cycle Analysis) the environmental performance of Irish livestock production systems in an international context and provide evidence to substantiate our claims of high environmental performance
D	**Futuristic farming systems**
■	Develop futuristic grass-based systems of production using field studies and modelling that combine increased production and profitability with improved environmental performance

3.3 Crops

In an increasingly competitive environment where commodity prices and access to feed and food can be unpredictable, there is a need to put in place research capacity that enhances the ability of Irish agriculture to meet and overcome these stresses. At a time when the annual increases in tillage crop yields are stagnating, primary consideration must be given to maximising the economic yields of the main Irish tillage crops coupled with a program that selects other newer high value crops with genetic characteristics that are suited to production under Irish climatic conditions. Whilst the Food Harvest 2020 report clearly sets out ambitious goals for both the livestock and food producing sectors, it is also inevitable that the arable sector will need to thrive and flourish in order to provide a sustainable supply of high quality, traceable, carbon friendly sources of grains, pulses, oilseeds and horticultural crops which can form the foundation stone of many of our value added food exports, thus being a valuable contributor to the "brand Ireland" image we wish to portray.

Cropping systems in Ireland and throughout the EU are subject to many regulatory constraints which are designed to protect the European consumer by ensuring the continued supply of safe, healthy and fully traceable foods and downstream feed ingredients. The continued moratorium imposed by many EU countries on GM crops and their research is a sensitive issue and remains a source of great debate, particularly at consumer level. In this light, the continued research into conventionally-bred crop production systems is of critical importance to maintain competitiveness, not only in Ireland, but also in the greater EU as a whole. On this basis, Ireland is very well placed as a crop producing nation, with our cereal yields being of the highest in the world, and our cool maritime climate providing all crops with sufficient moisture without much need for artificial irrigation. However, input costs and overall costs of production remain high, thus the need to deliver greater efficiencies remains a key priority.

The crop research priorities are those considered necessary to increase the competitiveness and efficiency of Irish crop production and to make it more responsive to the demands of the Irish and global markets.

WHAT CROP RESEARCH IS NEEDED?

Ranking	Research
A	**Understanding the crop (major Irish tillage crops)**
■	Crop physiological studies to understand crop yield limitations. As new varieties and agronomic practices are developed, the phases of a crops lifecycle during which yield formation can be restricted change. These changes are affected by the environment in which they are grown and can differ between countries and agro-climatic zones. A greater understanding is needed of the yield limiting processes to target future genetic and agronomic improvements and conversely to avoid excessive use of inputs during those parts of the lifecycle that are not critical for crop growth and yield formation
A	**Resistance development**
■	Study the development of resistance in important crops & develop strategies to counter this issue
■	Systems for plant pathogen detection and population monitoring
■	The introduction of new pesticide active substances or resistance genes for the control of plant pests or pathogens exerts a strong selection pressure on the pest/pathogen population. This can result in the rapid development of insensitivity or resistance to the pesticide or gene leading to rapid changes in the field performance of the pesticide or gene and significant reductions in yield. Monitoring pathogen or pest populations can identify such shifts prior to significant field performance failure and allow the development of anti-resistance strategies to reduce or avoid the impact of such changes
A	**Identification of suitable crop varieties (EBI - Economic Breeding Index)**
■	Develop improved testing systems and economic prioritisation of traits to identify varieties better suited to Irish conditions. The performance of varieties can vary considerably between environments depending on the suitability of their traits to the climate in which they are to be grown. There is considerable scope to improve crop performance by better identification of the combinations of traits best suited to Irish conditions and the subsequent identification of varieties with those desirable characteristics. Such cultivars will help to improve the competitiveness of Irish arable farming by providing Irish growers with seeds of highest yield and market potential that can maximise farm gross margins in a sustainable way

Ranking	Research
A	**Identify suitable high value crops / markets**
■	Develop varieties and new crops suitable for existing high value markets e.g. winter hardy milling oats
■	Allow farmers diversify their production and access premium value markets (e.g. milling wheat & oats, malting barley, sugar beet, certified seed etc)
■	Reduce dependency of farmers on the current narrow range of crops
■	Increase the economic viability of Irish agriculture by assessing higher value alternative markets
B	**Develop biotechnological techniques and the capacity to isolate and identify key desirable genetic traits**
■	Identification of important traits in Irish conditions
■	Investigations into the physiological and biochemical basis of economically and environmentally important traits
■	When traits have been identified, to identify the genetic basis of the trait so that it can be incorporated into a target crop

Ranking	Research
B	**Management strategies**
■	Bring the top 10% of Irish growers, who are amongst the best performing farmers in Europe, to even higher levels. Maintain this trend, and improve the performance of poorer performing producers to get their production systems operating at a higher and more efficient level
■	Modelling crop production systems and creating successful blueprints which can be replicated on a greater scale
■	Develop grass weed control strategies in min till and conventional production systems
■	Modifying agronomic practices to optimise the economic production (e.g. sowing dates, seed rates, fertiliser timing / type and rate)
■	Agronomic approach to reducing disease pressure (e.g. delaying drilling, variety choice, rotation)
■	Developing / optimising rotation crop options to improve soil and plant health and reduce production costs

Ranking	Research
B	**Access to and deployment of the latest production technologies (inc. machinery)**
■	Optimising cultivation strategies
■	Controlling machinery costs through development of appropriate ownership/use policies –(e.g. share farming, machinery pooling, lease hire)
■	Reduction of energy inputs to crop production
B	**Soil chemistry / structures and fertility**
■	Better understanding of the P and K requirements of crops in an environment where P levels have been reduced, the rate of K uptake and utilisation can change
■	Improving N use efficiency in crops including precision-agriculture based targeting strategies
■	Detect, evaluate and minimise compaction issue – increased mechanisation on the farm, higher traffic levels with heavier equipment
C	**Knowledge and application of Integrated Pest Management techniques**
■	Development of integrated crop production systems incl. development of biological control
■	Agronomic approaches to reduce disease pressure

Ranking	Research
■	Targeting crop disease control strategies according to risk
■	Transfer of information available on Integrated Crop / Pest Management (ICM/IPM) strategies to farmers with a view to improving their production system
C	**Precision Agriculture / targeted input applications.**
■	Using spatial information on a range of important decision making variables: disease development, nutrient availability, crop yield potential, water deficit status etc. to target control strategies
D	**Use of Artificial substrates**
■	Development of artificial growing media for use in horticulture
D	**Climatic factors**
■	Influence of climate change factors (drought, increased salinity of water used for irrigation, more intense rainfall, effects of higher wind conditions, more extreme cold and heat, etc) on crop growth and yield formation

3.4 Sustainability – Bio-energy and bio products, water, soil, climate change & transboundary gas emissions and biodiversity

For the purpose of this exercise, this Sub-Group is broken down into four areas: Bio-energy and Bio-products, Water, Climate Change & Transboundary Gas Emissions and Biodiversity.

3.4.1 Bio-energy and bio-products

Ireland has ambitious targets in terms of renewable energy production including an obligation pursuant to the Renewable Energy Directive that 16% of its overall energy usage be sourced from renewables by 2020. Sub targets within this ambition include 40% renewable electricity (wind being the largest contributor) and currently we are generating 15% of this target.

Other sub targets are 12% renewable heat (currently 4.2%) and 10% renewable transport fuels (3% currently). Additionally there is a growing international focus on the use of sustainable agri-feedstocks as sources of bio-polymers and bio- chemicals, which can potentially provide new multi-billion euro markets for the Irish agricultural sector. While these are cross sector targets, agriculture and land use can contribute significantly to achieving these targets.

WHAT BIO-ENERGY AND BIO-PRODUCTS RESEARCH IS NEEDED?

Ranking	Research
A	**Cost benefit analysis of redirecting land use from food production to non-food crops**
■	A cost-benefit analysis re developing a domestic bio-energy/bio-product industry
■	A methodology for determining acceptable profile of food vs. non-food land use
■	Development of integrated, coherent policy, planning, taxation and regulatory initiatives to support optimal balance of food vs. non-food land use

Ranking	Research
A	**Optimal market structure for non-food production**
■	Technological, economic and environmental analysis of domestic production vs Importation of biomass to meet Ireland's ambitious 2020 renewable energy objectives
■	Economic and environmental analysis of localised vs. centralised processing for different non-food systems, develop tools to assess localised versus centralised transformation processes to deliver an optimal approach to market development

Ranking	Research
B	**New products development – optimising land use for non-food production**
■	Technical, economic and environmental analysis of optimal bio–products suitable for production in Ireland (bio-fuels, bio-plastics and polymers, bio-chemicals and bio-fertilisers)
■	Technical, economic and environmental analysis of optimal non-food crops ■ Optimal crop varieties, establishment and management practices - See detailed research topics under "Crops" Section as these apply to non-food crops ■ Varietal analysis with regard to varying land types (particularly marginal lands)
■	Technical, economic and environmental analysis of optimal engineering processes ■ Development of optimal extraction / fractionation processes ■ Development of pilot plant demonstration facilities
B	**Environmental impacts of full non-food value chains, including**
■	Impact on water (implementing a water wise bio-based economy)
■	Impact on soil
■	Carbon and GHG emissions
C	**Sustainability indicators for non-food crops**
■	Development of a standard certification system for products and processes to facilitate regulatory compliance and incentivisation of sustainable products and practices

Ranking	Research
■	Develop the comparable environmental profiles / indicators of different non-food crops, e.g. emissions, carbon sequestration, biodiversity, water use
C	**Quantification of the total 'demand' and 'supply' for contrasting soil functions**
■	Determination of the availability of marginal lands for energy crop production, analysis of appropriate varietal species, agronomy and production processes and estimation of the productive capability of such lands
D	**Optimising renewable heat and electrical power**
■	CHP and Co- Firing of energy crops and wastes/residuals
■	Biogas from anaerobic digestion of energy crops, wastes and residuals
D	**Optimising mineral and nutrient recycling from bio-processing – technical, economic and environmental analysis of recovery and recycling minerals/nutrients from:**
■	Ash from CHP and Co- Firing of energy crops and wastes/residuals
■	Digestates and leachates from anaerobic digestion of energy crops, wastes and residuals

3.4.2 Water/soil

Implementation and delivery on the Water Framework Directive (WFD) sets the context for delivery in the area of water quality for some years to come and in particular over the period covered by the Food Harvest 2020 report. This directive requires that all water must achieve good status by 2015 (by 2021 and 2027 for certain bodies) and that there is no reduction in status of any water bodies already meeting required standards.

While water quality in Ireland is good by European standards, delivery on the WFD directive will require significant commitment. Nutrient loading arises from many activities including forestry, municipal and housing/septic tanks but with 70% of total loading arising from Agriculture (source: EPA), this activity has a significant impact on water quality. During the first National Action Programme for Nitrates, very significant progress was made in limiting the nutrient loss from Agriculture with notable highlights including an overall reduction in chemical fertiliser usage (up to 25%) and substantial investment in facilities for the storage and management of organic manures (> €2 billion). Not-withstanding the work completed to date, the potential increased nutrient loading arising from agriculture as the sector grows in response to Food Harvest 2020 targets, indicates a continued need for research in this area, in particular to facilitate appropriate targeting of measures to support the delivery of the WFD.

Research priorities include improving nutrient efficiency and recycling, addressing the question of sedimentation however, the following three areas in particular were considered essential:

Higher nutrient inputs associated with more highly stocked livestock systems pose additional pressures to water ecology, yet such farms have a major role in increased agricultural output. Indeed such farms can have a higher overall nutrient efficiency (milk or meat output/unit of nutrient input) than farms operating at a lower stocking rate.

Phosphorus (P) is seen as a priority area both from its impact on water quality but also given that it is a finite resource. Particular topics here include developing understanding of P availability in soils, pathways to loss and efficiency of nutrient use and transfer to the plant/animal.

In addition, Nitrogen (N) from mineral fertiliser and animal manure application are important sources of nutrients for agricultural production. However, maintaining delicate agro-ecosystems in order to achieve sustainable agricultural productivity while protecting the environment is a priority in terms of ensuring water quality. Excessive N surpluses can pose a threat to groundwaters/drinking water supplies and contribute to eutrophication of rivers, estuaries and coastal areas.

WHAT WATER / SOIL RESEARCH IS NEEDED?

Ranking	Research
A	**Nutrient management strategies for pristine (Q5) water bodies**
	Research study identifying:
■	Drivers in relation to "pristine" water bodies (individual catchments)
■	Sources of loss
■	Cost effective management strategies for individual catchments
A	**Point Source Nutrient Losses at Catchment level**
■	Further research studies at catchment level to understand nutrient pathways process & quantification of Point Source Nutrient Losses (organic & inorganic) and pollution
A	**Intensive farms- Improving N efficiency**
	Research to contribute to an improved understanding of:
■	Agricultural contribution to N losses
■	Critical loading
■	Impact of N inputs on surface water ecosystems
B	**Improved understanding of Sedimentation Loss:**
	There is a need to improve our knowledge of:
■	Source of sediment
■	Cost effective mitigation options to halt loss into water
■	Development of a range of cost-effective management options to reduce sediment loss
■	Avoidance of cost-prohibitive, one-size-fits-all measures

Ranking	Research
B	**Soil Specific Nitrogen Advice for grass and cereal crops[19] :**
■	In depth study to Identify soil parameters / management drivers that determine soil N supplying capacity of contrasting soils
■	Quantify the contribution that different soils make to the nutrition of a crop
■	Calibration of soil N test for Irish grasslands
	Nitrogen for Spring Cereals
■	Elucidate reasons for low protein levels
■	N management strategies to increase protein levels
C	**Phosphorus dynamics within the soil system**
	Improve the understanding of Phosphorus dynamics focusing on:
■	P Chemistry
■	P availability and utilisation
■	P Pathways of loss and rates of decline
■	P application
■	Efficient P nutrient delivery
D	**Protection and maintenance of soil quality**
	Research to contribute to an improved understanding of:
■	Soil organic carbon
■	Soil management incl. drainage, remediation

19 This knowledge deficit is linked to management strategies for crops on page 23

3.4.3 Climate change & transboundery cases

There are a number of drivers impacting on the need to mitigate greenhouse gas and ammonia emissions compared to a business as usual scenario. Nationally, Ireland is required to reduce its green house gas emissions by 20% by 2020[20] . Tougher targets, for both ammonia and greenhouse gases will be set in the medium to long term and agriculture must contribute to meeting these targets. It is crucial to further develop the agricultural inventories so that mitigation measures at farm level can be reflected in the inventory: otherwise the outcome of these measures will not be credited to the sector or product. Developing Irish specific emission factors will also be an important part of improving the national inventory. In addition, the importance of life cycle analysis modelling should not be understated; measures to reduce emissions in one part of a product life cycle may increase emissions in another part of the same system. Life cycle analysis modelling will also support Ireland's food marketing effort. As a food exporting country, it is recognised that many retailers are seeking to include sustainability information such as GHG emissions in their marketing initiatives.

Emissions to air represent a loss of inputs from the system and a financial loss to farmers, thereby impacting on competitiveness of the sector. For example, about 7% of ruminant energy intake is lost through enteric fermentation and an estimated farm gate balance indicates that over 75% N input is not recovered in farm output. When it is considered that a greater amount of nitrogen is lost from the system, most of it as harmless N2, than farmers purchase, the imperative of improving N use efficiency for competitiveness and sustainability becomes clear.

Given the targets for increased meat and milk production in the Food Harvest 2020 report, reductions in emission intensity per unit of milk/meat output will be required to meet the greenhouse gas reduction targets set for the agriculture sector. This will require development of mitigation techniques to reduce both methane and nitrous oxide emissions. Given that milk and beef production systems involve complex natural cycles, with physical limits on the extent of emission reduction, a systems approach is needed to consider all stages of the production cycle. This will involve reducing emissions through animal breeding and nutritional strategies, improving nutrient recovery from organic manures and reducing emissions from soils. In summary a reduction in greenhouse gas emission intensity per unit of livestock product is essential to meet National Emission reduction targets and also to sustain the high environmental credentials associated with Irish food production.

International verification of emissions reductions through an improved national inventory will support these efforts. All these demands (food production, competitiveness, targets and policy initiatives) combine to define the research priorities. In practice they are all closely linked so that the research priorities can be defined in terms of approaches to measure and improve the system productivity and efficiency of resource inputs in the sector and improved communication, through modelling initiatives, of the outcomes for Ireland's food production system. In terms of climate change adaptation –it is necessary to understand what system adjustments are required, so that Ireland can continue, in the long-term, its important contribution to sustainable food production.

[20] Ireland. National Climate Change Strategy 2007-2012. Dept. of the Environment, Heritage and Local Government(http://www.environ.ie/en/Publications/Environment/Atmosphere/FileDownLoad,1861,en.pdf)

WHAT CLIMATE CHANGE & TRANSBOUNDARY GAS EMISSIONS RESEARCH [21] IS NEEDED?

Ranking	Research

A **Mitigation techniques at farm level and approaches to reduce losses at farm level**

- Measurement of impact of mitigation strategies including development of emissions factors
- The research should contribute to the development of models that lead to more accurate emissions data for Irish agriculture, leading to an improvement in the national inventory

A **Grassland and Cropland Carbon Sequestration-**

Carbon sequestration research study to inform on:

- C stocks & fluxes
- Influence of management, soil type & regional climatic conditions
- Likely impacts of projected climate change; research will allow carbon sequestration to be included in modelling and may facilitate its inclusion in domestic offsetting schemes

Ranking	Research

A **Development of models /Metrics and advanced methodologies to verify environmental efficiency of Ireland's primary food production systems**

Measurable, Reportable and Verifiable (MRV) of sustainable practices:

- Development of internationally acceptable life cycle analysis (LCA) standards/metrics

B **Influence of land use and mitigation approaches on nitrogen related emissions. Requirement to develop models to assess mitigation techniques at farm level with overall objective of improving nitrogen use efficiency**

In-depth research is required at the farm level to investigate the influence of:

- Farm practices
- Soil dynamics
- Mitigation techniques at all stages of production in reducing nitrogen related emissions

The research should lead to the development of models that enable low cost simulation exercises to expand the usefulness of field data leading to more accurate N species emissions inventory for Irish agriculture.

[21] The knowledge deficits identified in this section are interlinked with some of the knowledge deficits identified in section 3.2, Animals Section

Ranking	Research

B **Influence of animal genetics on methane emissions**

Influence of improvements in efficiencies at farm level on methane emissions, in-depth research is required at the farm level to further improve our knowledge of the influence of:

- Animal genetics
- Feeding practices
- Mitigation approaches at all stages of production in reducing methane emissions

The research should lead to the development of models that l ead to more accurate methane emissions inventory for Irish agriculture.

Ranking	Research

C **International Policy Initiatives- Global understanding of appropriate approaches to agriculture**

- Verification and promotion of efficient food production systems and approaches
- Research to understand the contribution of different production systems to food supply; capacity and approaches to mitigation of greenhouse gases within these systems

D **MRV of ammonia emissions from agriculture**

Research to contribute to the development of:

- MRV of ammonia emissions from agriculture
- Irish specific emissions factors
- Strategies to reduce ammonia losses from housing and storage (specific to Irish conditions)

3.4.4 Biodiversity

European Union Biodiversity policy was driven by the targets set in 2001 to halt the biodiversity loss within the EU by 2010. Ireland produced its first National Biodiversity Plan in 2002, which comprised of a set of 91 Actions to halt the current and continuing loss of plant species, as well as vegetation and habitats they compose. In spite of actions taken by Ireland and the EU 27, there is evidence that the status and conditions of biodiversity and ecosystems continue to deteriorate.

In the EU, only 17% of habitats and species and 11% of key ecosystems protected are in a favourable state. Ireland and the EU will now focus on actions to halt the loss of biodiversity and the degradation of ecosystem services by 2020 and where possible restoring ecosystems. Agriculture and land use, along with other key sectors, can contribute significantly to achieving this halt in biodiversity loss and ecosystem degradation.

WHAT BIODIVERSITY RESEARCH IS NEEDED?

Ranking	Research
A	**Identification and knowledge of High Nature Value (HNV) farming systems**
■	National scale study to determine the extent of potential HNV lands within the country
B	**An understanding of the perceived negative impacts of intensive farming on biodiversity**
■	Identification of biodiversity on intensively farmed lands. Development of guidelines for biodiversity protection on intensively managed farms

Ranking	Research
C	**Proper targeting and delivery of agri-environmental schemes**
■	An evaluation of the environmental and economic impacts of agri-environmental schemes including cost effectiveness of individual measures
D	**Influence of changes in land use on biodiversity**
■	Assessment and monitoring of environmental impacts arising from changes in land management-intensification and extensification

3.5 Socio-economic, policy and other cross sectoral Issues

There is a need to support socio-economic research in order to inform policy development. Socio- economic research provides valuable information for evidence based policy formation within the agri-food sector. A number of socio-economic knowledge deficits are identified in the table below. The table also includes a cross sectoral knowledge deficit on the management of organic manures as it impacts on the three broad agricultural areas outlined in sections 3.2, 3.3 and 3.4.

WHAT SOCIO-ECONOMIC, POLICY AND OTHER CROSS SECTORAL RESEARCH IS NEEDED?

Ranking	Research
A	**Sociological Studies**
■	What are the drivers or motivating factors for the top performers in different farming sectors and corollary of this? For example, the reasons for lack of adoption of efficient grassland management practices on some commercial farms should be investigated. What are the inhibiting factors or fears that prevent other farmers from embracing new ideas or work practices?
A	**Management of Organic Manures**
■	As the dairy industry expands to meet the growth targets of Food Harvest 2020, there will be an increase in the volume of livestock manure, in addition to the surplus manure that already exists from the intensive pig and poultry sectors. Research is needed to determine the best use of this surplus manure. This is an issue that impacts on both crops and animals. Issues to be addressed will include: ■ Use of organic manures as a nutrient source in crop production, logistical issues and greater awareness in regard to consumer sentiment of using organic manures in crop production
■	Cost-effective, easy access and adaptive technologies including manure transport, separation and treatment technology, precision farming, and an adapted buffer strip management
A	**Land Markets, Farm Structures and Demographics (to include gender)**
■	The land market in Ireland is poorly researched and understood and is stagnant relative to land markets in many competitor countries. More land transactions should be encouraged if land is to be used more productively. It would be important to gain a better understanding of the factors that influence decision making at farm level if we are to devise incentives to encourage greater land transfer
■	There is a need to increase diversity within our farming population and encourage young people and new entrants into the sector. Research might consider possible mechanisms by which this could be achieved (e.g. share farming, share milking, partnerships etc)

Ranking	Research
B	**Drystock Sector Challenges**
■	Given the importance of this sector and the current poor returns to dry stock farmers research is needed to consider ways of improving farm margins. This would include improving productivity but also consideration of new ways to add value (e.g. product differentiation), and other options/diversification opportunities to complement dry stock farming and new collaborative farming models
B	**Environmental economics**
■	Research is needed to determine the economic costs and benefits of 'greener' farming practices. This should assist in the evaluation of agri-environmental schemes and in particular the cost effectiveness of individual measures. Given the strong green message underpinning the Food Harvest 2020 report, research is needed to underpin the environmental claims

Ranking	Research
C	**Lack of knowledge in relation to the impact of novel transgenic crops**
■	Assess the risks / benefits of adopting GM technology to provide evidence for policy development
■	Consumer acceptability studies will be a key part of any proposal

CHAPTER FOUR
NEXT STEPS

Department of
Agriculture,
Food and the Marine
An Roinn
Talmhaíochta,
Bia agus Mara

4.1 Implementation

The implementation of this SRA will be dependent on the following factors:

1. Availability of national and international funds
2. Priorities identified under Food Harvest 2020 Report
3. National Research Prioritisation Exercise[22] Report and associated action plans
4. National Recovery Plan 2011-2014
5. Developments in relation to the Joint Programming Initiative on Agriculture, Food Security and Climate Change and the Global Research Alliance on Agricultural Greenhouse Gases.

4.2 Research Stimulus Fund

The RSF is the Department's primary funding mechanism for primary agricultural production based research. Subject to the availability of Exchequer funds, DAFM would hope to issue research calls to address some of the knowledge deficits identified in this report. Further details on RSF are contained in Appendix 3.

4.3 Joint RSF/FIRM calls

Some of the knowledge deficits identified in this agenda may be suited to funding as part of a Joint FIRM[23] /RSF Call.

4.4 Knowledge transfer

The importance of transferring the outputs of research to the appropriate end user should not be underestimated. In relation to agricultural production based research, the farmer is ultimately the end user in many cases. Teagasc through their network of agricultural advisors, the independent agricultural consultants and industry and farming interactions have a crucial role to play in ensuring the outputs of research are disseminated widely. Increasing specialised industry expertise is also playing an ever increasing role in knowledge transfer. Dissemination can occur through writing technical articles in newspapers and other printed media, information campaigns, seminars, workshops and conferences, through discussion group activities, and in one-to-one interactions between advisers and farmers. New and innovative ways to disseminate this information must be considered. Farmers will learn from each other and getting a small number of leading farmers to adopt a technology can lead to its adoption by many other farmers. The Teagasc-Farmers Journal 'Better Farm' model has shown this to be the case, where farmers are challenged by the performance of their peers in order to improve their overall performance levels.

22 National Research Prioritisation Exercise: This study aims to identify a number of priority areas and approaches to tackling national challenges and opportunities (henceforth to be referred to as priority areas) around which future investment in publicly-funded STI should be focused. The project will take account of future economic and social opportunities and fields of research activity where Ireland has built significant strength to date. An action plan for each of the areas identified will be developed. These action plans will set out specific goals to be realised in the medium term (5 years) and beyond and the measures required to realise these goals. The Exercise is being conducted under the direction of a specially appointed High Level Steering Group, chaired by Jim O'Hara facilated by Forfas. The Steering Group commenced its work in October 2010 and has been requested to report by September 2011.

23 FIRM -Food Institutional Research Measure: One of DAFM's three competitive research funding programmes. This measure has been in operation since 2000, and is the main for funding of food research in public research institutions in Ireland. The programme has funded 239 project to date to the value of circa. €140m. The aim of FIRM is to develop public good technologies that will underpin a competitive, innovative and sustainable food manufacturing and marketing sector.

4.5 Collaboration

Collaboration at different levels will ensure maximum value from any investments made. Collaboration will occur at many different levels, including Inter-institutional collaboration and collaboration involving industry partners and research institutions. DAFM will continue to ensure collaboration is widely adopted in its Research Stimulus Programme. Internationally, collaboration should also be encouraged and facilitated where possible. The Joint Programming Initiative and Global Alliance on Agricultural Greenhouse Gases will provide a platform for Irish based researchers to participate in international research calls. DAFM will closely monitor developments in relation to these international initiatives to ensure that Irish researchers are afforded the opportunities to participate in research calls co-ordinated by these initiatives.

4.6 Review clause

SSAPRI will primarily act as a roadmap for guiding DAFM's investment in agricultural production based research. To ensure that the Agenda remains relevant to the needs of all the various stakeholders, it is recommended that it be reviewed periodically. In this regard, it is proposed that the AREA committee continue to meet on a much less frequent basis than heretofore in order to undertake a number of activities including:

- Periodic review and, if necessary, update the SSAPRI agenda
- Address the other issues in the Terms of Reference

APPENDICES

Department of
Agriculture,
Food and the Marine
An Roinn
Talmhaíochta,
Bia agus Mara

APPENDIX 1
Ireland's research infrastructure

The agriculture research infrastructure is extensive and has embraced significant change over the past decade. Increased levels of public investment have been the driving force behind this change, through successive National Development Plans, which placed emphasis on research as an instrument for economic growth. The principal research institutions within the Irish research and development infrastructure, namely Teagasc and the Higher Education Institutes, adopt a multi-disciplinary approach, with specialist units in all of the key research areas.

TEAGASC

Teagasc, the Agriculture and Food Development Authority is by far the biggest public research organisation in Ireland outside of the University sector. It was established under the Agriculture (Research, Training and Advice) Act, 1988, to provide agriculture and food research, advice and education. It was formed by bringing together the Agriculture Institute (AFT) and ACOT, the advisory service. The Agricultural Institute was founded in 1958 with the assistance of Marshall Aid money from the United States. This money was set aside by the US Government to help in the post-war reconstruction of Europe. Increased food production, based on scientific research, was a key aim.

Among research institutes internationally, Teagasc is unique in combining research and extension (and education) in one organisation and Ireland is one of the few countries to have maintained a state extension service. This ability to combine research and extension ensures that Teagasc are at the forefront of delivering solutions on farm and to the wider agri-food sector. Its mission is to 'support science-based innovation in the agri-food sector and the broader bio economy'. It is focused on applied research that can make an impact on the profitability, competitiveness and sustainability of the agri-food industry. Teagasc's agricultural research programme is provided by research scientists, technicians and other support staff organised in three core programmes: Animal & Grassland Research and Innovation Centre (Moorepark, Grange and Athenry), Crops, Environment and Land-Use Centre (Johnstown Castle and Oakpark) and Rural Economy and Development Centre (Athenry and Ashtown). Teagasc also has a very significant Food research programme (Moorepark and Ashtown). Research at Teagasc is mainly focused on applied research but with approximately one quarter of the programme devoted to strategic research, and the organisation is very focused on achieving impact on knowledge transfer, with researchers working in an integrated manner with advisory staff to achieve this.

HIGHER EDUCATION INSTITUTIONS

Irish Universities

There are seven Universities in Ireland, collectively, under the Irish Universities Association, their aim is to develop and sustain a dynamic research environment.

- University College Dublin – veterinary clinical medicine, animal science, agri-environment, plant bioscience, horticulture, forestry, food science, agri-economics and biosystems engineering. UCD has a particularly important role in training Agricultural Science and Veterinary Medicine graduates
- University College Cork – environment and plant bioscience and food science
- National University of Ireland Galway – Plant biosciences, bioenergy & environment
- National University of Ireland Maynooth – climate change and plant bioscience

- University of Limerick – soil, bioenergy, equine & food science
- Trinity College Dublin – animal genetics, animal immunology and environment
- Dublin City University - soil

Institutes of Technology

There are 13 Institutes of Technology (IOTs) in Ireland. Some are more active/relevant than others to the agriculture sector e.g. Waterford IT, Cork IT, Carlow IT, Galway-Mayo IT, and Tralee IT. Research now forms a core component of each of the institutes, with the majority now identifying themselves as: 'a research-led Institute which has developed its own research specialists, established internationally recognised centres of excellence that have substantive collaborative links with leading universities and industrial partners'. The IOT's play an integral role in creating Ireland's postgraduate research community and are particularly effective at pre-commercial research and have strong links with industry.

DAFM LABORATORY SERVICES

DAFM provides a range of regulatory and diagnostic services from a central laboratory complex at Backweston, Co. Kildare and a network of regional laboratories. DAFM also supports some applied research carried out by its Veterinary Laboratory Service (VLS) which is comprised of the Central Veterinary Research Laboratory at Backweston, a research farm facility near Clane in Co Kildare and Regional Veterinary Laboratories at five other sites. The Veterinary Research Laboratory has been engaged in research on production diseases of farmed animals in Ireland since the 1920s. The current research focus of the VLS relates to endemic infectious diseases of farmed animals (both regulated and non-regulated diseases) and related matters of food and feed safety, public health and environmental health. Much of this work is carried out in collaboration with universities and other agencies in Ireland, the UK and elsewhere within the EU.

CENTRE FOR VETERINARY EPIDEMIOLOGY AND RISK ANALYSIS (CVERA)

CVERA is the national resource centre for veterinary epidemiology in Ireland, located within the UCD School of Veterinary Medicine at University College Dublin. The Centre is staffed by employees of University College Dublin and the Department of Agriculture, Food and the Marine. CVERA staff work closely with national policy-makers, both in government and industry. Much of the output of CVERA constitutes applied research and is published in the peer-reviewed veterinary literature. The Centre was initially established as the Tuberculosis Investigation Unit and one of its main functions is to provide epidemiological support for DAFM disease eradication schemes such as that for Bovine Tuberculosis. In recent years CVERA has broadened its remit to provide epidemiological support for a wider range of animal health and welfare matters, including technical support for Animal Health Ireland.

NORTHERN IRELAND

The challenges facing the agriculture industry in both Northern Ireland and Ireland are similar. DAFM has encouraged the establishment of collaborative links between research Institutes in both jurisdictions in the area of agri-food research. Northern Ireland public research organisations are entitled to compete for Stimulus funds as project partners and the following research organizations have been in receipt of funds under previous Stimulus calls:

- Agri-Food and Biosciences Institute (AFBI)
- Queens University Belfast
- University of Ulster

APPENDIX 2

National agricultural research strengths

Irish agricultural research helps the agri-food industry to respond to consumer demands through the generation of new knowledge and serves as a conduit for knowledge generated by the international scientific community. Many countries have a similar structure as Ireland for delivering agriculture research, namely a research institute operating outside the higher education sector (e.g. INRA in France, USDA Agriculture Research Service, AgResearch in New Zealand, MTT in Finland) and universities which have agriculture or science/biology schools researching agriculture. Ireland has a very strong agri-food research base in Teagasc and the Universities. Recent data from Forfas showed that Ireland produced 1.18% of world documents on Web of Science in the 10 years from 2000-09 in the area of Agriculture, and these had an impact of 1.34 relative to a world average of 1. The equivalent figures for the area Food Science and Technology were 1.56% and an impact of 1.24. The following pages summarise Ireland's major agricultural research strengths.

ANIMAL BREEDING AND GENETICS

In Ireland over the last number of decades there have been significant improvements in both animal yields (milk and meat) and growth rates, with such improvements being cumulative and permanent. Profit based breeding objectives and selection criteria have been developed, which are continually enhanced to take account of new scientific knowledge and are supported by a world-class database that is now a major strategic asset in facilitating animal breeding and genetics research. The database is also being increasingly used in research relevant to animal health, disease control and farm management. Close linkages between the research community and the cattle and sheep breeding industries have also enabled research findings to be quickly and efficiently implemented within the industry.

Cattle breeding is currently undergoing a major revolution as a consequence of developments in DNA technologies and the mapping of the bovine genome that have created opportunities for rapid improvement in the rate of genetic gain achievable by national bovine breeding programmes. The introduction of 'genomic selection' enables suitable breeding animals to be chosen at a much younger age and their genetics released to Irish farmers much more quickly, thus resulting in higher rates of genetic gain in a much shorter time frame and at a lower cost. This increase in efficiency is worth in excess of €10 million per annum in terms of additional genetic gain over and above the existing levels already being achieved heretofore by Ireland's dairy farmers through our national breeding programme. Ireland was the second country in the world to include this new technology in their national genetic evaluation system and is leading the way with regard to international collaboration and further innovation in this area. This technology is being extended to beef cattle and sheep breeding and is expected to have a dramatic impact on these sectors by 2020.

In the area of horse genomics, there have also been huge advances with the recent development of a genetic test that can identify the optimum racing distance for individual Thoroughbred horses. The identification of 'The Speed Gene' is the first known characterisation of a gene contributing to a specific athletic trait in Thoroughbred horses. This test has the potential to transform decision-making processes in the global bloodstock industry.

New scientific approaches using genome-wide analyses, including gene and microRNA expression profiling (RNAseq), proteomics, genome sequencing (Illumina & 454), epigenomics and metagenomics are employed by animal researchers to investigate important aspects of bovine biology with significant economic impact including traits such as production, nutrition, reproduction, immunity and disease. In the area of functional genomics, new insights into the responses of individual animals – for example in relation to immune responses (pathogens, vaccines) or stress responses (climate, housing) are being provided.

New insights into the interaction between environmental factors, such as diet, pathogens and climate, and genomes will help researchers develop novel management strategies, particularly in relation to genotypes most suited to Irish grass-based production systems and that have a low environmental impact. These management strategies will deliver improvements against the wider range of consumer expectations, including product quality, animal welfare and environmental effects of animal production systems. Research is underway to incorporate the latest findings on greenhouse gas emissions and the use of genomics into Irish breeding programs which will enable Ireland be one of the first countries to adopt this knowledge.

ANIMAL HEALTH AND REPRODUCTION

Animal health and food safety are critical contributors to Ireland's international competitiveness as a result of the impact of animal diseases on product quality and safety and also because of the special importance that animal health and food safety have in international trade. Ireland's agri-food exports reached almost €8bn in 2010, the bulk of which comprised of milk and meat products. Ensuring the highest possible animal health status for our industry is of huge importance in order to maximise the value of our exports and to continue to gain access to premium markets world-wide. High animal health is also a major contributor to optimal efficiency and profitability at farm level. Research into improved diagnostics, therapeutics, vaccinations and selection for disease resistant animals are areas of active research that contribute to our success in achieving continued high herd health status. Key infectious diseases (endemic and zoonotic) of national importance under investigation include: Bovine Tuberculosis (TB); Brucellosis; Mastitis; Metritis; Neosporis; Leptosporosis; Toxoplasmosis and Chylamidia abortus. Elucidation of the factors at molecular and genetic level of the host response and subsequent disease resistance / susceptibility through the application of comparative and functional genomic technologies is key to identifying biomarkers, novel diagnostics and therapies.

In 2009, the Animal Health Ireland (AHI) initiative was launched to improve herd health by identifying and prioritising non-regulated diseases (e.g. IBR, BVD, Johne's) and conditions that impact negatively from both a financial and disease perspective in Irish livestock. The initiative brings together farmers, processors, marketers, animal health advisors, researchers, vets and government to identify what needs to be achieved over a defined period in the area of non-regulatory diseases of animals to secure improved profitability for Irish farms and international competitiveness of Irish livestock products. The initial remit of AHI is to focus on bovine animals; however this is expected to be extended to sheep, pigs and poultry in due course.

Another important area of research relating to animal health is bovine reproduction. Reproductive loss represents a huge financial burden for dairy and beef farmers annually and reduces overall production efficiency. Poor fertility can be caused by a range of different conditions including poor expression and detection of heat, mistiming of insemination, poor oocyte and embryo quality and inadequate uterine environment preventing the establishment and maintenance of pregnancy. Research is underway by a multidisciplinary team of scientists and bioengineers, who are investigating the biochemistry of regulation of fertility in dairy cows using various 'omic' approaches - transcriptomics, glycomics, metabolomics, proteomics - in vitro and in vivo models, for the purpose of developing new diagnostic tools and clinical therapies. Researchers are also examining genetic variation in fertility and management strategies to improve it.

GRASSLAND MANAGEMENT AND BREEDING

The production of milk and meat from low cost grass- based systems in our temperate climate is where Ireland's agriculture sector excels in the global food market in terms of having a competitive advantage. The recognition that grass based systems are, in general the most profitable form of livestock production systems in Ireland means that continued improvements and advances in grass breeding and management technologies must be identified and applied to exploit this competitive advantage. Perennial ryegrass continues to be the main grass species under investigation given its dominance in Irish pasture. Metabolomics technologies have been applied to uncover mechanisms involved in its response to multiple environmental stresses (water stress, Phosphorus deficiency, Nitrogen use and Crown Rust) for the purpose of identifying functional markers in perennial ryegrass for marker assisted breeding. Through conventional and genomic assisted breeding, researchers and breeders alike seek to develop new grass varieties that can reduce input costs, increase grazing length and DM intake by the grazing animal and offer flexibility across a range of management systems and geographic regions.

A recent breakthrough in the development of a grass economic index will underpin grass breeding and evaluation for Irish grass based production systems. The economic index for grass cultivars will apply monetary values to each cultivar which will include parameters that influence animal performance. Application of near-infrared spectroscopy (NIRS) technologies will allow the rapid analysis of cultivars in evaluation schemes and enhance information which is included on DAFM recommended lists. The research will ultimately increase profitability for grassland farmers and enhance the competitiveness of pasture-based systems of animal production in Ireland, whilst also contributing to our green economy image with the promotion of grassland as a sustainable resource.

SOIL, WATER & BIODIVERSITY

Soil is a fundamental natural resource on which life depends. It supports many essential services including provision of food and fibre; nutrient cycling; carbon sequestration; water management and purification; platform for infrastructure; habitat for soil organisms; and support for valuable biodiversity and ecosystems. Increasing demands for food and fuel from a growing global population and more significantly climate change mean that our soils face new threats in providing their range of essential services. Soil systems are the interface between agriculture and the environment and knowledge of the dynamics of this important system is fundamental for maintaining and supporting a competitive and sustainable agriculture and in playing a role in the fight against climate change.

Ireland's soil research employs an integrated scientific approach incorporating soil chemistry, agronomy, soil biology and physics. Much of the research is focussed on: understanding the importance of soil processes and their protection within the agricultural environment; nutrient applications, recycling, mobilisation and behaviour; pesticide mobility within different soil types; microbial denitrification process within subsoil/groundwater and Carbon and Nitrogen dynamics within the soil with a view to quantifying soil as sources or sinks of carbon dioxide, to maximise carbon sequestration, and to minimise soil emissions of nitrous oxide. Use of modern molecular biological and microbiological techniques - including PCR based techniques and 'omic' approaches - contribute to our improved understanding of the soil system and enhance carbon uptake and retention in soils and for the development of systems and tools to monitor changes.

Research is currently underway on the completion of a soils map of the country. Application of modern digital soil mapping techniques deployed in tandem with traditional field survey techniques for sampling and validation will result in the development of a 1:250,000 soils map of Ireland and an associated Soil Information System which will be accessible to all, serving as a valuable national resource for soil users and policy makers. This map will also act as a fundamental reporting tool for Ireland under the proposed Soil Framework Directive thereby fulfilling our reporting requirements at European level. Other ongoing soil research is aimed at establishing a network of benchmark sites throughout Ireland using existing national sites for the measurement of soil hydrological properties and the establishment of a hydrological classification of Irish soils. A process based soil hydrological model will be employed and developed with modules for erosion, surface sealing, compaction, landslides and loss of organic matter. The model will be combined with Irish geo-spatial data to develop a GIS-based risk assessment tool to predict impacts on soil quality based on hydrology, land use and climate change. As new scientific knowledge is developed in the area, various management tools will be developed that will be of practical significance at a farm level that will safeguard our soils' functions in the long term.

Ireland's waters are one of our major natural resources. While water quality in Ireland is good by European standards, improving water quality status is a national priority for Ireland with the EU Water Framework Directive being the main driver to achieving 'good status' for surface and groundwater by 2015. Nationally, agricultural activities are one of the main sources of pressure on water quality and can contribute to nutrient enrichment, organic pollution and siltation of water bodies. The implementation and enforcement of the Nitrates Action Plan under the EU Nitrates Directive is the most important measure to address diffuse agricultural pollution of freshwaters in Ireland.

In 2008, the Agricultural Catchments Programme (ACP) was launched to monitor and evaluate the effectiveness of Ireland's National Action Programme. The action research programme is providing data to inform its review in 2013 and supports the continuation of Ireland's Nitrates derogation. The programme is identifying, quantifying and assessing the management of nutrient sources on the farms and in the soils in a group of predominantly agricultural catchments. Other national funded research is focussed on investigating the effects of farm management practices on nutrient run-off, and leaching from various soil types with a view to informing best practice management.

Biodiversity refers to the variety and abundance of species, their genetic composition, the natural communities, ecosystem, and landscapes in which they occur. Biodiversity makes an important economic contribution to the provision of ecosystem services: provision of food and fibre, regulation of climate, pollination, maintenance of soil fertility, water purification and regulation of pest population. The loss of biodiversity is one of the main global challenges facing agriculture. For the EU and its Member States, biodiversity continues to be a key environmental objective. The EU is strengthening its policy framework and commitment to halting the loss of biodiversity and the degradation of ecosystem services by 2020, and restoring them in so far as possible.

At a national level, there is significant research activity in the monitoring and evaluation of agricultural practices and agri-environmental scheme measures. A range of agri-environmental indicators are assessed including habitat quality, biodiversity, nutrient inputs and agronomic indicators. The research outputs provide information to facilitate evaluation of the relationships between farming practice, environmental conditions and farmland biodiversity which ultimately supports the decision-making of policymakers and researchers about the appropriate design and implementation and monitoring of agri-environmental schemes. Limited research is also active on High Nature Value (HNV) farmland, whereby remote sensing and GIS technology is utilised to develop methodology which can be used to identify the extent and quality of HNV farmland.

CROPS

Crops form the basis for our food and feed industry in Ireland. Ireland's crop yields are among the highest in the world due to Ireland's favourable soil and climatic conditions and technically advanced systems of production. In light of expected increases in global population, the challenge is not only to satisfy a growing population but also to do it in a sustainable environmental manner. Through advanced science-based approaches Irish crop research will contribute to satisfying emerging needs for food, feed, energy and renewable raw materials in a sustainable and competitive manner.

Fundamental agronomic research seeks to develop more efficient and sustainable production systems and is concerned with the major arable crops - cereals, potatoes and oil seed rape, while plant breeding research is focussed on perennial ryegrass, clover and potatoes, the latter still considered the staple carbohydrate of the Irish diet. Irish potato researchers formed part of the global consortium that recently published the world's first high-quality draft sequence of the potato genome. This breakthrough will effectively reduce the period of time required to breed new varieties, enabling further enhancements in yield, disease resistance, nutritional value and production efficiency underpinning our continued success in both Irish and international markets.

Plant pathology research is ongoing on economically important pathogens and pests of wheat, barley and potato to understand pathogenicity and disease processes. The research spans plant and pathogen genomics; comparative genomics; plant-pathogen interactions and epidemiology of pathogen populations. The research also seeks to understand and predict how environmental changes will impact on disease incidence and the emergence of new strains or pathogens and resistance durability. Changes in global climate, agricultural policies and regulations emphasise the need to develop more sustainable and efficient crop production systems in Ireland requiring natural or biological methods to be found to maintain crop yields. Considerable research is now focussed on bacteria present in the soil and phyto-chemical compounds that have a natural ability to tackle a variety of crop and plant pathogens.

The needs to reduce GHG emissions and dependency on fossil fuel have been the main driving forces towards the non-food crops sector in Ireland. Research is ongoing into identifying suitable crops and sustainable production systems for bio-fuel and bio-industrial applications. Much of the research has focussed on the main bioenergy crops, willow, miscanthus and more recently grass. Ireland's climatic and soil conditions are suitable for growing some of these crops and offer an entry for agriculture to a large expanding energy market. These crops can deliver positive outcomes in terms of reduced CO_2 emissions and potentially deliver extra sources of income for rural communities. More applied research is concerned with biorefining and involves the application of bio- refining and fractionation technology to biomass to extract energy, high value bio-chemicals, bio-polymers and fibres

Climate change and transboundery gas mitigation

Ireland is committed to playing its part in mitigation of climate change by substantially reducing the levels of greenhouse and transboundary gas emissions in the agriculture sector. Irish agriculture is faced with the challenge of reducing gaseous emissions, while increasing output to meet with the targets set out in Food Harvest 2020. Continued progress in national climate change mitigation research can turn this challenge into an opportunity for Irish agriculture.

In a recent study published by the Joint Research Centre of the EU Commission, Ireland was rated amongst the best in Europe for carbon footprint of milk, pork and poultry meat. The study entitled "Evaluation of the livestock sector contribution to the EU Greenhouse Gas (GHG) emissions"[24] evaluated the full net carbon emissions of a range of livestock products, taking account of all on-farm emissions related to livestock rearing and the production of animal feed (even where this feed production takes place outside the EU), as well as emissions caused by providing input of mineral fertilizers, pesticides, energy, and land for the production of feed. The study highlights our strength in relation to efficiency and sustainability of production which offers us a unique advantage when it comes to increasing food production to meet a growing populations needs. To gain international recognition as a producer of environmentally sustainable food Ireland must continue to prioritise environmental protection and must continue to scientifically validate the country's environmental credentials.

National research aims to:

- Improve quantification of GHG and transboundary gas emissions associated with different agricultural practices and land-use types for inclusion into national inventories
- Refine the inventory emissions factors for agriculturally important GHGs and ammonia
- Investigate underlying processes (both soil and atmospheric) that drive the C and N cycles
- Quantify the main sources and sinks of GHGs, and identify potential abatement strategies at the farm level.

Livestock production research is active in the area of investigating animal and dietary variables that can be manipulated to reduce enteric methane emissions. Rumen microbiology research employs artificial rumen systems, in vitro gas production and novel molecular techniques that allow various dietary components to be screened for their effect on methane emissions, rumen fermentation and microbial community. Metagenomic investigations are currently underway to investigate the effect of the animal genome on rumen microbial populations in cattle and their associated environmental impact by way of methane emissions. Research to date demonstrates that emissions per kg of animal product for cattle can be reduced through full adoption of research technologies in relation to grassland management (increasing grazing season length, strategic Nitrogen application, inclusion of white clover) and genetic merit (Increased selection for profitability). For the most part, reductions in emissions are win-win in that they contribute to improved efficiency and profitability at farm level. Grassland and tillage research is concerned with the impact of various management practices, (fertiliser applications including application of nitrification and urease inhibitors, use of clover), soil quality characteristics, (C-sequestration potential and enhancement of this), and the impact of changing from intensive pasture and marginal grassland to biomass crops on GHG and ammonia emissions for the purpose of developing and assessing appropriate mitigation strategies.

24 http://ec.europa.eu/agriculture/analysis/external/livestock-gas/full_text_en.pdf

By adopting a whole farm and life cycle assessment approach, the research reviews and scientifically evaluates existing and potential mitigation strategies for use under Irish conditions. Research outputs will underpin the development of the most appropriate policy options for Irish agriculture production systems enabling cost effective abatement strategies be implemented at farm level to contribute to Ireland's sustainable agriculture production system while achieving our international commitments to reduce GHG and transboundary gas emissions. Ireland's commitment to research in the area is further strengthened by its proactive participation in European and International Climate Change Initiatives namely Food Agriculture and Climate Change (FACCE) and Global Research Alliance.

AGRI-ECONOMICS AND POLICY

Improving the sustainable and competitive growth of our agriculture industry and its contribution to the environment and rural society requires research into agricultural trade, production economics, environmental policy analysis and social science. Over the last decade there have been numerous agricultural policy reforms and such research has examined the impact on the economic, social and environmental sustainability of Irish farming. The ability of our agriculture sector to compete at or near world prices is crucial and ongoing research into our international competitiveness and productivity is the subject of much of this research.

Agri-economic research utilises National Farm Survey (NFS) data, climatic data and various modelling scenarios to investigate the various challenges facing the sector and provides advice to farmers and more importantly policy makers to plan for the future and to formulate the most appropriate policies to ensure the competitiveness of the sector and viability of rural areas. In key areas, this research is assisting Ireland meet the challenge of milk production post 2015; research is underway to identify strategies that will allow the dairy farm and processing model to respond to milk quota reform. Such strategies will boost competitiveness of the industry and future viability of the farming sector. In the climate change area, various models are employed to examine the impact of developments in agricultural markets and in agricultural policy on Irish GHG emissions. The subsequent impact on agricultural production and agricultural sector incomes of policies that seek to address environmental challenges is also examined providing valuable advice to policy makers on the costs/benefits of adopting various abatement strategies and on the impact of market based mechanisms and emission charges in reducing emissions from agriculture

APPENDIX 3

Funding mechanisms for primary agricultural research

NATIONAL FUNDING MECHANISMS

DAFM –Research Stimulus Fund Programme and Core Grant in Aid to Teagasc

The mission statement of the Department of Agriculture, Food and the Marine is:

"TO LEAD THE DEVELOPMENT OF A COMPETITIVE SUSTAINABLE AND CONSUMER-FOCUSED AGRI-FOOD SECTOR AND A VIBRANT RURAL ECONOMY AND SOCIETY"

The mission covers a multitude of policy issues and presents a significant challenge to the research agenda of DAFM. The changing face of agriculture, food, fisheries and forestry production means a constantly moving agenda needing to be informed / underpinned by sound scientific research. Research across these domains is a multidisciplinary activity with an ever-expanding range of sciences that have redefined the term "agriculture". DAFM has invested significantly in developing the research capacity and capability in Agriculture through Grant-in-Aid to Teagasc and via its competitive, public good, research funding programmes.

Research Stimulus Fund (RSF)

Agriculture research is supported under RSF which is a public good funding programme that is operated on a competitive basis. This programme has funded 113 project to date to the value of circa €48m. The RSF complements Teagasc's long term, mission-oriented, applied research programme by funding production agriculture research, on a relatively short term project basis, along the length of the research continuum from basic through to pre-commercial, focusing in particular on the modern biosciences. The main aim of the RSF programme is to create knowledge that will enable Irish agriculture to become a vibrant, competitive industry with improved productivity that is also environmentally sustainable. The theme areas covered include efficient animal and crop production, animal and plant health, agri-environment, sustainable non-food land uses, and the rural economy. This public good support provides funding, mainly on a collaborative basis, to a range of research institutes across an increasingly multidisciplinary, inter-institutional constituency. A second aim of the Stimulus programme is to develop scientific capability within the Irish research community to provide world class research for the Irish agri-food sector. Being internationally competitive allows them to apply successfully for non exchequer funding sources such as the EU Framework Programme. The programme has been at the forefront in developing core expertise in agriculture research within both Teagasc and the Higher Education Institute Network in Ireland, North and South.

In the period 2006 -2010, approx. €121m was spent on agricultural research through DAFM Core Grant-in-Aid to Teagasc and RSF. This provided a knowledge capacity within the sector to underpin its future sustainable development both in terms of food production, the delivery of environmental goods and services and examining the potential of crops for energy and other non-food products. By focussing on the modern biosciences and on underpinning the overall sustainability of agriculture policies and farming practices, the research also contributes to developing the knowledge economy. This is particularly evident in areas such as genetic improvement of plants and animals, development of novel treatments to combat pests and diseases, exploring the potential for non-food uses of agricultural land, finding cost effective ways to comply with ever demanding environmental legislation including, for example, with regard to mitigation of climate change related gaseous emissions, etc. The research supported is also making a

valuable contribution to informing policy formulation and rendering farming practices more competitive and sustainable. This direction is supported by the structures within Teagasc where its extension service disseminates the results of research thereby making a real difference to end users.

Core Grant-in-Aid to Teagasc

Teagasc is supported 75% through Irish exchequer funding, with the remainder from the EU and earned income. Approximately 40% of its annual operating budget, currently running at €127m, is devoted to research. This is comprised both of core or Grant-in-Aid (GIA) funding, competitive funding awards from national and international programmes, and earned income. The GIA, provided via DAFM, is negotiated and agreed annually with the Dept. of Public Expenditure & Reform as part of the Estimates process and forms part of the DAFM Vote announced on Budget day. The proportion devoted to research is a matter for the Teagasc Authority following consultation with DAFM on Teagasc's annual programme of activities. The GIA is similar to the Block Grant of the HEI's in that it funds salaries and overhead costs. Importantly, it also provides funding to Teagasc to conduct research projects and thus enables Teagasc to operate a planned research programme to deliver on the obligations of its mandate. This funding also allows training of PhD and postdoctoral fellows thereby increasing the knowledge base in the country.

Other National Funders of Primary Agricultural Research

Major Contributors	Minor Contributors
Higher Education Authority - Programme for Research in Third-Level Institutions (PRTLI) & Irish Research Council for Science Engineering and Technology (IRCSET) Post graduate and Post doctorate Schemes	**Sustainable Energy Authority of Ireland (SEAI)** - Renewable Energy-Research, Development and Demonstration Programme.
Environmental Protection Agency (EPA) - Science Technology, Research and Innovation for the Environment (STRIVE) Programme	**National Parks and Wildlife Services**
Science Foundation Ireland - Strategic Research Clusters, Charles Parsons Initiative and Awards to Individual Researchers	

INDUSTRY INITIATIVES FOR FUNDING PRIMARY AGRICULTURAL PRODUCTION RESEARCH

Dairy Levy Research Fund

The Irish dairy industry part-fund the research programme at Teagasc Moorpark through its voluntary research levy. The board of the Dairy Research Trust administers the dairy industry funding on behalf of all Irish dairy farmers which includes representatives from all key stakeholders. Moorepark is the lead provider of this research on behalf of Irish dairy farmers. The levy amounts to 0.035c/l of which 60% is used for farm research and 40% for milk processing research.

Pig Research Levy

Irish Association of Pigmeat Processors (IAPP) and their producer suppliers' jointly contribute to a research fund that is used to encourage research in relevant area of the pig sector. Research is generally focused at production level. The fund contributes to research conducted by Teagasc, UCD and some independent veterinary experts.

EU FUNDING MECHANISMS FOR AGRICULTURE RESEARCH IN IRELAND

The Seventh EU Framework Programme (FP7) for research and technological development is the European Union's main instrument for funding research in Europe. The programme which runs from 2007 to 2013 has a budget of €53.2bn. FP7 is a key tool to respond to Europe's needs in terms of jobs and competitiveness, and to maintain leadership in the global knowledge economy.

The Framework Programmes for Research have two main strategic objectives:

- To strengthen the scientific and technological base of European industry;
- To encourage its international competitiveness, while promoting research that supports EU policies.

In order to complement national research programmes, activities funded from FP7 must have a "European added value". One key aspect of the European added value is the transnationality of many actions: research projects are carried out by consortia which include participants from different European (and other) countries; fellowships in FP7 require mobility over national borders. Indeed, many research challenges (e.g. fusion research, etc), are so complex that they can only be addressed at European level. In FP7 there is also a new action for "individual teams" with no obligation for trans-national cooperation. In this case, the "European added value" lies in raising the competition between scientists in fundamental "frontier" research from the national to the European level.

The broad objectives of FP7 have been grouped into four categories: **Cooperation, Ideas, People** and **Capacities**. For each type of objective, there is a specific programme corresponding to the main areas of EU research policy. All specific programmes work together to promote and encourage the creation of European poles of scientific excellence.

Irish researchers in the agri-food and forestry sector focus mainly on Theme 2: 'Food, Agriculture and Fisheries, and Biotechnology' (FAFB) of the Cooperation Programme for funding. This theme has a budget €1.9bn over its seven year duration and is dedicated to research in the food, agriculture, fisheries and biotechnology theme area. The primary aim of this theme is to build a European Knowledge Based Bio-Economy (KBBE).

This theme is built around three major activities:

- Sustainable production and management of biological resources from land, forest and aquatic environments;
- Fork to farm: Food (including seafood), health and well-being;
- Life sciences, biotechnology and biochemistry for sustainable non-food products and processes.

There are also cross linkages between FAFB and other theme areas such as Health, Energy, Environment or ICT, which often contain agri-food related topics. Certain elements of the other three FP Programmes are also of some relevance to Irish agricultural production researchers e.g. the Marie Curie element of the People Programme and the Research Infrastructures element of the Capacities Programme.

Irish researchers in the agriculture area continue to be the most successful in terms of the percentage of available budget secured for Ireland. An analysis conducted by DAFM in 2011 showed that Irish agri-food researchers are the most successful in terms of the percentage of available budget secured for Ireland (1.8%), relative to Irish researchers in other research disciplines. Figures in 2011 show Ireland's drawdown in this theme to be €20.3 million with a total of 62 Irish participants, since the commencement of the FP7 programme.

Horizon 2020

At the time of going to print little detail is known about the shape of FP7's successor other than that it will be called Horizon 2020 and will fund research through a Common Strategic Framework integrating elements of the existing Framework Programme, the Competitiveness & Innovation Programme, and the Structural Funds aimed at addressing major societal challenges including sustainable food security, energy and climate. It is also likely to be simplified and will focus heavily on bridging the research to commercialisation gap through innovation and on fostering academic-enterprise linkages through public-private partnership and funding arrangements.

The Innovation Union initiative launched by the EU Commission in 2008 is also relevant in that it aims to make better use of the results from research in terms of developing new products and services. It is proposed to form a number of Innovation Partnerships including one on Agriculture. These proposed partnerships will bring together all actors and will attempt to foster better links between industry and the research community with the objective of increasing levels of innovation.

Voluntary Transnational Agricultural Research Initiatives

Although FP7 is the largest funding programme in Europe it is a fraction (estimated to be 5%) of the total spend on research across the EU. The majority of money committed to research is through national programmes, which can result in duplicity of effort and inefficiencies in problem solving. Against this background there is a growing realisation both in the European Commission and MS capitals of the need for greater degree of coordinated transnational cooperation of research efforts both within Europe and indeed across the globe. This has led to a number of initiatives the most relevant of which is outlined below.

Agriculture related European Research Area Networks (ERA-NETs)
ERA-NETs represent the first attempt at embracing this change of direction with the objective being to step up the cooperation and coordination of research activities carried out at national or regional level in the Member States and Associated States through the networking of research activities, and the mutual opening of national and regional research programmes. They provide a framework for actors implementing public research programmes to coordinate their activities and reduce the fragmentation of the European Research Area.

Ireland is currently a member of the following ERA-NETs relevant to the agriculture research domain:

- **CORE ORGANIC**: The aim of this ERA-NET is to enhance the quality, relevance and utilisation of resources in European research in organic food and farming through coordination and collaboration.

- **EMIDA** (Emerging and Major Infectious Diseases of Livestock): The aim of this ERA-NET project is to develop a durable focused network of national research funders in Member and Associated States of the EU for the purpose of sharing information, coordinating activities and working towards a common research agenda and mutual research funding activities in the field of animal health. The scope includes emerging and major infectious diseases of production animals, including fish and bees and including those conditions which pose a threat to human health but excluding food safety issues relating to the handling of livestock products and diseases of wildlife except where they act as reservoirs of infection for humans or production animals.
- **EUPHRESCO**: This is an ERA-NET project for research policy development and implementation in the field of statutory and emerging plant pests, diseases and invasive species (but not: GMO's).
- **ICT AGRI**: This is a cross thematic ERA-NET spanning the the FP7 themes: Agricultural Full Supply; Environmtal and Climate; and Information and Communication Technology. The ERA-NET aims to develop a common European research agenda concerning ICT and robotics in agriculture.
- **RURAGRI**: This ERA-NET aims to improve coordination between on-going and future European, national and regional research programmes dealing with the new relationships between rural areas and agriculture in Europe and the challenge of sustainability.
- **ERA-Net Bioenergy**: The ERA-NET Bioenergy networks national bioenergy research programmes to improve cost-effectiveness and ensure the maximum research impacts for the bioenergy sector.

Animal Task Force (ATF)

In 2008-09, the ATF was initiated, it comprises of a group of stakeholders that work for sustainable and competitive livestock and companion animal sectors at the forefront of technological development and other innovations through the creation of an enabling environment and adoption of an integrated approach across the value chain. This cooperative initiative is made up of European bodies concerned with knowledge and industry in animal production: Technology Platforms; knowledge, education and dissemination organisations, and research providers. These are the major public and private components of European livestock production which together aim to provide a positive image of the entire sector, and facilitate discussions on matters relating to future EU regulations that affect the sustainability and competitiveness of the sector. The ATF aims to mobilise resources from governments and industry for collaborative research on overarching themes in the livestock and companion animal sectors. By providing an enabling environment, knowledge transfer from the research base to the end users will be improved, and ATF will also promote lifelong learning for this production sector.

Joint Programming Initiatives (JPI)

The JPI concept stems from the realisation that a more coordinated approach is needed to optimise the value of research conducted across the EU and that certain research is best conducted on a pan-European basis. Building on the more limited ERA-Net model, it is a new bottom-up approach aimed at combining the national research effort (and related funding) of interested EU Member and Associated States, on a voluntary variable geometry basis, to tackle major societal challenges.

The "Agriculture, Food Security and Climate Change (FACCE)" JPI led by France and supported by a joint UK/French secretariat is of considerable relevance to agricultural production research. Ireland is a member and is represented on the Governing Board by both DAFM and Teagasc. The objective of the initiative, which currently comprises 20 member countries, is to co-ordinate research across Member States to address the major societal challenge of producing enough food while simultaneously addressing the challenge of reducing GHG emissions from the sector. Ireland may need to commit resources to this initiative in time.

Ireland also participates in the "Water Challenges for a Changing World" JPI. The objective of the initiative, which currently comprises 13 member countries, is to co-ordinate research across Member States to address the major societal challenge of water quantity and quality, and extreme events related to water. A whole variety of economic, ecological, social and technological challenges revolve around these two problems including developing a water-wise bio-based economy.

Global Research Alliance on Agricultural Greenhouse Gases

The Global Research Alliance (GRA) on Agricultural Greenhouse Gases was launced in the margins of the Copenhagen Climate Change Summit on 16th December 2009 with Ireland as a founder member. The Alliance is focused on research, development and extension of technologies and practices that will increase food production without increasing emissions of greenhouse gases at farm level. Currently there are 31 member countries in the Alliance, with representation spread right across the world.

The Alliance operates through a Governing Council (GC) and five (three vertical and two cross-cutting) Research Groups namely; Crops, Livestock, Paddy Rice, Soil Carbon & Nitrogen Cycling, and Inventory & Measurement. DAFM sits on the GC while Teagasc attends the Crops, Livestock, and Soil Carbon Groups and EPA is represented on the Inventory & Measurement Group. Similar to the case of the Joint Programming Initiative, Ireland may need to provide resources to fully participate in the work of the GRA.

SCAR & Foresight Exercises

The Standing Committee on Agricultural Research (SCAR) is an advisory committee charged with advising the Commission and Member States on the co-ordination of agricultural research across the European Research Area. DAFM and Teagasc represent Ireland on the SCAR. One of the core activities of the SCAR is the foresight process undertaken periodically. In this regard, the SCAR has undertaken three foresight exercises since 2006 and the findings of the two previous foresight exercises played a key role in identifying research areas where Member States should combine their efforts, in particular through platforms such as the ERA-NETs. The 3rd foresight exercise was entitled 'Sustainable Food Consumption in a resource-constrained world' and was launched at a conference in Budapest in May 2011. Over the years SCAR has launched a number of Collaborative Working Groups (CWG's); these include Susfood and Agricultural Knowledge & Information Systems (AKIS). There is awareness across Europe that the system for translating knowledge accumulated in institutes through publicly funded research into development, adoption & application of innovative technologies on farm is defective and needs attention. The AKIS CWG was formed to address this issue and Teagasc participates in its work. Ireland is fortunate to have an organisation like Teagasc, a dedicated organisation mandated to serve the research, education and advisory needs of agriculture in an integrated manner.

APPENDIX 4 Summary of estimates research costs and benefits of seven case studies examined by Boyle et al. (2002)

	Period of research	End date for study purposes	Sum of gross real benefits Discounted	Discounted sum of gross real benefits	Sum of real programme costs	Discounted sum of real programme costs	Discounted Benefit-cost ratio (DBCR)	Net present value (NPV) Internal rate of return	Internal rate of return (IRR%)
Potato breeding research	1962-1998	1998	€106.7m	€18.8m	€24.1m	€9.5m	2	€9.3m	9%
Milking machine research	1975-1998	1998	€799.5m	€242.7m	€6.4m	€3.8m	67	€239.0m	44
Silage research	1960-1990	1999	€5.7b	€1.3b	€42.6m	€17.7m	77	€1.3b	46%
Malting barley research	1985-1995	1999	€73.7m	€36.8m	€2.1m	€1.7m	22	€35.6m	95%
Pig breed evaluation research	1990-1998	1999	€16.5m	€8.9m	€1.0m	€0.8m	12	€8.9m	74%
Phosphorus on grassland research	1986-1998	1999	€269.2m	€115.6m	€1.1m	€0.8m	140	€115.6m	69%
Mushroom-growing research	1969-1995	1999	€825.5m	€362.0m	€5.5m	€2.4m	153	€199.4m	47%

DBCR: This is the ratio of the discounted stream (at 5% per annum) of benefits to the discounted stream of costs, both denominated in constant prices, from the inception of the programme up to a termination date.

NPV: This involves discounting the stream of net benefits, denominated in constant prices, from the inception of the programme up to a termination date by an assumed discount rate (5% as recommended by the Dept. of Finance). While a positive number indicates value for money, the bigger the number the better the return and thus the measure can be used to rank diverse projects in terms of the scale of the project.

IRR%: this is the rate of discount that ensures that the sum of the stream of net benefits, denominated in constant prices, from the inception of the programme up to a termination date, is zero. An IRR in excess of 5% would indicate good value for money. Moreover, the typical IRR for "successful" research projects in the international literature is substantially in excess of 5%

APPENDIX 5 Area group terms of reference

To provide expert advice to the Department of Agriculture, Food and the Marine on the development of an SRA relating to primary agricultural production and land use generally in connection with the following:

a) Future Calls under the Department's competitive, public good, funding programme known as the Research Stimulus Fund;

b) Participation in the Joint Programming Initiative on "Agriculture, Food Security and Climate Change" and the Global Research Alliance on Agricultural Greenhouse Gases;

c) The national public research prioritisation exercise led by the Dept. of Enterprise, Trade & Innovation;

d) EU Framework Programme.

APPENDIX 6 Area Group membership

Members	Body
Mr. Matthew Dempsey (Chair)	Irish Farmers Journal
Mr. Pearse Buckley	SEAI
Dr. Brian Wickham	Irish Cattle Breeding Federation (ICBF)
Dr. Frank O'Mara	Teagasc
Prof. Maurice Boland	UCD
Ms. Laura Burke	EPA
Mr. Brendan Barnes	Animal and Plan Health Association (APHA)
Mr. Ray Doyle	Irish Co-operative Organisation Society (ICOS)
Mr. Bart Bonsall	Bioenergy & Biorefinery Competence Centre
Mr. James Fitzgerald	Agricultural Consultants Association (ACA)
Mr. James Brett	Brett Brothers
Mr Donal Fitzgerald	Goldcrop Ltd
Dr. Sinclair Mayne	Department of Agriculture and Rural Development, Northern Ireland (DARD Northern Ireland)
Mr. Pat Smith	Irish Farmers Association
Dr. Donal Sammin	DAFM
Dr. Dan O'Sullivan	DAFM
Mr. Bill Callanan	DAFM
Mr. Richard Howell	Secretariat
Mr. Dale Crammond	Secretariat
Ms. Carol Howard	Secretariat

Area Sub-Group membership

Animal	Members	Body
	Dr. Donal Sammin	DAFM (Chair)
	Prof. Maurice Boland	UCD
	Dr. Frank O'Mara	Teagasc
	Dr. Brian Wickham	ICBF
	Mr. Brendan Barnes	APHA
	Dr. Sinclair Mayne	DARD Northern Ireland
	Mr. Pat Smith	IFA
Crops	**Dr. Dan O'Sullivan**	DAFM (Chair)
	Mr. James Brett	Brett Brothers
	Dr. John Spink	Teagasc
	Mr. Donal Fitzgerald	Goldcrop Ltd
	Mr. Brendan Barnes	APHA
Sustainability	**Mr. Bill Callanan**	DAFM (Chair)
	Ms. Laura Burke	EPA
	Mr. Bart Bonsall	Bioenergy & Biorefinery Competence Centre
	Mr. Pearse Buckley	SEAI
	Dr. Noel Culleton	Teagasc
	Mr. Ray Doyle	ICOS
	Ms. Ciara Daly	DAFM
	Mr. James Fitzgerald	ACA

APPENDIX 7

Area Group working methodology

The Group met on eight occasions between February and October 2011. At one of its first meetings the Group decided to undertake its work through three subgroups covering:

1. Animals (including issues relating to grass management / utilisation));
2. Crops; and
3. Sustainability: water, climate change & land use (including bio-energy)

During the course of the exercise a number of cross sectoral issues needing research also emerged in addition to research relating to economics, policy analysis and modelling.

A coordinator was appointed for each Sub-Group and a working methodology agreed which included the possibility to work electronically and / or hold actual meetings and to involve additional experts as deemed necessary. Each Sub-Group identified the issues requiring research (i.e. the research agenda) through the 4 step approach below and captured their findings using the template below:

1. Key drivers (national and international) were identified;
2. Knowledge deficits were defined;
3. The benefit to the agri-sector if knowledge deficit was addressed;
4. Research goals were formulated to address the knowledge deficits;

The full AREA Group was informed of, and reviewed progress on, the development of the research agenda at each of its meetings throughout the process. Towards the latter stages the Group requested each Sub-Group to categorise the research agenda into 4 categories (A, B, C, & D) in order of priority having regard to the following criteria:

1) Extent of knowledge deficit
2) Benefit accruing
3) Feasibility of carrying out research

To develop a Strategic Research Agenda for Agriculture Research

Strategic work areas for additional basic research	Drivers (legislation, policy documents, economic development etc)	Knowledge Deficit	Benefit to Agri Sector if knowledge deficit was addressed	Details of research needed to address issue

Department of
Agriculture,
Food and the Marine

An Roinn
Talmhaíochta,
Bia agus Mara